Understanding and Correcting False Beliefs: Studies in Vaccination and Genetically Modified Organisms

by

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DEDICATION

To my family and partner.

Thank you for your love, support, and never-ending encouragement.

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ABSTRACT

Every day, individuals are bombarded with readily available information, not all of which is accurate. Unfortunately, people make all kinds of decisions based on this faulty information, such as whether they should vaccinate their children, who to vote for, or what medical treatment to select. Furthermore, much research has established that it is extremely difficult to alter people's false beliefs and that correcting false beliefs can backfire. One promising approach (Horne et al., 2015) is actually to *not* address the false belief per se, and instead focus on individuals' decision-making processes associated with those beliefs. For example, when deciding whether to vaccinate one's children, one must weigh the possible risks of a vaccine (including, possibly, the false belief that vaccines cause autism) and the risk of the diseases that they prevent. Horne and colleagues found that focusing attention on disease risk led to changes in attitudes towards vaccines without explicitly addressing people's false beliefs.

In Studies 1 and 2, I replicated and extended this approach in the context of vaccination. Study 1 directly replicated Horne et al (2015). As predicted, a focus on disease risk was more effective than an intervention that directly countered false beliefs about vaccines and autism. Study 2 extended this line of research with three specific aims: (1) again replicate the Horne et al (2015) and Study 1 findings, (2) address a potential confound in the earlier work, and (3) test a combined correction approach. Specifically, the earlier disease risk condition in the original studies included pictures and was significantly longer than the autism correction condition. Thus, Study 2 included a

more thorough autism correction condition. Overall, there was no differential impact of the various interventions on attitudes and beliefs about vaccination, suggesting that the impact of addressing disease risk may not be robust.

The third study in this dissertation used a similar approach to Horne et al (2015) and Studies 1 and 2 but applied to a different context; the safety of human consumption of genetically modified organisms (GMOs). Specifically, Studies 3a and 3b addressed a common misperception about the safety of GMOs in food. Study 3a found a marginal effect of a GMO explanation condition (designed to parallel the disease risk condition seen in Studies 1 and 2 and proposed by Horne et al (2015)) on individual beliefs about GMOs. Additionally, the GMO explanation condition was the most effective at altering GMO behavior/intentions scale items and individual beliefs about the environmental impact of GMOs. Finally, Study 3b was a preregistered replication of Study 3a, with a larger sample size (n = 692). The results of Study 3b suggested that a GMO explanation condition designed to parallel the disease risk condition, was successful at altering individual attitudes, beliefs, and behavior/intentions toward GMOs. These findings further support that effective misinformation correction approaches may applicable to different contexts when focusing on the risks associated with failing to engage in a certain behavior and the influence it has on the individual and society.

CHAPTER 1

Introduction

Now more than ever, with the emergence of smartphones, iPads, and other handheld computers, individuals can access massive amounts of information with just the swipe of a finger. Unfortunately, in the current era of “fake news” and “alternative facts,” not all readily available information is accurate, and individuals are required to distinguish between what information is true and what is false. There are many different sources of inaccurate – or false – information. Although we cannot control the types or amount of information we are exposed to, we can control where and what kind of information we actively seek out. Typically, individuals search for information in sources that they themselves trust, even if the “trusted” source is not credible in an objective, scientific sense. This approach is problematic when the information provided is inaccurate. That individual is then unknowingly left believing in misinformation. Lewandowsky and colleagues (2012) note that misinformation can have various sources, including: rumors, media, religion, politics, family, and the internet. Regardless of their origins, beliefs -- regardless of whether they are true or false -- influence how individuals evaluate various elements of the world (i.e., the self, different topics of the world). Furthermore, holding false beliefs differs from ignorance, which is the *absence* of information or knowledge on a certain topic or issue (Lewandowsky et al., 2012).

Once individuals hold a false belief, they tend to adhere to that belief even when explicitly told that their belief is incorrect (Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). Because false beliefs can have serious consequences for behavior, there is a large body of research that addresses how misinformation is most effectively corrected (Lewandowsky et al., 2012; Nyhan & Reifler, 2010; Stanovich & West, 2000). Perhaps the most consistent finding across this large body of research is that correcting false beliefs turns out to be, perhaps surprisingly, extremely difficult.

This dissertation investigates different methods for attempting to correct misinformation. Specifically, I focus on two relatively common false beliefs: the belief that vaccines cause autism, and the belief that genetically modified organisms (GMOs) are unhealthy for human consumption. I elected to focus on these two topics because decisions made about them have important societal consequences. Furthermore, there is a large body of research on correcting false beliefs about vaccines yet many tested approaches have not been successful. I test one approach that was found to have some success (Horne, Powell, Hummel, & Holyoak, 2015; discussed in detail below). Unlike the issue of vaccines and autism, there is little research on correcting misinformation in the context of GMOs. I test whether or not the underlying principles for successful vaccine misinformation correction might be applied to this new context.

Why is Misinformation Correction Difficult?

Several cognitive and motivational biases underlie the difficulty individuals may have in changing their minds once they hold a false belief. First, memory biases (in particular, a bias called the “continued-influence effect”) may impact people’s ability to encode, remember, and use new information. Second, there is a tendency to value information derived from personal experience of first-hand accounts compared to statistical information. Given that many false beliefs may arise initially from personal encounters, people may not attend to misinformation correction methods that provide empirical evidence. Third, people are often overconfident in their beliefs and this, too, may lead to ignoring new information. Finally, individuals often reasoning about information in a biased manner because they have motivations to maintain their beliefs, sometimes even when they are false. Below, I provide a brief introduction to each of these potential influences on misinformation correction.

Continued-Influence Effect

The continued-influence effect is a phenomenon in which initially learned information is difficult to delete from memory (de Vega, Urrutia, & Riffo, 2007; Wilkes & Leatherbarrow, 1988). Thus, even when new, correct information is presented, individuals tend to continue to remember and believe what they initially learned. In a classic study of the continued influence effect, Johnson and Seifert (1994) presented participants with a news story that contained misinformation. For example, one story was about a fire in a warehouse. Initially, it was reported that there were flammables in the warehouse. Then, the misinformation was corrected to state that the initial report was in error. Regardless of when the misinformation that was corrected (either immediately after presented with misinformation or later), participants continued to make inferences about the fire based on that misinformation. It was especially difficult for participants to update their memories of the story when the false information was necessary to support the causal structure of the story. Furthermore, if a new causal structure was provided, participants were better at updating their memories. This set of experiences both nicely illustrate the continued-influence effect, and also suggest that one way of reducing the impact of discredited information is to provide readers with a clear causal explanation that does not rely on that false information.

Rich and Zaragoza (2016) extended this line of research and found that implied misinformation was more difficult to correct than explicit misinformation. They argued that this might be for two reasons: that it is easier to notice the mismatch between the correction and the misinformation when it explicit, and also because self-generated misinformation is more difficult to correct. This study, too, provides some guidance regarding the continued influence of misinformation. In particular, approaches that first explicitize and acknowledge what a person believes and then corrects that belief might be more effective in misinformation correction.

Preference for Narrative Reasoning over Abstract Numerical Reasoning

Another possible mechanism for the persistence of false beliefs is that, in some contexts, false beliefs may be learned through personal sources such as friends or familiar news providers or through personal experience. For example, many individuals who believe that vaccines cause autism report that they learned this information through personal social networks and, in particular, often know someone who they believe contracted autism due to vaccination (Professor & Niemeyer, 2004). However, one common approach to correcting false beliefs about vaccines and autism is to provide statistical data demonstrating that vaccination is not associated with autism and that there are few serious potential side effects of vaccination (CDC, 2015).

Unfortunately, people tend to hold favor concrete, personal narratives in making judgments and decisions over statistical information (e.g., Hinyard & Kreuter, 2007;

Reinard, 1988; Taylor and Thompson, 1982). One early demonstration of this phenomenon (Borgida & Nisbett, 1977) asked University of Michigan undergraduates (primarily prospective psychology majors) enrolled in introduction to psychology what to select courses that they planned to take. They were randomly assigned to a statistical condition that provided mean course ratings or a face-to-face condition. In general, undergraduates were influenced by face-to-face interactions when making their decisions, but not by course ratings. Borgida and Nisbett (1977) argued that this was due to the vividness of the concrete information over the abstract quantitative information. Numerous other studies have found that individuals tend to value concrete and personal information over abstract statistical information (even though, when explicitly comparing the two types of information people often report that they find statistical information more persuasive) (Allen & Priess, 1997).

There are several reasons why abstract, statistical information may hold less weight in judgments and decisions relative to concrete, narrative information. As Borgida and Nisbett (1977) argued, narrative information is more concrete and vivid. Second, people may find it easier to identify with an individual rather than identifying with a "statistically average person." Anecdotal experiences warrant more of an emotional response than statistical information, and thus might be especially persuasive (Fagerlin, Wang, & Ubel, 2005). In general, narrative, anecdotal information promotes and supports heuristic, experiential reasoning. In contrast, processing statistical information may require more effortful, analytic thinking. Another factor that might lead to the individuals valuing narrative reasoning, therefore, might be "cognitive miserliness" or avoiding cognitive effort required to process data (Toplak, West, & Stanovich, 2014).

Several factors influence how impactful a narrative is (Hinyard & Kreuter, 2007). In general, the source of the narrative has a major influence on whether or not they are persuasive. If the source is trusted, viewed as an expert, and similar to the receiver then the message is deemed more persuasive. Narratives are also more influential when addressing issues in which scientific reasoning may be limited (i.e., religion, personal values, morality, etc.) (Polkinghorne, 1988). Additionally, some groups (e.g., African Americans, Mexican Americans) respond better to a more narrative based form of communication, specifically when promoting health related behavior (Yoo, Kreuter, Lai, & Fu, 2014; Hinyard & Kreuter, 2007; Murphy, Frank, Chatterjee, & Baezconde-Garbanati, 2014).

The review above provides some potential mechanisms by which providing individuals with statistical information (about, say, the safety of vaccines or GMO's) may not be very persuasive, at least alone. Some research has examined the methods to increase the relative salience and value individuals place on statistical information. One finding is that presenting quantitative data in graphical format may increase attention to that information (Fagerlin, Wang, & Ubel, 2005; Chua, Yates, & Shah, 2006). In the current set of studies, misinformation correction approaches contained both narratives and graphical information to maximize their likely effectiveness.

Overconfidence & Belief Superiority

Another reasoning bias that could impact how individuals perceive new information is people's general tendency to be overconfident about their level of knowledge and skills in their cognitive, social abilities (Kruger & Dunning, 1999; Moore & Healy, 2008). One consequence of their overconfidence can be adherence to ignorance that they do not have adequate knowledge or expertise underlying their beliefs (Dunning, 2011). If so, then people who are especially overconfident in their beliefs in controversial domains may be most likely to hold those false beliefs. In fact, Motta, Callaghan, and Sylvester (2018) recently tested the possibility that individual differences in overconfidence would be associated with the belief that vaccines cause autism. They found that more than a third of participants rated their level of knowledge about the cause of autism to be higher than those of doctors and scientists. As predicted, these individuals were most likely to believe that vaccines cause autism (Motta, Callaghan, & Sylvester, 2018).

Related to the Dunning-Kruger effect is the notion of “belief superiority” (Raimi & Leary, 2014). Belief superiority is defined as “the belief that one’s own beliefs or opinions are more correct that other viewpoints” (Raimi & Leary, 2014; pp. 76). Individuals differ in the extent to which they hold belief superiority, and this individual difference may be related to the degree to which they overestimate their own knowledge (Hall & Raimi, 2018). Individuals who have high levels of belief superiority also hold more polarized views.

In sum, susceptibility to overconfidence and belief superiority may both impact the extent to which individuals might be amenable to belief change and explain why those individuals who hold false beliefs about polarizing topics may especially be susceptible to holding false beliefs.

Motivated Reasoning

The theory of *motivated reasoning* is that “motivation may affect reasoning through reliance on a biased set of cognitive processes: strategies for accessing, constructing, and evaluating beliefs" (Kunda, 1990, pp. 480). Motivations, according to a classic review by Kunda (1990), can include both a motivation to be accurate (e.g., James & Van Ryzin, 2017) or a motivation to come to a particular conclusion. Each type of motivation can influence cognitive processing. The motivation to be accurate without a preference for any particular conclusion leads to relatively high-quality reasoning processes. In contrast, the motivation to come to a desired conclusion leads to the use of biased cognitive strategies (Kunda, 1990; Taber & Lodge, 2006; James & Van Ryzin, 2017). Many types of motives may underlie the general motivation to arrive at a specific conclusion: protecting one's self-esteem, viewing oneself in a positive light, or viewing other individuals or events in a specific manner, desire to persuade, agreement with a peer group, self-image, and self-preservation (Epley & Gilovich, 2016; Kunda, 1990).

Klaczynski (2000) extended the research on motivated reasoning by proposing a model that highlights the cognitive and motivational components underlying biased reasoning. This model of what Klaczynski refers to as "theory-motivated reasoning" -- the failure of individuals to reason in a way that is Independent of their beliefs -- is comprised of multiple components; analytic and heuristic information processing systems (Klaczynski, 2000). Analytic processing "relies on the abilities (e.g., scientific reasoning)" and "are often normatively prescribed for sound decision making" while heuristic processing is "preconscious, rapid, and effortless" and judgments made using this type of processing are considered more "appealing because (individuals) 'feel' intuitively correct" (Klaczynski, 2000, pp. 1348; Epstein, 1994). According to this model, analytic processing is typically used when individuals are presented with information that is incongruent with their beliefs while information that is congruent with an individual's beliefs are processed heuristically. Based on this model, an individual who holds the false belief “vaccines cause autism” may reject views that argue “vaccines do not cause autism” in order to preserve his or her initial theory about vaccines (Klaczynski, 2000).

The literature on motivated reasoning is vast and there are a plethora of underlying motives and consequent cognitive biases. Below, I limit my discussion to one motive that may have major impact on reasoning about false beliefs and their correction is the motive of avoiding or reducing cognitive dissonance (Festinger, 1957). Following a discussion of cognitive dissonance, I discuss a single cognitive reasoning bias most likely relevant to the evaluation of misinformation correction messages: confirmation bias (Wason, 1960).

Cognitive Dissonance

Cognitive dissonance involves holding or displaying multiple inconsistent thoughts, beliefs, attitudes, and behaviors. Festinger (1957) argued that cognitive dissonance leads to feelings of discomfort or unease. Therefore, one of the motives that impact motivated reasoning is the goal of reducing or avoiding feelings of dissonance (Zunda & Sinclair, 1999).

In general, people align their beliefs with their behavior (Harmon-Jones & Mills, 1999). For example, someone who believes that GMOs are unsafe would choose not to purchase or consume GMOs. When one is faced with new information (for example, that GMOs are actually safe for consumption) that is inconsistent with the behavior of avoiding GMOs, they will feel discomfort and cognitive stress (Festinger, 1957; Harmon-Jones & Mills, 1999). Therefore, they may engage in motivated reasoning with the goal of discrediting the new and contradictory information (Keller & Block, 1999). Some research classifies this type of reasoning as a form of “identity self-defense” -- that is, individuals are unconsciously motivated to avoid factual information if that information is contrary to their “identified group” (Kahan, 2013; Cohen, Bastardi, Sherman, Hsu, McGoey, & Ross, 2007). Alternatively, they may reconcile their behaviors with the new information by creating cognitive consonance (for example, in the context of GMOs, individuals may reconcile behavioral and attitude inconsistencies by consuming GMOs in moderation rather than avoiding them entirely). This reconciliation of cognitive dissonance through cognitive consonance specifically occurs when individuals highlight the positive aspects of their decisions while deemphasizing the negative aspects (Festinger, 1964; Aronson, 1969).

Confirmation Bias

One cognitive bias associated with motivated reasoning is confirmation bias. Confirmation bias is seeking out evidence that is in favor of your desired outcome and avoiding or criticizing or avoiding/not seeking out evidence that is in support of your desired outcome (Wason, 1960).

One classic demonstration of confirmation bias is the Lord, Ross, and Lepper (1979) study of belief polarization. Researchers hypothesized that beliefs would remain polarized when presenting individuals with information that is inconclusive or debatable. Researchers gave participants questionnaires about their views regarding capital punishment. Participants were then asked to evaluate one of two empirical studies about the deterrent effect of capital punishment; one of these studies found a positive impact of capital punishment and the other did not. Finally, participants were again assessed about their attitude toward capital punishment. Lord, Ross, and Lepper found that individuals were more convinced by evidence that was consistent with their prior beliefs. Indeed, regardless of which study they read and their prior beliefs, participants believed that the empirical study supported their beliefs. This tendency to focus on information that supports or confirms what an individual already believes is sometimes referred to as confirmation bias.

In addition to criticizing information that is not consistent with one's beliefs, confirmation bias is associated with the failure to engage with information that contradicts one's beliefs. This aspect of confirmation bias is sometimes referred to as "selective exposure" (Earl & Nisson, 2015; Jonas, Schulz-Hardy, Frey, & Thelen, 2001; Snyder & Swann, 1978). "Selective exposure enables people to defend their attitudes, beliefs, and behaviors by avoiding information likely to challenge them and seeking information likely to support them" (Hall, Albarracin, Eagly, Brechan, Lindberg, & Merrill, 2009, pp. 2). Furthermore, selective exposure in the context of misinformation (specifically, misinformation presented online) has the potential to create "filter bubbles" -- "a self-reinforcing pattern of narrowing exposure that reduces user creativity, learning, and connecting" (Nguyen, Hui, Harper, Terveen, & Konstan, 2014, pp. 677; Pariser, 2011). For example, individuals who seek out information confirming the false belief "vaccines cause autism", are less likely to be presented with information incongruent to their viewpoint. This constant repetition of misinformation can actually strengthen the individual memory for the misinformation (Skurnik, Yoon, Park, & Schwarz, 2005).

Related to selective exposure is myside bias. In myside bias, individuals are more likely to seek out evidence and form arguments supporting their personal viewpoint rather than attending to evidence that supports an alternative viewpoint (Stanovich, West,

& Toplak, 2013). Specifically, myside bias is the tendency individuals have to "ignore information of the side that one disagrees with...in favor of information that supports one's position 'myside'" (Wolfe, 2012, pp. 478). Confirmation and myside bias share the characteristic that they both involve an inability to separate prior beliefs from analytical evaluation of new information (Macpherson & Stanovich, 2007). However, the slight difference between the two phenomena is that myside bias specifically occurs when individuals seeks out information that confirms what they already believe while *ignoring* information that is incongruent with their beliefs (Perkins, Bushey, & Farady, 1986; Baron, 2000). Furthermore, myside bias often refers to the contexts in which individuals generate an argument and present it to others with bias, rather than merely evaluating information. In general, myside bias is strongest when an individual has strong beliefs, the more neutral or unsure an individual is on a certain issue, the more likely they are to evaluate information in a more balanced manner (Sawicki et al., 2011). If an individual who has strong beliefs about vaccines causing autism, they may generate a coherent narrative about this topic that ignores counterevidence.

In summary, individuals who are prone to evaluating information based on whether that information confirms what they already believe (i.e., confirmation bias) may fail to acknowledge, or even ignore information that opposes their viewpoint, regardless of the accuracy of that information. This can be potentially problematic for correcting biased beliefs about the cause of autism or the presumed safety of GMO consumption, both of which are somewhat polarized topics, and can ultimately interfere with one's ability to make rational decisions (Robbins & Judge, 2007; Young, Tiedens, Jung, & Tsai, 2011).

Two Important Misconceptions: Vaccines and GMOs

Two important misconceptions that are the focus of this dissertation are: (1) the false belief that vaccines cause autism and (2) the false belief that GMOs are hazardous for human consumption. Both of these specific false beliefs have potential impact for public health and the environment. Several of the factors discussed above are relevant to the misinformation surrounding vaccines and GMOs.

The strong false belief that vaccines cause autism is pervasive, despite the fact that global public health communities strongly support vaccinations and many highly respected organizations such as the World Health Organization (WHO), American Medical Association (AMA), and American Pediatric Association (APA), explicitly communicate the message that “vaccines do not cause autism”. This community of anti-vaxxers is vocal and there has been a decline in vaccination rates and, unfortunately there has been a rise of vaccine-preventable outbreaks such as measles and an even more recent polio-like illness, acute flaccid myelitis (AFM). AFM is a rare but seriously illness that specifically impacts children. This polio-like illness which has been linked to vaccination declines, impacts the nervous system especially the spinal cord, causes muscle weakness, and can lead to the sudden onset of paralysis (Messacar, Schreiner, Haren, Yang, Glaser, Tyler, & Dominguez, 2016). As recently as this month (February 2019), there are reports of vaccine-preventable outbreaks in places such as Washington state, which has identified 36 confirmed cases of measles and 12 suspected cases still under examination (Wilson, 2019). The failure of parents to vaccinate their children has dire consequences not only for children that are not receiving vaccines but also to the greater population.

Similar concerns can be seen in different contexts as well, such as in the case of human consumption of GMOs. Many individuals avoid the consumption of GMOs under the incorrect belief that GMOs are hazardous to human health. Not only has research found that GMOs are perfectly safe for human consumption, but it has also found numerous other benefits of GMOs, such as higher crop yields, and a longer-shelf life for fruits and vegetables. The reduction or stoppage of GMO production could have drastic global consequences such as fewer crops, higher use of pesticides, and more environmental food waste (Mannion & Morse, 2012). Despite scientific evidence supporting the use of GMOs, many individuals prefer organic, non-GMO ingredients in their diet and even encourage the removal of GMO products; an action that could have greater detrimental impact than they may realize.

In this dissertation, I consider these common and particularly problematic false beliefs to examine the effectiveness of different misinformation correction approaches. There are numerous studies that have examined methods for addressing the false belief that vaccines cause autism (but only one study (Bode & Vraga, 2015) that I am aware of that addresses altering attitudes about GMOs). Wallis (2014) argues that simply telling people that there is plenty of scientific evidence that vaccines do not cause autism is unlikely to be effective, some have argued that this type of direct correction can produce a "backfire effect" – when individuals are presented with information that contradicts the beliefs one holds, their beliefs strengthen (Nyhan & Reifler, 2010). Indeed, a study by Nyhan and colleagues (2014) confirms this prediction. They used materials from the Centers for Disease Control and Prevention (CDC) stating that vaccines do not cause autism as a misinformation correction approach to alter anti-vaxxer attitudes. Nyhan and colleagues (2014) found that while the corrective information debunking the false belief "vaccines cause autism" reduced participant misconceptions about vaccines, it also resulted in a decrease in parent intention to vaccinate. Furthermore, corrective approaches that included images of children with measles, mumps, and rubella, as well as a narrative about a child who contracted measles "actually increased beliefs in serious vaccine side effects" (Nyhan et al., 2014, pp. 7).

An Unlikely Pairing

At first glance, vaccines and GMOs have very little in common. Vaccines are used to protect individuals from harmful illnesses to avoid contraction of preventable diseases, whereas GMOs are used by certain farmers to enhance their crops. Despite these surface differences, attitudes and beliefs about these contexts share some similar features.

In both cases, there is a potential threat to the individual or family (because of the belief that there for potential health consequences to vaccination or consuming GMOs) and there is also a potential benefit to society (public health and/or environment) and to the self (protection from measles, for example). When anti-vaxxers choose not to vaccinate, they are primarily concerned about their own children. However, the community risk associated with the failure to vaccinate is often overlooked. Specifically, not vaccinating an individual child poses a direct threat to herd immunity – the notion that if most people are vaccinated then a disease is unlikely to spread even if some people are unable to be vaccinated for medical reasons (Anderson & May, 1985; Salmon et al., 1999). Furthermore, the threat to the self for not vaccination is also ignored or minimized (e.g., by stating that measles or chickenpox are not dangerous, common childhood infections). Similarly, when individuals choose to avoid GMOs under the belief that these foods are unfit for human consumption, it ultimately only impacts the individual. However, when those anti-GMO beliefs and attitudes are translated into behavior – such as in the case of GMO opposers to ban the use of those crop modifications – that this action can become problematic to the greater community. GMO plants typically lead to higher crop yields, are more resilient, and less susceptible to various threats (thereby reducing use of dangerous pesticides and herbicides). These factors impact the global environment (Nicolia, Manzo, Veronesi, & Rosellini, 2013; Mannion & Morse, 2012). One potential question to ask in addition to whether or not individuals will alter their attitudes surrounding these two heavily debated topics, is whether or not the potential negative impact on the community results in greater attitude change.

Approaches to Correcting Misinformation

Though misinformation correction has many aspects that make correcting individual misconceptions difficult, there are many misinformation correction approaches that show promise. As noted earlier, Johnson and Seifert (1994) proposed an effective misinformation correction approach in the form of a causal model alternative combat previously retracted or contradicted information.

Another approach to successfully intervening may be to focus on specific individuals who are more likely to change their minds. Betsch, Korn, and Holtmann (2015) note that strength of pre-existing beliefs can account for the degree to which an individual alters their attitudes, beliefs, and intentions. In the case of anti-vaxxers, Betsch, Korn, and Holtmann argue that researchers should aim at altering the attitudes of "fence-sitters" – individuals who are neither anti-vaxxers nor vaccine supporters but rather possess a neutral stance on the topic. In a reanalysis of one study that found some success in altering views of anti-vaxxers (Horne et al, 2015), Betsch, Korn, and Holtmann found their success was primarily due to belief change of fence-sitters.

Other researchers argue that the key to successfully altering attitudes, beliefs, and even future behavior is through theory-based explanations of the initial misconception (Weisman & Markman, 2016). Weisman and Markman (2016) explored theory-based explanations in four different contexts: (1) hand-washing to prevent viral epidemics, (2) parental vaccination of their children to prevent a preventable disease outbreak, (3) completion of full antibiotic prescription to reduce antibiotic resistance, and (4) eating healthy foods to reduce unhealthy diets. Researchers noted that in every context, the most effective correction approaches provided participants with coherent explanatory frameworks to promote healthier behaviors. Given the promising results noted in the previously mentioned contexts, Weisman and Markman suggest this theory-based explanation approach is an effective correction intervention that researchers should apply in their studies.

Harm Approach & Fear Appeals

One tactic that has been used as an attempt to get individuals to engage in a certain behavior, such as vaccinating their children, is a fear appeal. Janis (1967) proposes that emotionally-arousing campaigns ("fear appeals" or "scare tactics") tend to have an inverted U-shape in terms of their effectiveness. In other words, low-levels of emotional arousal do not have any effects on individual response to the topic at hand, while emotional arousal on the high-end will lead to resistance and defensiveness to "detach from the threat" – very similar to a backfire effect. Instead, the ideal fear appeal has a moderate impact on emotional arousal. Not only does the level of emotional arousal influence the effectiveness of a fear appeal, but also how individuals evaluate the appeal message (Witte, 1992). As is common with other types of strong emotionally charged opposing intervention strategies, the results can sometimes lead to a backfire effect (Lennon, Rentfro, & O'Leary, 2010).

Another potential approach to address misconceptions is to appeal to utilitarian views in the context of moral dilemmas (Marcus, 1980). In general, individuals select options that lead to harming the fewest number of individuals. However, the contexts of interest in this dissertation focus on dilemmas in which the potential harm/benefit is either to one's own family, or to society at large (more people, but more distance). In the case of vaccines, parents face one of two choices: (1) have their children vaccinated to protect them from potentially life-threatening illnesses for themselves and others, or (2) fail to have their children vaccinated because they are concerned that their own child will develop autism. In the decision to avoid or consume GMOs, individuals are also presented with two choices: (1) consume GMOs with their environmental benefits, or (2) consume GMOs and face potential – though highly unlikely – health consequences.

As noted previously, many studies have examined vaccine misinformation correction approaches (Horne et al., 2015; Nyhan & Reifler, 2014; Nyhan & Reifler 2010). While this context has been studied, much less (or no) research has attempted to alter individual beliefs about GMOs . To my knowledge, there is only one study that examines individual attitudes toward GMOs and their safety (Bode & Vraga, 2015). Bode and Vraga (2015) conducted a study focusing primarily on the "intersection of misinformation and social media"; specifically, how social media influences both the establishment of misinformation and their correction. While these researchers also examined false beliefs surrounding vaccines and autism and the safety of GMOs for consumption, due to the novelty of their exploration of GMO misinformation correction, I will focus on that particular facet of their study.

In Bode and Vraga's (2015) study of social media and misconceptions, participants were randomly assigned to one of eight conditions. Every condition contained information that supported the notion "GMOs make you sick"and included a Facebook NewsFeed story with two related links supporting the false claim (one from a website that focuses on rumors and "urban legends" and one from the American Medical Association). After viewing the simulated Facebook NewsFeed and materials, participants were then assigned to a separate posttest matching the previously viewed issue. Attitudes toward GMOs and their safety was measured using three items: (1) "Genetically modified foods are safe to eat", (2), "Genetically modified foods give you cancer", and (3) "I try to avoid genetically modified foods". Results suggested GMO attitude change is possible when individuals are exposed to corrective information found in social media. Aside from Bode and Vraga's study, most research on beliefs about GMOs have studied, rather, why people are attracted to arguments in which claims are made about the negative health consequences of GMOs and, general public perception of GMOs (Beckwith et al., 2013; Blancke et al., 2015; Saletan, 2015; Maghari & Ardekani, 2011).

Beliefs and Attitudes

Misinformation correction approaches tend to address beliefs (e.g., the belief that vaccines cause autism). However, addressing beliefs can also impact people's attitudes and behaviors. Wogalter and DeJoy (1999) define *beliefs* as thoughts and opinions about various topics and phenomena that are treated as true regardless of accuracy, and act as "building blocks" for attitudes. Beliefs generally refer to "an association between an entity and an attribute or outcome" (Hart, Albarracin, Eagly, Brechan, Lindberg, & Merrill, 2009). In the context of vaccines, the most prevalent false belief is that "vaccines cause autism". The entity here being "vaccines" may lead to some undesirable outcome, in this case the development of autism.

Attitudes on the other hand are "an individual's evaluation of an entity (an issue, person, event, object, or behavior)" (Hart, Albarracin, Eagly, Brechan, Lindberg, & Merrill, 2009). Furthermore, Betsch, Korn, and Holtmann (2015) operationalize attitudes as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor". For example, an individual who believes "vaccines cause autism" may also have negative attitudes about vaccines (e.g., vaccines are harmful). Using a vaccine example, an individual may *believe* that vaccines cause autism, therefore hold negative *attitudes* toward vaccines, and therefore *decide* to forgo vaccines. Prior research has suggested that misinformation correction approaches may need to consider both beliefs and attitudes in order to effectively correction misconceptions (Nyhan & Reifler, 2013; Betsch, Korn, & Holymann, 2015). In evaluating the effectiveness of the correction message in the studies in this dissertation, we include questions about people's beliefs as well as their attitudes; because some assessment items (taken from prior studies) incorporate beliefs and attitudes, we consider these factors together. Furthermore, I test how addressing misconceptions about vaccines and GMOs affect people's intended behaviors and other decisions.

Decisions

Ultimately, the goal of misinformation correction is to not only alter beliefs and attitudes, but also change decisions individuals might make.

Decision-making is often framed in terms of expected utility. The expected utility of a particular decision (say, voting for an individual for president) is a sum of the weight of each potential consequence (signed as to whether it is positive or negative) multiplied by the likelihood of that consequence. To decide between two candidates, one would compare the expected utility of each candidate. The expected utility of any decision can be described by the formula below, in which x is a decision, p represents the probability of each outcome, and u represents the utility of that outcome:

$$\Sigma[u(x)] = [p_1 * u_1] + [p_2 * u_2] + [p_3 * u_3]\ldots$$

In the case of vaccinating one's child or consuming GMOs, the expected utility might be described by the probability times utility of benefits (e.g., avoiding risk of measles) minus the probability times utility of risks (e.g., developing autism). In general, people prefer decisions decisions that maximize expected utility (Westen 1985; Westen, Blagov, Harenski, Kilts, & Hamann, 2006). Although many approaches to correcting misinformation focus on altering the incorrect negative risks (e.g., stating that there is no or miniscule probability that vaccines cause autism or that GMOs are unhealthy), an alternative might be to address the benefit side of the equation. In the case of vaccines, that would be avoiding the diseases that may be avoided by vaccination, and in the case of GMOs, it would be consideration of the environmental and food production consequences of GMOs. Indeed, that is the approach taken by Horne et al. (2015) in their study of vaccination attitudes. They compared a "autism correction" (direct correction) intervention that claimed autism was not associated with vaccines to a "disease risk" intervention that focused on the negative consequences of the diseases avoided by vaccinating against measles, mumps, and rubella. Furthermore, Horne and colleagues (2015) found the newly generated "disease risk" approach to be effective at altering attitudes toward vaccines without causing a backfire effect (*see* Chapter 2).

The Current Studies

The goal of this dissertation is to assess whether the approach of focusing on the positive consequences of vaccination and consuming GMOs may be more effective than correcting misinformation regarding vaccines and GMOs. Specifically, I first examine whether the findings of Horne et al. (2015) are replicable. Then, I address one potential confound in their study to further understand the impact of their approach. Finally, I extend this approach to a new context, the consumption of GMOs.

If the correction approach developed by Horne and colleagues (2015) can transcend contexts, the act of getting parents to vaccinate their children and humans to fearlessly consume GMOs may be positively impacted by increasing the estimates of the positive effects of receiving vaccines and GMOs rather than attempting to decrease estimates of the probability of the negative side effects.

Despite the initial findings of the approach proposed by Horne et al (2015) that were promising, there are still several things that are unclear about their approach. The first concern about the proposed approach is the relatively small effect size based on the categorizations proposed by Leppink, O'Sullivan, and Winston (2016). Researchers initially found an effect size of $d = .41$, which suggests that while an effect of condition was found (the disease risk condition was more effective than a direct autism correction condition and control) it is possible that these findings may not always replicate due to a lack of robustness. In addition to concerns about effect size, the vaccine scale developed by Horne and colleagues failed to parse vaccine attitudes, beliefs, and intentions into separate measurements, a concern raised by Betsch, Korn, and Holtmann (2015). This lack of subsets leads one to question if the proposed disease risk intervention really alters individual behavior. Although the scale proved to be highly reliable and correlated with individual past vaccine behaviors (*see* Chapter 3), the scale did not include a measure of participant agreement with the common misconception "vaccines cause autism". The inclusion of clarity between scale items (e.g., measurements of beliefs, attitudes, intentions, etc.) could further justify what aspects of human cognition are impacted by these proposed interventions.

Overview of Dissertation

Although all the aforementioned can be potential contributing factors of correcting misinformation that can hinder the appropriate change in attitude in the presence of factual opposing information, they are not impossible to account for. The goal of the proposed set of studies was to examine various aspects of the expected utility formula applied to different topics (vaccines and autism, and GMOs) to investigate the degree to which individuals alter their attitudes and beliefs on these topics. More specifically, the current set of studies had three specific aims: (1) to evaluate the degree to which individuals alter their incorrect attitudes through a series of intervention studies, (2) to test whether the proposed intervention studies are effective across different domains, and (3) further examine the weight individuals place on anecdotal experiences compared to population statistics and facts by using the expected utility formula to weigh both positive and negative probabilities and utility of partaking in certain behaviors. The current studies used specific topics that individuals – typically – have a polarized reaction to. The use of different contexts allowed us to fully examine the extent to which individuals alter their attitudes and beliefs based on the proposed interventions.

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Chapter 2

Study 1: Direct Replication of Horne et al. (2015)

Introduction

In recent years there has been a significant increase in vaccine-preventable illnesses such as measles, mumps, and rubella (MMR) (Althaus & Salathe, 2015; CDC, 2015). This disturbing trend arises in part from a parent hesitation to vaccinate their children due to the mistaken belief that vaccines may cause autism (Pluviano, Watt, & Sala, 2017; Rao & Andrade, 2011). Nonetheless, the evidence is clear that vaccines do not cause autism, and there is no link between the two whatsoever (Taylor, Swerdfeger, & Eslick, 2014; Jain, Marshall, Buikema, Bancroft, Kelly, & Newschaffer, 2015; Kaye, del Mar Melero-Montes, & Jick, 2001). Thus, an important issue in public health is correcting false beliefs about the relationship between vaccines and autism with the hope that it will increase the likelihood that parents choose to vaccinate their children (Nyhan, Reifler, Richey, & Freed, 2014; Horne, Powell, Hummel, & Holyoak, 2015). Unfortunately, simply telling people that vaccines do not cause autism (autism correction) is not effective. Indeed, some studies have suggested that directly confronting false beliefs can even result in a backfire effect in which an individual's original belief (regardless of accuracy) is strengthened in the presence of opposing information (Pluviano, Watt, & Sala, 2017; Masaryk & Hatokova, 2016; Peter & Koch, 2016).

In a recent paper, Horne et al. (2015) found a successful approach to changing attitudes towards vaccination. The decision to vaccinate, they note, involves computing an expected utility function of vaccination by weighing the relative risks (of putative side effects such as autism) and benefits (reducing risks of disease). Most public health approaches to changing attitudes towards vaccination focus on correcting misinformation directly (i.e., stating that vaccines do not cause autism). For example, the United States Centers for Disease Control and Prevention (CDC) takes this approach by clearly and explicitly stating on their website "Vaccines Do Not Cause Autism," "There is no link between vaccines and autism," and "Vaccine ingredients do not cause autism." (https://www.cdc.gov/vaccinesafety/concerns/autism.html). Horne and colleagues, following Nyhan et al. (2014), chose to focus on the other component of the equation: the risk of diseases prevented by vaccination. Originally, Nyhan et al. created three versions of a disease risk intervention: (1) three different photos of children who had contracted measles, mumps, and rubella respectively, (2) an anecdotal story about a mother whose child contracted measles, and (3) a paragraph composed of three brief warnings about the importance of vaccination. Individually, these were not successful (Nyhan et al., 2014). However, Horne et al. combined these three elements to create a more comprehensive disease risk intervention. This "disease risk" intervention, as predicted, led to significant change in attitudes towards vaccination compared to a more traditional intervention that focused on an "autism correction" intervention.

The Horne et al. (2015) study is important to replicate for several reasons. First, it has major public policy/health policy implications: countering misinformation that vaccine preventable diseases (i.e., mumps, measles, rubella) are no longer a threat to people (which in actuality they still are for a variety of well understood reasons). The "correcting misinformation" condition of the Horne et al. (2015) study was not effective, yet it was modeled after current CDC practice. Second, the impact of their intervention was relatively small (Cohen's $d = .41$), however, according to the meta-analytic effect size of social psychology expectancy effects (on average $d = .16$) their intervention was substantial (Richard, Bond, & Stokes-Zoota, 2003); replicating their findings before making policy recommendations is necessary. Third, future research aimed at understanding how to counter misinformation will benefit from confidence in the findings of the initial, groundbreaking Horne et al. (2015) study. Finally, there are inconsistencies in the correcting misinformation literature regarding the effectiveness of focusing on the risk of the diseases that vaccines prevent. While the Horne et al. (2015) study found a comprehensive disease risk intervention to be effective in changing attitudes, Nyhan et al. (2014)'s disease risk interventions did not successfully change people's attitudes. While there have been other researchers who have examined similar constructs surrounding vaccines – such as Scherer et al. (2016) who studied the human papillomavirus (HPV) and vaccine adverse event reports (VAERS) to determine trust and concern about vaccine use and Witteman et al. (2015) who prompted participants to think about how values correspond to risk of obtaining a vaccine (which is similar to the disease risk condition proposed by Horne et al. (2015)) – the overall study and methodology proposed by Horne and colleagues (2015) is more applicable and appropriate to our proposed research question. Thus, we directly replicated the Horne et al. (2015) study in Study 1.

In Study 2, we addressed one potential alternative interpretation for the benefit of the disease risk intervention but not the autism correction intervention in the Horne et al. (2015) study. In the original study, the disease risk condition was much longer than the autism correction condition and included not only factual content about disease risk but also pictures and a narrative story. In contrast, the autism correction condition is a series of short factual claims that includes citations for participants to read if they chose to do so. This choice was made in the original study to reflect the approach used on the CDC website. Nonetheless, is not clear whether the disease risk condition is more effective than the autism correction condition due to these qualitative and quantitative differences, and we controlled for those factors in Study 2.

Study 1

To assess whether the comprehensive disease risk intervention effect (Horne et al., 2015) is replicable, we directly replicated their study using scripts (programmed in Qualtrics) provided by the research team. We recruited participants from approximately the same population (MTurk participants) with roughly the sample size of the original study, and data were analyzed in a similar fashion as the original study.

Method

The current study was a direct replication of Horne et al. (2015). We followed the exact same methods as Horne and colleagues (2015). A direct replication with identical methods allows for better evaluation of both potential significant (comprehensive intervention) and null (individual intervention) results if the original findings are replicated.

Participants

All participants were recruited through Amazon Mechanical Turk (MTurk) to ensure filtering out of participants that had previously participated in similar vaccine studies and the same inclusion criteria as Horne et al. (2015) was used (i.e., including native English speakers in the US, and participants who correctly answered all attention check items). Participants that failed to pass any attention check items were excluded from participating in the second study session available on the following day (see *Procedure*). Participants were provided with a consent form prior to completing any portion of the study. Following Horne et al. (2015), the study recruited participants in multiple sessions (session one and session two) (see *Procedure*). We made two power calculations using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) that focused on the results of two key analyses in the Horne et al. (2015) study. Horne et al. (2015) reported an effect size of Cohen's $d = .41$ for change in the vaccine attitude change scores (posttest minus pretest) for the disease risk condition compared to the control condition ($t(212) = 3.04$, $p = .003$); because publication bias tends to lead to overestimations of effect sizes in the published literature, we chose a conservative assumed effect size $d = .15$, which is consistent with other studies of attitude change (Richard, Bond, & Stokes-Zoota, 2003). The results of this analysis suggested that to achieve a power of .8 at the $p = .01$ level, we would require a minimum of 778 participants. The second power analysis was based on all three conditions ($F(2, 312) = 5.287$, $p = .006$ in Horne et al. (2015)). Using a more conservative effect size .15, this yielded a sample size of 924 participants to achieve a power = .8 and alpha of .01. Assuming an attrition rate of 25% between two sessions, we recruited 1000 participants to complete the first session of the study. Participants who passed the attention check items (see *Procedure*) were invited to participate in the second session. Participants were paid $.75 for their participation during session one, and $1.35 if they returned for session two, for a total of $2.10.

Vaccine Scale

The primary dependent variable in this study was the five-item vaccine attitude scale that was developed by Horne and colleagues (2015), as well as answers to the component questions. The vaccine scale was designed to assess individual general attitudes towards vaccines using a six-point Likert scale ranging from *"Strongly Disagree"* to *"Strongly Agree"* (*see* Appendix). Some of the items featured in the scale were reverse-coded. Examples of some of the response statements include "The risk of side effects outweighs any protective benefits of vaccines" and "I plan to vaccinate my children". Additionally, researchers included a sixth item in their scale assessing vaccine attitudes "Some vaccines cause autism in healthy children", however this question was not included in the original five-item vaccine attitude scale. This scale was taken at the end of the first study session, as well as at the end of the second study session. In the original study, to assess each participant's change in attitudes toward vaccines, the first study session (pretest) was subtracted from the second study session (posttest) to yield a vaccine-attitude change score. We used this same approach but also analyzed the responses to the individual vaccine-related questions, including the sixth question as described below. As with the original study (Horne et al., 2015) we also assessed participant vaccine behaviors and family structure (i.e., "Have you had a flu shot in the last year", "Are you a parent", "Have you ever refused or elected to forgo a vaccine your doctor recommended for your children") at the end of the second session. The inclusion of these behavioral questions further aids in assessing individual vaccine attitude change.

Procedure

As in Horne et al. (2015) the proposed study was administered over two sessions. During session one, participants were asked to provide some demographic information (age, sex, income, political preference, etc.) and to rate their level of agreement on a six-point vaccine attitude scale in addition to rating their pre-existing beliefs on various morality scales including: euthanasia, abortion, and consequentialism (*see* Appendix). The morality scales were included to blind participants to the true purpose of the study. Attention check questions were randomly placed throughout these scales to ensure that participants are paying close attention to the questions. For example, one attention check stated, "We just want to make sure you are paying attention. Select 'somewhat disagree' from the options below to pass this attention check." At the end of session one, participants that successfully answered the attention check questions were invited to return for session two. In the original study, the second session was released to MTurk at 9am (PST) the following day and participants were instructed to complete session two between 9am-8pm (PST).

During session two of the study, participants were randomly assigned to one of three conditions (disease risk condition, autism correction condition, control condition) drawn directly from materials by Horne and colleagues (2015) (*see* Appendix A). These materials were originally derived from the CDC website and a previous study (Nyhan et al., 2014). Participants assigned to the disease risk condition were given three pieces of information: (1) a paragraph written from a mother's perspective about her child who contracted measles, (2) pictures of children with measles, mumps, and rubella, and (3) three brief warnings about the importance of vaccinations; these three components were presented in random order. Participants assigned to the autism correction condition read information stating that vaccines do no increase the risk of autism. Those participants assigned to the control condition read an unrelated scientific article used previously by Horne et al. (2015) and Nyhan et al. (2014).

Results

Results were analyzed with SPSS 24. Following the data analysis from the original study (Horne et al., 2015), incomplete data were not used for data analysis. Our primary analyses were to repeat the key analyses in Horne et al. (2015). With very similar samples sizes (n = 364, Horne et al. (2015) n = 316), recruitment methods, and procedure, after conducting a one-way ANOVA to examine vaccine attitude change score by condition (disease risk, autism, control), results were significant and replicated the original study findings, $F(2, 361) = 3.356$, $p = .036$, $\eta = .018$ (see figure 2.1). When only examining the autism condition and control condition, there was a marginal effect of condition on vaccine attitude change score, $t(243) = 1.776$, p = .077, $d = .23$. In addition, when comparing the frequency of pretest vaccine attitude scores for the Horne et al. (2015) study ($M = 4.84$, $SD = 1.05$) with the current study ($M = 4.95$, $SD = .96$), there was no significant difference between pretest scores, $t(643.99) = -1.450$, $p = .148$, $d = .11$.

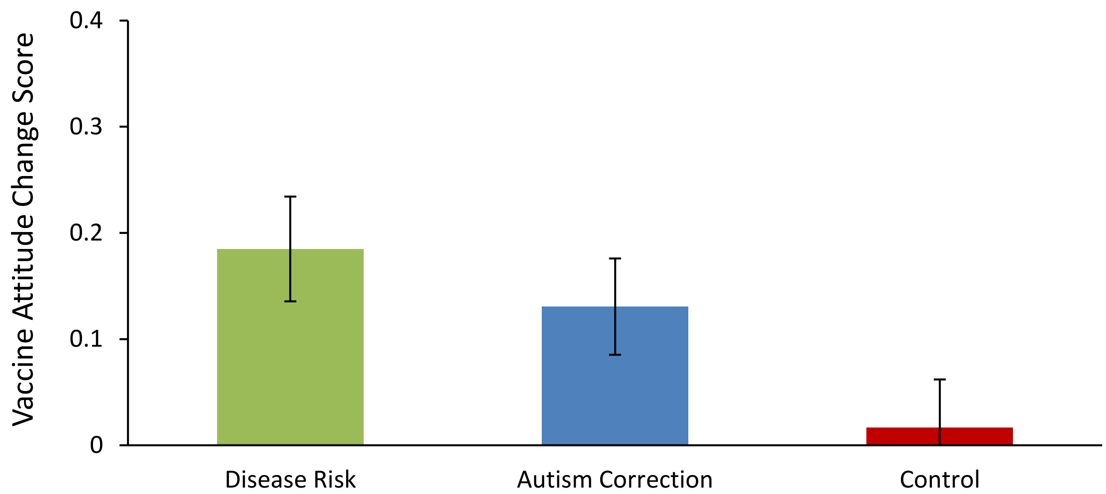

Figure 2.1. Vaccine attitude change score by condition.

In addition, we also analyzed vaccine attitude change score by condition after parsing the original five item vaccine attitude scale (including hidden question six: *"Some vaccines cause autism in healthy children"*) into three subscales measuring: attitudes, beliefs, and intentions. A one-way ANOVA was conducted to examine the effect of condition on vaccine attitude (i.e., "*The risk of side effects outweighs any protective benefits of vaccines"; "Vaccinating healthy children helps protect others by stopping the disease";* and *"Doctors would not recommend vaccines if they were unsafe"*) questions one, two, and five respectively. Results were nonsignificant, $F(2, 361) = 2.176$, $p = .115$, $\eta^2 = .012$. A one-way ANOVA examined the effect of condition on vaccine intentions, question three (*"I plan to vaccinate my children"*) and found a marginal effect, $F(2, 361) = 2.460$, $p = .087$, $\eta^2 = .013$, with the disease risk condition ($M = .18$, $SD = .61$), demonstrating the most change from pre to posttest for future vaccine intentions, compared to the autism correction condition ($M = .13$, $SD = .57$), and control ($M = .02$, $SD = .62$) (see figure 2.2). Independent sample t-test confirmed the disease risk condition was significantly better than the control, $t(238) = 2.122$, $p = .035$, $d = .26$. No significant group differences were found when comparing the autism correction condition and control, $t(243) = 1.481$, $p = .140$. Additionally, a one-way ANOVA was conducted to examine the impact of vaccine beliefs (i.e., *"Children do not need vaccines for disease that are not common anymore", "Some vaccines cause autism in healthy children"*) question four and hidden question six respectively. Results were nonsignificant, $F(2, 361) = 2.065$, $p = .128$, $\eta^2 = .011$.

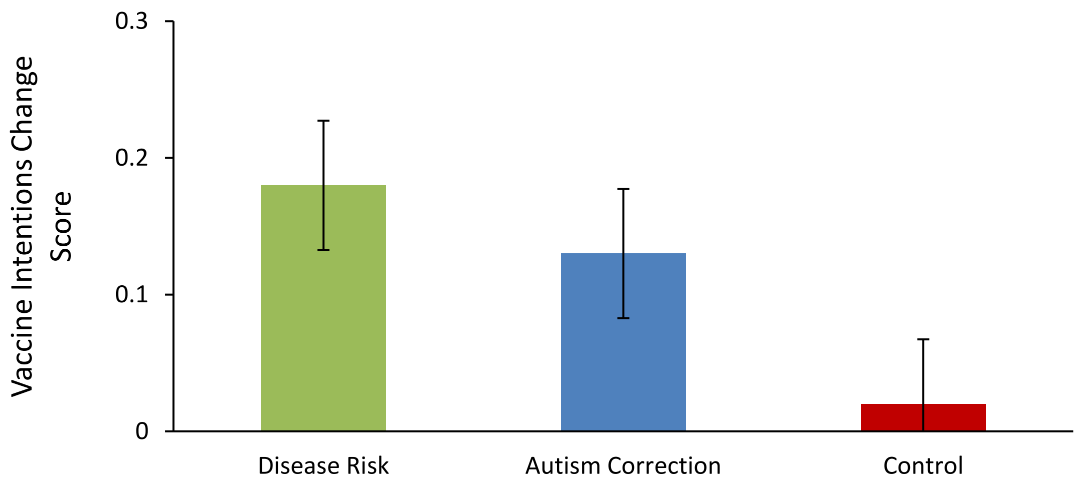

Figure 2.2. Average change score for vaccine question three examining intentions (*"I plan to vaccinate my children"*) by condition show the disease risk was the most effective at altering vaccine intentions.

While the original tercile analysis was likely influenced by regression to the mean and the ceiling effect of the six-point scale, we still replicated that analysis to keep the replication analyses as similar as possible. We examined the effects of vaccine attitude change score based on condition and terciles generated from participant pretest scores, tercile cutoffs were identical to the ones Horne and colleagues (2015). A 3 X 3 factorial ANOVA was conducted examining tercile (bottom, middle, top) and condition (disease risk, autism, control) on vaccine attitude change scores. There was a significant main effect of condition, $F(2, 355) = 3.177$, $p = .043$, $\eta = .018$, a significant main effect of pretest tercile, $F(2, 355) = 28.625$, $p < .001$, $\eta = .139$, but no significant interaction between the two, $F(4, 355) = .644$, $p = .631$, $\eta = .007$ (see figure 2.3). Though these results match the findings from the original study (except for the interaction results), it is important to note that this analysis does suffer from regression to the mean and its findings should be interpreted lightly.

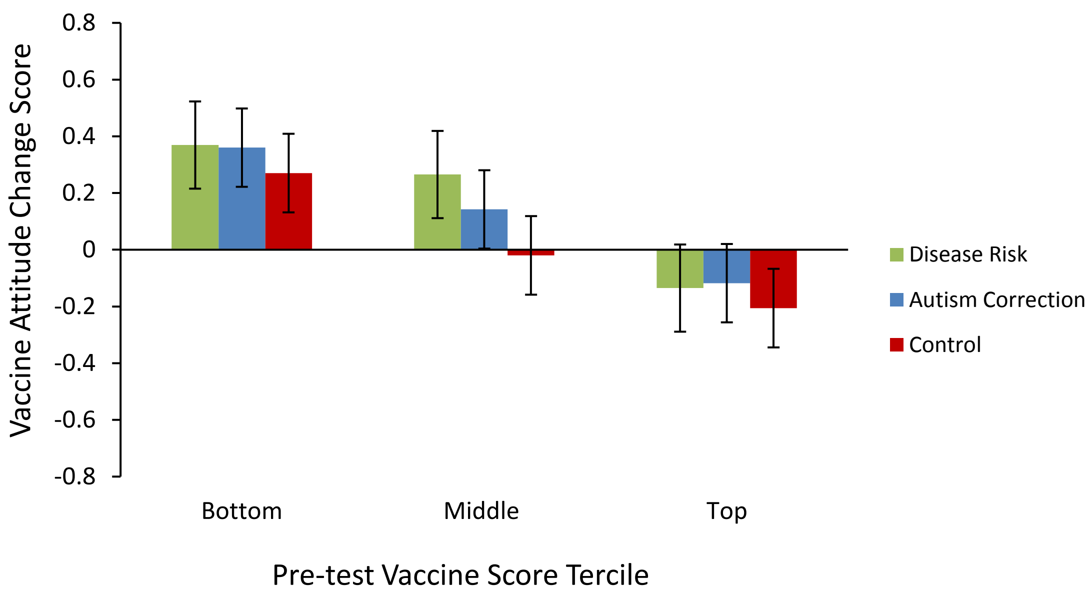

Figure 2.3. Vaccine attitude change score by condition divided into terciles based on vaccine attitude pretest score.

To account for potential parental differences in vaccine perceptions, we will also conduct a 2 X 3 factorial ANOVA exploring parent status (parent vs. non-parent) and condition on vaccine attitude change score. A 2 X 3 factorial ANOVA was conducting examining parent status (parent (n = 203) vs. non-parent (n = 161)) and condition (disease risk, autism, control) on vaccine attitude change score. There was a significant main effect of condition, $F(2, 358) = 3.256$, $p = .039$, $\eta^2 = .018$ (see figure 2.4). Specifically, the disease risk condition was marginally better than the control condition for both parents, $t(130) = 1.814$, $p = .072$, $d = .32$, as well as for non-parents, $t(106) =$

1.750, p = .083, d = .34. Results found no significant effect of parent status, $F(1, 358)$ = .132, p = .717, $\eta^2 < .001$, and no significant interaction, $F(2, 358)$ = .032, p = .968 $\eta^2 < .001$.

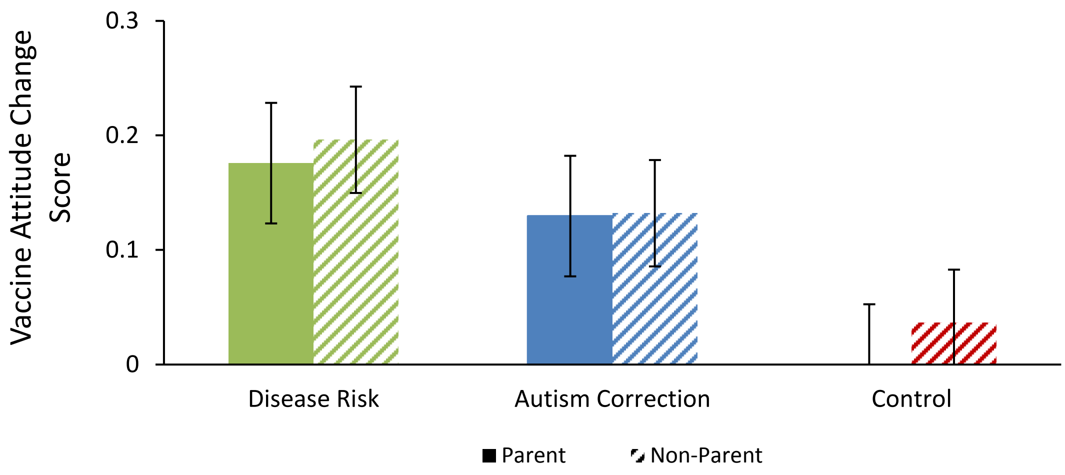

Figure 2.4. Vaccine attitude change score by condition and parent status (parent or non-parent).

An area of interest that may arise when discussing participants who have a choice to complete the second session of a study, may be whether there are pretest differences in individuals who were eligible to return and did not compared to those participants who were eligible and completed session two of the study. Results show there is no difference between those individuals eligible and return (n = 364) and those who failed to return (n = 489); $F(1, 851) = 2.674$, p = .102.

In addition to these replicated analyses, we also examined condition on vaccine scale question six (i.e., "Some vaccines cause autism in healthy children."). This is the main piece of misinformation surrounding the vaccine-autism debate, and we wanted to know how the correction interventions influenced attitudes on this statement. A one-way ANOVA found a significant difference between groups (disease risk: M = .135, SD = .700; autism: M = .419, SD = .817; control: M = .066, SD = .574) when examining change score for question six, $F(2, 361) = 8.666$, $p < .001$, $\eta = .046$ (see figure 2.5). Specifically, an Independent samples t-test found a significant difference between the autism correction condition and control group, $t(243) = 3.097$, $p < .001$, $d = .50$.

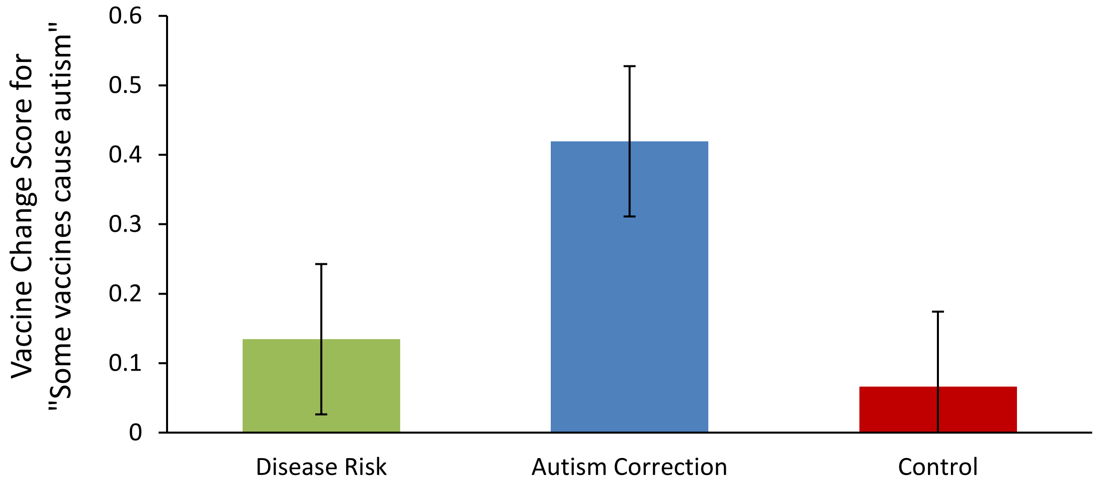

Figure 2.5. Average change score for vaccine hidden question six ("*Some vaccines cause autism in healthy children*") by condition.

Exploration of Individual Factors

In addition to replicating the main analyses from Horne et al., we also conducted some exploratory analyses to examine individual differences that might provide some insight for future research in this area. Some research has suggested there are differences in individual beliefs, based on political party preference (partisanship), which could be potentially done through political motivated reasoning (Van Bavel & Periera, 2018). Political party preference – also referred to as partisanship – can influence many aspects of one's life aside from whom they vote for, such as attitudes, behaviors, and decision-making (Van Bavel & Periera, 2018). Previous research has found significant differences among partisanship and belief of scientific findings such as in the case of climate change (Van Bavel & Periera, 2018; Rutjens, Sutton, & van der Lee, 2018).

Using these findings, a one-way ANOVA was conducted to examine partisanship on pre-test vaccine scores (prior to receiving any intervention), results found a significant difference when looking at all six political categories (Republican (n = 85), Democrat (n = 139), Independent (n = 98), non-political (n = 17), moderate (n = 15), and libertarian (n = 8), ($F(5, 344) = 4.524$, $p < .001$, $\eta^2 = .06$ (see figure 2.6). These results are still significant when only examining the three main political parties (Republican ($M = 4.77$, $SD = .90$), Democrat ($M = 5.14$, $SD = .92$), and Independent ($M = 4.95$, $SD = .92$)), $F(2, 313) = 4.434$, $p = .013$, $\eta^2 = .03$. Additionally, we also examined partisanship on vaccine attitude change score. Results were non-significant when taking into account all six parties, $F(5, 356) = .687$, $p = .634$, nor when only examining the three main political parties, $F(2, 319) = .875$, $p = .418$.

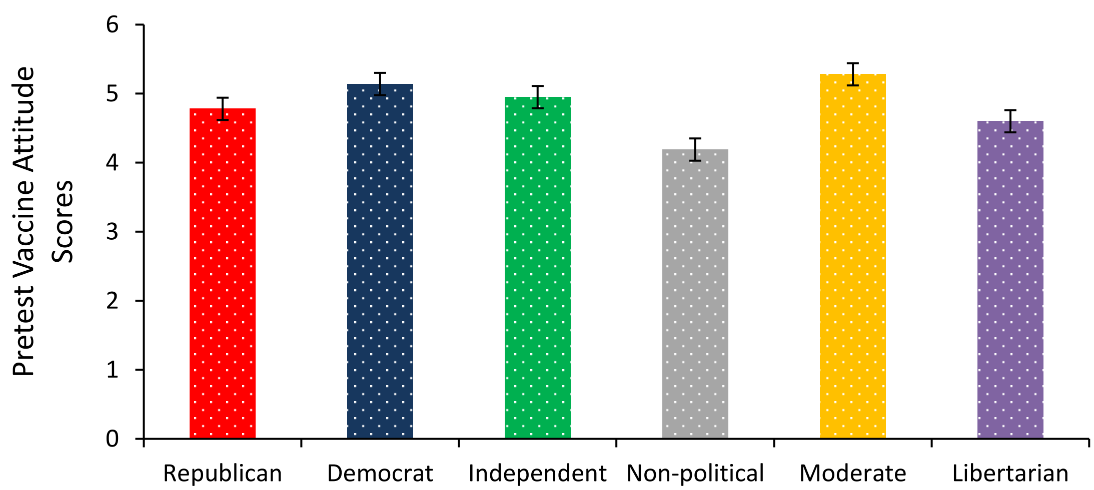

Figure 2.6. Average pretest vaccine attitude score by political party preference.

Additional exploration of Republican vaccine pretest attitudes found that while on average, Republicans are slightly pro-vaccine, a surprising 51.6% of Republicans score below the group average. However, only 5.8% of Republicans held actual anti-vaccine attitudes (*score of less than or equal to three on a six-point scale*) (posttest: 3.5% held anti-vaccine attitudes), in comparison to 3.7% of Democrats (posttest: 2.9% held anti-vaccine attitudes), and 3.7% of Independents (posttest: 2.9% held anti-vaccine attitudes).

We were also curious about how partisanship might play an impact on hidden question six (*"Some vaccines cause autism in healthy children."*). Interestingly enough, a one-way ANOVA found significant differences in attitude change score from pre- to posttest on hidden question six, $F(2, 319) = 4.109$, $p = .017$, $\eta = .025$ (see figure 2.7). Specifically, Republicans ($M = .39$, $SD = .85$), showed more change from pre to posttest than Democrats ($M = .13$, $SD = .65$), $t(222) = 2.579$, $p = .011$, $d = .34$. An Independent samples t-test also showed significant group differences between Republicans and Independents ($M = .12$, $SD = .71$), $t(181) = 2.314$, $p = .022$, $d = .34$. When examining partisanship in tandem with condition (disease risk, autism correction, control), on hidden question six change score, there is a significant main effect for partisanship, $F(2, 313) = 4.229$, $p = .015$, $\eta = .026$; a significant main effect of condition, $F(2, 313) = 7.929$, $p < .001$, $\eta = .048$; but no significant interaction between the two, $F(4, 313) = 1.255$, $p < .288$, $\eta = .016$. A Tukey post hoc test revealed a significant difference between the autism correction and disease risk conditions, $p = .003$, as well as a significant difference between the autism correction condition and control group, $p = .003$.

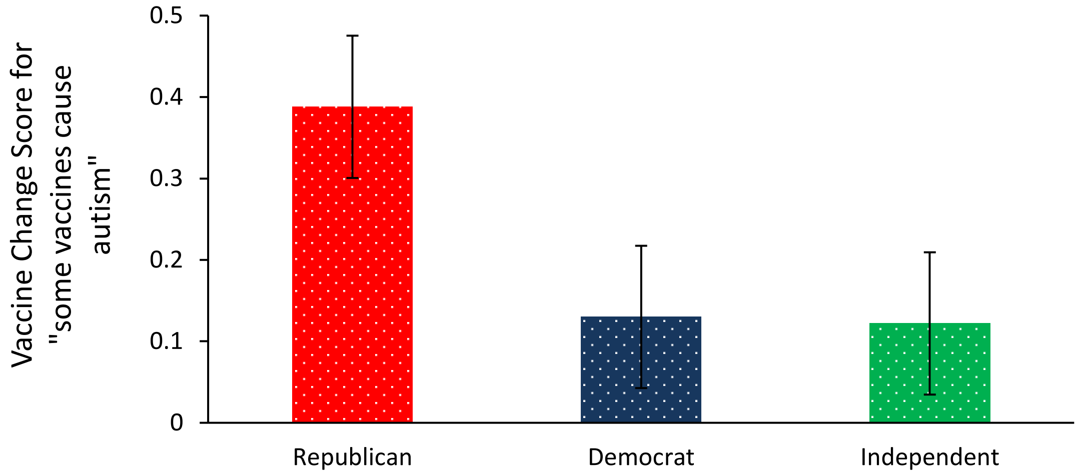

Figure 2.7. Average change score for vaccine hidden question six ("*Some vaccines cause autism in healthy children*") by the three main political party preference.

Discussion

The goal of the present study was to further assess if the results of Horne et al. (2015) were replicable, more specifically, if the disease risk condition was the most effective in terms of altering individual attitudes toward vaccines. A direct replication was conducted to further examine this phenomenon. The results of the pure replication study were consistent with previous findings. To summarize the findings, the disease risk condition was the most effective condition in terms of altering vaccine attitudes. However, when comparing only the autism condition with the control condition there was a marginal effect on attitude change score, implying that this condition for the given sample was slightly more impactful on altering attitudes than the original autism correction condition study sample. Interestingly enough, when analyzing the impact of condition on subscales (attitudes, beliefs, and intentions) of the vaccine attitude scale, results were not significant with the exception of a marginal effect on future intent to vaccinate one's child. It could be the case that the proposed interventions are more effective when discussing all aspects of vaccine misinformation in tandem. Parsing apart the vaccine attitude scale items in the manner that was conducted is similar to the work of Nyhan et al. (2014), which also found insignificant results. This could be one of the reasons why the items were analyzed together in later studies.

Parent status had no significant impact on vaccine attitude change score. When examining hidden question six (*"Some vaccines cause autism in healthy children."*), the autism condition was the most effective in changing attitudes on that question. These results further support the claim that altering anti-vaccine attitudes is most impacted when framing vaccine correction arguments in terms of disease risk (i.e., if one chooses not to vaccinate their child, then they are putting them at risk for contracting very serious, and sometimes life-threatening, diseases).

The findings of our exploratory partisanship analyses further add to the literature on science skepticism and misinformation correction. While we found significant differences in partisanship as it relates to attitudes toward vaccines (Republicans were slightly more opposed to vaccines than Democrats or Independents), these results are not consistent with previous findings that conservatives (compared to liberals) were not more prone to vaccine opposition (Rutjens, Sutton, & van der Lee, 2018; Kahan, 2015). Yet despite these pretest differences, Republicans also displayed more vaccine attitude change score on hidden question six (*"Some vaccines cause autism in healthy children."*); the main component of the misinformation surrounding vaccines. These results could also be explained by pretest scores; Republicans had the lowest vaccine attitude pretest scores, therefore they also had more room for attitude change from anti- to pro-vaccination.

These direct replication findings further support the idea that the way to alter anti-vaccine attitudes is through framing of the costs associated with parental failure to vaccinate their children. However, Study 1a is not without its limitations. One potential reason that the disease risk condition was found to be effective could be due to the qualitative and quantitative differences noted between conditions (which was controlled for in Study 2).

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Appendix

Assessment Scales used for Studies 1 & 2

For all scales, participants were asked to rate their agreement with each of these items on a six-point Likert scale from Strongly Disagree to Strongly Agree.

Vaccination Scale (Horne et al., 2015)

1. The risk of side effects outweighs any protective benefits of vaccines.
2. Vaccinating healthy children helps protect others by stopping the spread of disease.
3. I plan to vaccinate my children.
4. Children do not need vaccines for diseases that are not common anymore.
5. Doctors would not recommend vaccines if they were unsafe

Distractor Scales (Horne et al., 2015)

Abortion

1. A pregnant woman has an obligation to bring her fetus to term.
2. Abortion should be illegal.
3. An unborn child's right to life is more important than a pregnant woman's right to make decisions about her body.
4. A pregnant woman should always have the right to choose whether to continue her pregnancy.
5. It is morally acceptable to terminate a pregnancy even if the mother's life is not in danger.

Consequentialism

1. In life or death situations, one should take whatever means necessary to save the most lives
2. Lying is always wrong
3. The end result is the most important thing to consider when judging someone's actions
4. It is never acceptable to harm someone, even if doing so would help many other people.
5. People have an obligation to act in service of the greater good, even if that means hurting someone else.

Euthanasia

1. Terminally-ill people who are suffering should have the right to choose to die.
2. People should not be allowed to kill themselves, even when they are in a lot of pain.
3. Suffering at the end of life can be worse than death.
4. Even if a patient wishes to die, doctors have an obligation to perform life-saving procedures.
5. There are some contexts in which euthanasia should be legal.

Questions about Vaccines (Horne et al., 2015)

Participants were also asked a series of questions about vaccines
1. Have you had a flu shot in the last year?
2. Do you expect to get a flu shot in the next year?
3. Have any of your children had a flu shot in the last year?
4. Do you expect that any of your children will get a flu shot in the next year?
5. Have you ever refused or elected to forgo a vaccine your doctor recommended for your children?
6. Does vaccinating your child (or not vaccinating your child) affect only your child or could it affect both your child and other people in your community?

Original Autism Correction Condition (Horne et al., 2015)

Please examine the following information about measles, mumps, and rubella carefully.

All children should be vaccinated for measles, mumps, and rubella. The measles, mumps, and rubella vaccine (MMR) is safe and effective.

Because signs of autism may appear around the same time children receive the MMR vaccine, some parents may worry that the vaccine causes autism. Vaccine safety experts, including experts at the Centers for Disease Control (CDC) and the American Academy of Pediatrics, agree that MMR vaccine is not responsible for recent increases in the number of children with autism. A 2004 Institute of Medicine report concluded that there is no link between autism and MMR vaccine, and that there is no link between autism and vaccines that contain thimerosal as a preservative.

Many scientific studies have found no link between MMR vaccine and autism. These studies include:

1) A September 2008 study published in *Public Library of Science* was conducted to determine whether results from an earlier study claiming to find measles virus RNA in the intestinal tissue of autistic children could be confirmed. The results could not be confirmed, and no link between MMR and autism was found.

2) A 2006 study published in the *Journal of Autism and Developmental Disorders* of 351 children with autism and 31 typically developing children did not find a link between MMR vaccination and autism.

3) A 2002 study by CDC in the *New England Journal of Medicine* followed more than 500,000 children and found no association between MMR vaccination and autism.

<u>Disease Risk Condition (Horne et al., 2015)</u>

Warning

You or your child could catch these diseases by being around someone who has them. They spread from person to person through the air.

Measles, mumps, and rubella (MMR) vaccine can prevent these diseases. Most children who get their MMR shots will not get these diseases. Many more children would get them if we stopped vaccinating.

Anecdote

Here is a true story that shows why vaccination is so important.

If you hear “106 degrees” you probably think “heat wave,” not a baby’s temperature. But for Megan Campbell’s 10-month-old son, a life-threatening bout of measles caused fevers spiking to 106 degrees and sent him to the hospital. “We spent 3 days in the hospital fearing we might lose our baby boy,” Campbell said. “He couldn't drink or eat, so he was on an IV, and for a while he seemed to be wasting away. When he could drink again, we got to take him home. But the doctors told us to expect the disease to continue to run its course, including high fever – which spiked as high as 106 degrees. We spent a week waking at all hours and soothing him with damp washcloths.”

Thankfully, the baby recovered fully.

Megan now knows that her son was exposed to measles when another mother brought her ill son into their pediatrician’s waiting room.

Pictures

All children should be vaccinated for measles, mumps, and rubella. These are serious diseases. Please read the descriptions of these diseases and carefully view the pictures.

Measles
Measles virus causes rash, cough, runny nose, eye irritation, and fever.
It can lead to ear infections, pneumonia, seizures (jerking and staring), brain damage, and death.

Figure 2.A1. Illustration of a child with measles as presented to participants in the disease risk condition.

Mumps
Mumps virus causes fever, headache, and swollen glands.
It can lead to deafness, meningitis (infection of the brain and spinal cord covering), painful swelling of the testicles or ovaries, and, rarely, death.

Figure 2.A2. Illustration of a child with mumps as presented to participants in the disease risk condition.

Rubella (German Measles)
Rubella virus causes rash, mild fever, and arthritis (mostly in women).
If a woman gets rubella while she is pregnant, she could have a miscarriage or her baby could be born with serious birth defects.

Figure 2.A3. Illustration of a child with rubella as presented to participants in the disease risk condition.

Chapter 3

Study 2: Extended Replication of Horne et al. (2015)

Introduction

Study 2 addressed the quantitative and qualitative differences noted between the autism correction condition and disease risk condition in Study 1 as well as a combination condition (using both disease risk and a newly alternate autism correction approach). In Study 1 and Horne et al (2015), participants in the autism correction condition received a brief, direct misinformation correction intervention, while the disease risk condition was comprised of three components (i.e., anecdotal story, warning, pictorial evidence) and was significantly longer than the autism correction condition.

Study 2 tested the effectiveness of a more thorough autism correction condition that included three components parallel to the three components from the disease risk condition. This new and more thorough alternate autism condition included a “warning” (in this case, acknowledging that autism is on the rise and vaccines are more prevalent, but that does not mean that the two factors are related), an anecdotal story (explaining where the misconception that autism causes vaccines came from), and visually-presented data about the lack of link between autism and vaccines (with 3 graphs, to correspond to the three photos in the disease risk condition) (*see* Appendix). This newly proposed comprehensive autism correction condition primarily focused on addressing the initial reasoning behind why individuals may think that vaccines cause autism and further elaborate on correcting the misconception that vaccines do not cause autism. Together, these three features may be more effective than the original autism correction condition because each component addresses one of the features by which misinformation tends to be “sticky” (Brehm & Brehm, 1981; Lewandowsky et al., 2012). By acknowledging individual concerns about vaccines and autism, it is possible that readers will be less likely to fall prey to “reactance,” which is a knee-jerk social response to being told what to believe (Lewandowsky et al., 2012). Instead, individuals will have a more profound understanding as to why the vaccine-autism debate arose, and thus will be able to avoid reactance when discussing the issue of vaccines and autism. Providing a coherent explanation for why the misconception may have arisen also increases the likelihood that it can be corrected (Lewandowsky, Stritzke, Oberauer, & Morales, 2005; 2009; Weisman & Markman, 2016). Finally, repeated corrections in which multiple graphs of data are presented are also likely to increase the potential efficacy of correction (Ecker, Lewandowsky, Swire, & Chang, 2011). Furthermore, pictorially-presented data may be more effective at communicating data because it may be taken more seriously than when data are presented numerically or textually (Chua, Yates, & Shah, 2006).

In addition to testing a more comprehensive alternate autism correction condition, the current study also tested a “combination condition” which is a combination of both the newly extended alternate autism correction condition as well as the original disease risk condition proposed by Horne et al. (2015). To further compare if the effects of both the extended alternate autism correction condition and the combination condition were more or equally as effective as the original three conditions developed by Horne and colleagues, we looked at all five conditions together.

We recruited participants from the same population (MTurk participants), using the same power analysis parameters noted in Study 1, and data were analyzed identically to the original study and Study 1.

Method

Study 2 followed the same methods as Horne and colleagues (2015) as well as in Study 1 with the exception that the autism correction condition was closely matched in length and type of content to the disease risk condition, and a combination condition was included to test the impact of both a disease risk and more comprehensive alternate autism correction condition when presented together. Participants were randomly assigned to one of five conditions (original disease risk, original autism correction, alternate autism correction, combination condition, original control). In addition, participants were given a four to 78-hour time frame to complete the second study session.

Participants

All participants were recruited through Amazon Mechanical Turk (MTurk) using the same inclusion criteria as Horne et al. (2015) and Study 1. Participants were provided with a consent form prior to completing any portion of the study. Similar to Study 1, the proposed study also recruited participants in two study sessions (see *Procedure*). A total of 1939 participants were recruited to complete the first study session. Based on their responses to randomly placed attention check items, 1715 of the 1939 (88.4%) participants were invited back to complete session two. Of the 1715 participants, 656 returned to complete session two and successfully answered the attention check items (female: n = 328, male: n = 328; age: *M* = 38.02, *SD* = 12.78). This participant dropout rate was slightly higher than the dropout rates of Horne et al. (2015) (of the 720 participants that qualified to complete session two, 315 returned and successfully completed all attention checks). Figures 3.1 and 3.2 show the distribution of pretest vaccine attitude scores for the original three conditions and all five conditions respectively, while figure 3.3 displays a comparison of percentage scores from Horne et al. (2015) and the current study. Pretest vaccine attitude scores did differ between participants who were eligible and completed session two of the study, (n = 656, *M* = 4.86, *SD* = 1.02) and those eligible to complete session two that did not return, (n = 1059, *M* = 3.93, *SD* = .32), $t(1713) = 27.67$, $p < .001$. In addition to randomly placed attention checks, participants were asked if anything affected their participation negatively as well as how much effort was put into their responses. Of the 656 participants, six (.9% of participants) mentioned that something else negatively affected their participation. Five hundred and eighty-four individuals (89% of participants) reported "a lot of efforts in their responses, 68 participants (10.4% of participants) reported using "some effort", three participants (.5% of participants) reported "very little effort", and one participant (.2%) reported "no effort at all" in their responses.

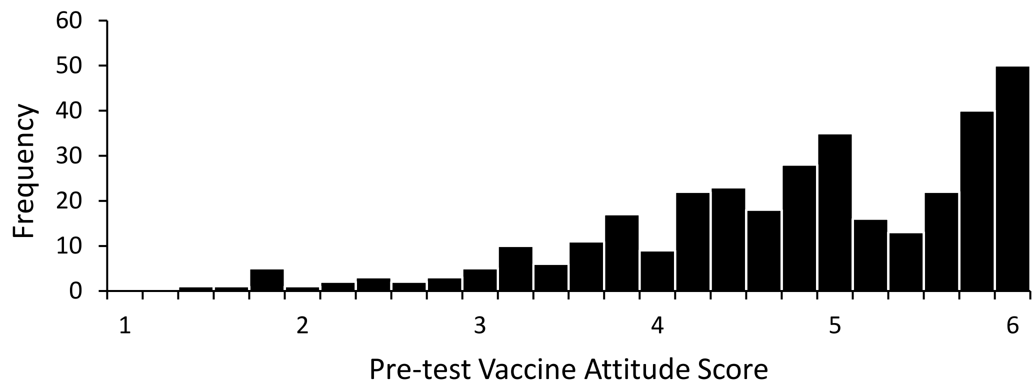

Figure 3.1. Frequency of pretest vaccine attitude scores for the original three conditions.

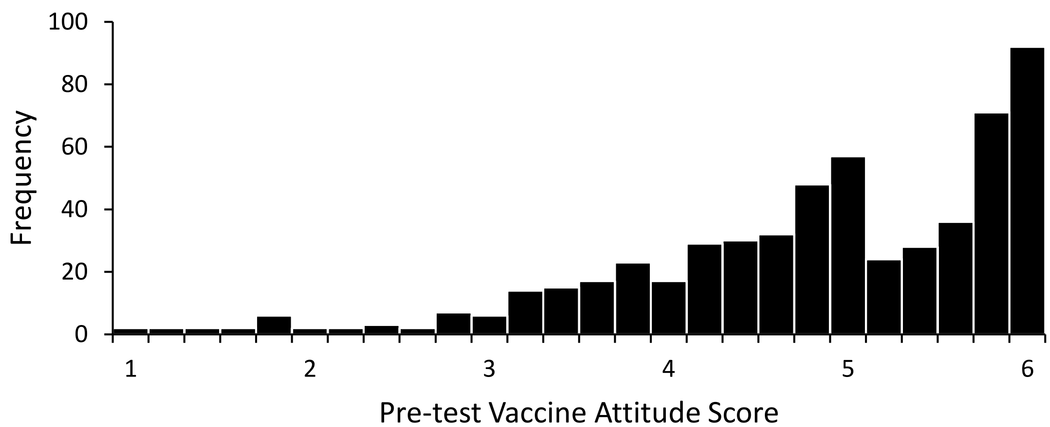

Figure 3.2. Frequency of pretest vaccine attitude scores for all five conditions.

Participants who failed to pass the attention check items and/or answer all questions were excluded from data analysis. Participants were paid $.75 for their participation during session one, and $1.35 if they returned for session two, for a total of $2.10.

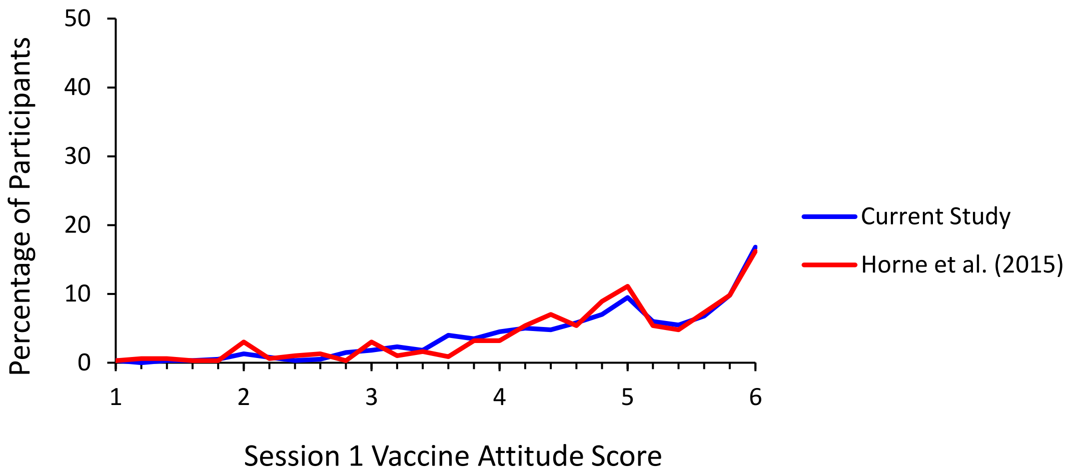

Figure 3.3. Frequency of pretest vaccine attitude scores for Horne et al. (2015) in comparison to the current study using only the original three conditions (disease risk, autism correction, control).

Vaccine Scale

The primary dependent variable in the current study was the five-item vaccine attitude scale that was developed by Horne and colleagues (2015). Additionally, researchers included a sixth item in their scale assessing the statement "*Some vaccines cause autism in healthy children*", however this question was not included in the five-item vaccine attitude scale.

Procedure

The current study was identical to Study 1 with the exception that the autism correction condition was more thorough, and a combination condition was included to examine the effects of both disease risk and the extended alternate autism correction when presented together. Participants were randomly assigned to one of five conditions: the disease risk condition, autism correction condition, and control condition which were all derived from Study 1, Horne et al. (2015), and Nyhan et al. (2014), a new, extended alternate autism correction condition, and a combined condition which consisted of the information from the original disease risk condition as well as the extended alternate autism correction condition.

The new extended alternate autism correction group received three pieces of information presented in a randomized order: (1) a brief paragraph stating reasons why people may think vaccines cause autism, (2) information explaining the controversy surrounding Andrew Wakefield's retracted "study" suggesting vaccines cause autism, and (3) graphical information from previous researchers displaying the lack of a link between vaccines and autism. Participants assigned to the combination condition were presented with six pieces of information (in a randomized order) compiled from the extended alternate autism correction condition and the original disease risk condition. The rationale behind a more thorough autism correction condition and combination condition, was to assess whether providing more information about the vaccine-autism controversy, together with a graphic representation of the evidence, would affect belief in the original autism-immunization claim.

Additionally, at the end of session one, participants that successfully answered the attention check items were invited to return for session two. Participants were instructed to complete session two of the study up to 78 hours after their completion of session one. The second session was released to MTurk four hours after the release of session one.

Results

Results were analyzed with SPSS 24. Similar to Study 1 and Horne et al. (2015), incomplete data was not included in data analysis. As in the original study and Study 1, we computed a vaccination attitude change score calculated as the difference between participants' posttest and pretest vaccination attitude scores.

Overall Impact of Interventions

A one-way ANOVA was conducted using only the original three conditions proposed by Horne et al (2015) as used in Study 1 to determine statistically significant differences between disease risk, autism correction, control on vaccine attitude change score. Results failed to replicate the original findings as well as the findings in Study 1, $F(2, 397) = .517$, $p = .597$. While in our Study 1 as well as Horne et al. (2015), results suggested the disease risk condition resulted in greater attitude change than the autism correction condition, and control, the current extended replication found no relative improvement with the correction (see figure 3.4). Comparing all five conditions (including the combination condition and the extended autism correction) vaccine attitude change scores did not differ, $F(4, 651) = .740$, $p = .565$, $\eta^2 = .005$, (see figure 3.5).

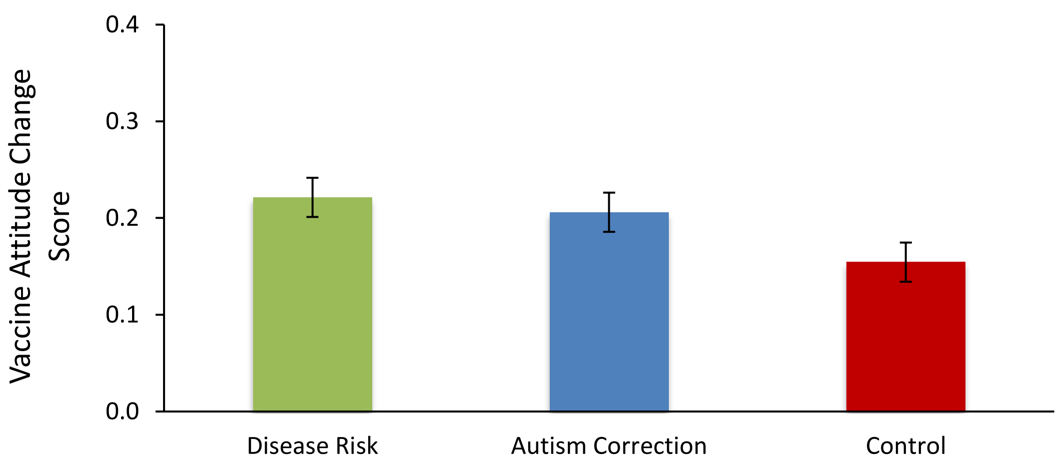

Figure 3.4. Vaccine attitude change score by the original three conditions (disease risk, autism correction, control).

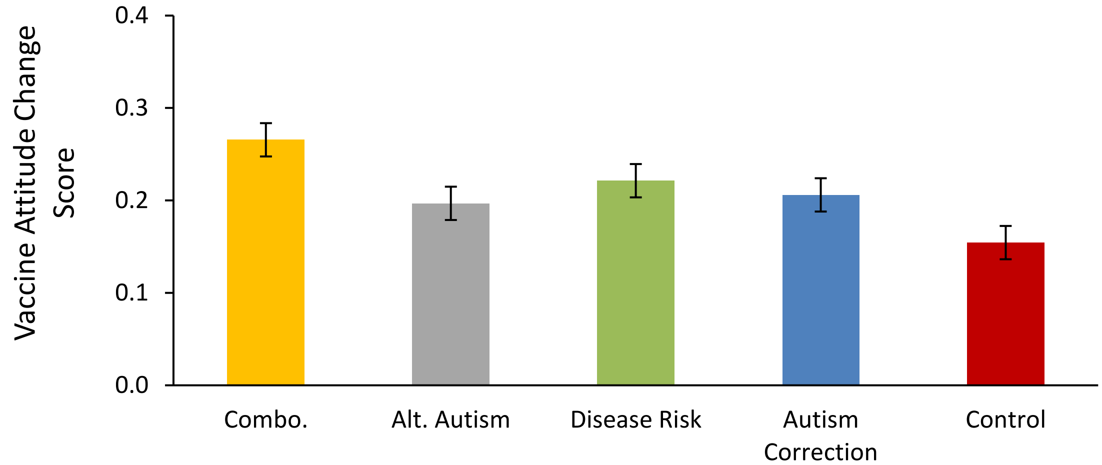

Figure 3.5. Vaccine attitude change score by all five conditions.

Tercile Analysis

As in the original study and Study 1, analyses were conducted to determine whether the added information may have caused different effects based on pretest vaccine scores. The effects of condition were examined based on terciles generated from pretest vaccine attitude scores. Individuals with lower vaccine attitude scores (bottom tercile) would have the greatest potential to modify their attitude with the added information. A 3 X 3 factorial ANOVA examining the original three conditions and tercile found no significant main effect of condition, $F(2, 391) = .320$, $p = .726$, $\eta^2 = .002$, a main effect of tercile, $F(2, 391) = 27.020$, $p < .001$, $\eta^2 = .121$, and no significant interaction, $F(4, 391) = .151$, $p = .963$, $\eta^2 = .002$, (see figure 3.6). The same series of analyses were also conducted using all five conditions and yielded similar results. There was no significant main effect of condition, $F(4, 641) = .985$, $p = .415$, $\eta^2 = .006$, a main effect of tercile, $F(2, 641) = 47.221$, $p < .001$, $\eta^2 = .128$, and no significant interaction was observed, $F(8, 641) = .357$, $p = .943$, $\eta^2 = .004$, (see figure 3.7).

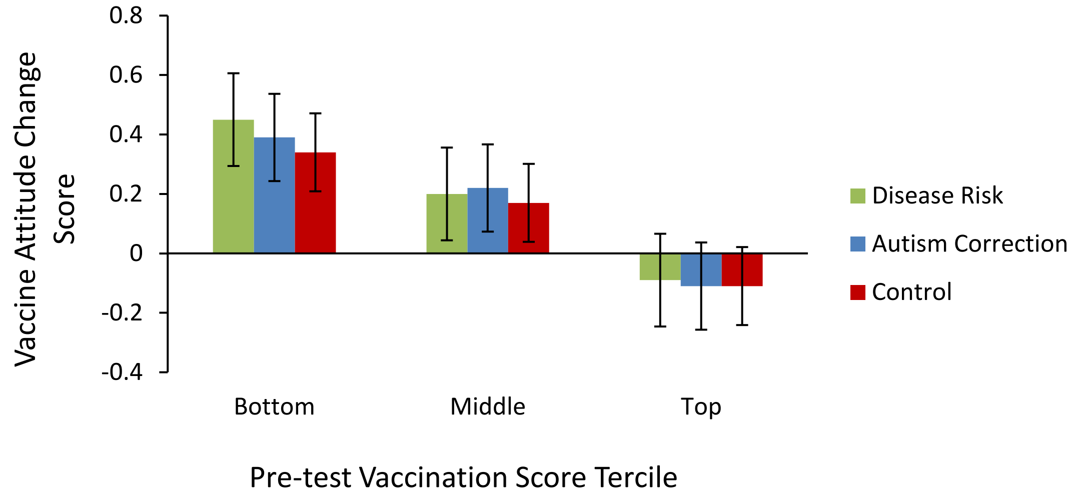

Figure 3.6. Vaccine attitude change scores across the original three conditions separated into pretest vaccine score terciles.

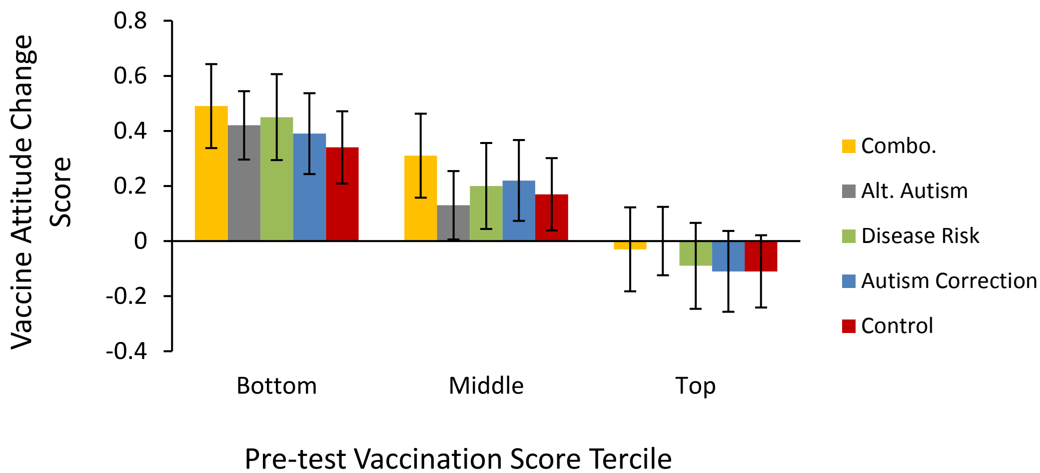

Figure 3.7. Vaccine attitude change score across all five conditions separated into pretest vaccine score terciles.

"Fence-Sitters" Analysis

In a letter challenging Horne and colleagues' (2015) tercile analysis boundaries, Betsch, Korn, and Holtmann (2015) argue that the bottom tercile is not representative of an anti-vaxxer – who when given the vaccine attitude scale used in the current study, would score on average below three on – but rather of the bottom tercile of that current sample. We further examined this concern by conducting a "fence-sitters" analysis on the current data. For this analysis, individuals who scored below a three on the vaccine attitude scale were considered anti-vaxxers, those who scored a three were considered the "fence-sitters", and individuals who scored above three were considered pro-vaccine (see table 3.1 and 3.2).

Table 3.1
Descriptive statistics for "fence-sitters" breakdown using original three conditions.

	N	Percent
Anti-vaxxers	22	5.5
Fence-sitters	7	1.8
Pro-vaccines	371	92.8

Note. Anti-vaxxers = participants who scored in the bottom tercile, fence-sitters = participants who scored in the middle tercile, pro-vaccines = participants who scored in the top tercile.

Table 3.2
Descriptive statistics for "fence-sitters" breakdown using all five conditions.

	N	Percent
Anti-vaxxers	31	4.7
Fence-sitters	13	2.0
Pro-vaccines	612	93.3

Note. Anti-vaxxers = participants who scored in the bottom tercile, fence-sitters = participants who scored in the middle tercile, pro-vaccines = participants who scored in the top tercile.

A 3 X 3 factorial ANOVA was conducted to examine the influence of vaccine attitude pretest terciles (as determine by Betsch, Korn, and Holtmann (2015)) and condition on vaccine attitude change scores. There was no main effect of condition, $F(2, 391) = .007$, $p = .993$, no main effect of vaccine attitude pretest tercile, $F(2, 391) = 1.516$, $p = .221$, nor was there a significant interaction, $F(4, 391) = 1.571$, $p = .181$. When conducting the same analysis using all five conditions, all results were non-significant, $p > .15$.

Separation of Vaccine Scale Items

In addition to analyzing the vaccine attitude scale in its entirety, we also analyzed vaccine attitude change score by condition after parsing the original five item vaccine attitude scale (including the originally omitted scale item: *"Some vaccines cause autism in healthy children"*) into individual categories (e.g., condition by vaccine intentions). By parsing vaccine scale items, we were able to further assess the degree to which individuals alter not only their attitudes towards vaccines, but also their future intentions. Additional analyses were also conducted on the main misconception about vaccines (i.e., *"some vaccines cause autism in healthy children"*) from the vaccine attitude scale.

Attitudes & Beliefs towards Vaccines

A one-way ANOVA was conducted to examine the effect of condition on vaccine attitudes and beliefs (i.e., "*The risk of side effects outweighs any protective benefits of vaccines"; "Vaccinating healthy children helps protect others by stopping the disease";* and *"Doctors would not recommend vaccines if they were unsafe"*) questions one, two, and five respectively. When examining only the original three conditions, omnibus ANOVA was nonsignificant, $F(2, 397) = .099$, $p = .906$, $\eta^2 < .001$. There were also no significant differences between all five conditions and change scores, $F(4, 651) = .329$, $p = .858$, $\eta^2 = .002$.

Vaccine Intentions

A one-way ANOVA examined the effect of condition on vaccine intentions, question three (*"I plan to vaccinate my children"*) for the original three conditions (disease risk, autism correction, control) and all five conditions (original three including combination condition and extended autism correction). When examining the original three conditions, results were nonsignificant, $F(2, 397) = 1.493$, $p = .226$, $\eta^2 = .007$. This pattern was also noted when examining all five conditions, $F(4, 651) = 1.021$, $p = .396$, $\eta^2 = .006$.

"Some Vaccines Cause Autism in Healthy Children"

In the original Horne et al. (2015) study, a sixth question ("*Some vaccines cause autism in healthy children*") was included in the vaccine attitude change scales but excluded from analyses. Here, we directly assessed the main piece of misinformation surrounding vaccines ("*Some vaccines cause autism in healthy children*") measure. When examining the original three conditions on hidden question six (*"Some vaccines cause autism in healthy children"),* results were nonsignificant, $F(2, 397) = 1.367$, $p = .256$. However, when taking into account all five conditions, vaccine attitude change score for hidden question six was significantly impacted, $F(4, 651) = 2.494$, $p = .042$, $\eta^2 = .015$ (see figure 3.8). Specifically, the newly created alternate autism correction condition ($M = .54$, $SD = 1.01$) demonstrated the most change pre to posttest, compared to the disease risk condition ($M = .21$, $SD = .99$), $t(257) = 2.613$, $p = .009$, $d = .33$.

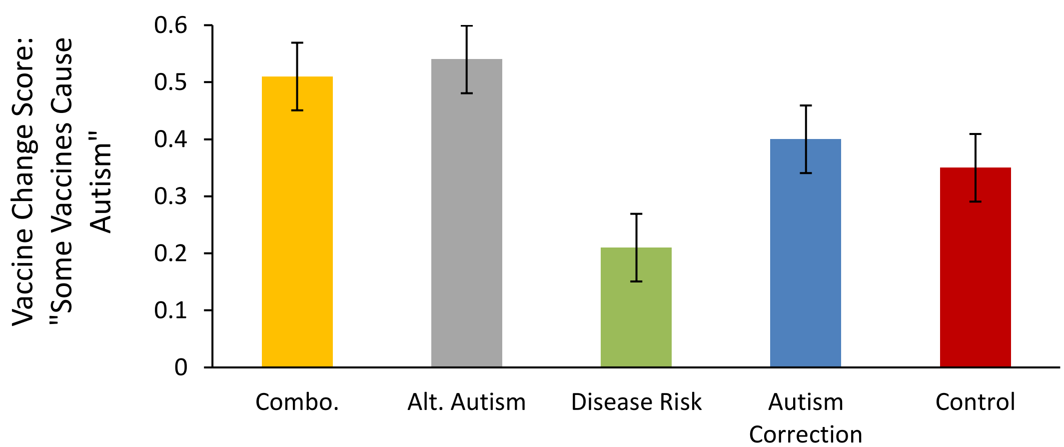

Figure 3.8. Vaccine belief change score for the false belief "*some vaccines cause autism in healthy children"* across all five conditions.

Parent Status

A 2 X 3 factorial ANOVA was conducted to compare the effects of the original three conditions (disease risk, autism correction, control) and parent status (parents vs. nonparent) on vaccine attitude change score. All results were non-significant at the .05 level (see table 3.3) with the exception of parent status on vaccine attitude change score (parents: *M* .24, *SD* = .60; non-parents: *M* = .15, *SD* = .52), which was marginal, $F(2, 394) = 2.867$, $p = .091$, $\eta^2 = .007$. We also conducted a factorial ANOVA comparing the effects of all five conditions and parent status on vaccine attitude change score. All effects were not statistically significant at the .05 level (see table 3.4).

Table 3.3
Factorial ANOVA results examining parent status on the original three vaccine conditions (disease risk, autism correction, control).

	df	F	Sig.
Condition	2	.680	.507
Parent Status	1	2.867	.091
Cond. X Parent	2	.891	.411

Note. Cond. X Parent = interaction of condition by parent status.

Table 3.4
Factorial ANOVA results examining parent status on the original three vaccine conditions (disease risk, autism correction, control) with the additional two extended conditions (alternate autism correction, alternate autism correction/disease risk combination).

	df	F	Sig.
Condition	4	.799	.526
Parent Status	1	2.603	.107
Cond. X Parent	4	.757	.554

Note. Cond. X Parent = interaction of condition by parent status.

To reconcile the original findings with this failure to replicate, we also examined participant pretest vaccine attitude scores from Horne et al. (2015) ($M = 4.84$) with the pretest vaccine attitude scores from the current study ($M = 4.87$). An Independent samples t-test revealed no significant difference, $t(969) = .350$, $p = .727$, $d = .01$. Compared to vaccination attitudes from 2015, participant attitudes have not drastically changed in the past couple of years.

We also examined the validity of the vaccine scale by correlating past vaccine behaviors and intentions to vaccine. Within this original three conditions, among parents (n = 191), pretest vaccine attitude scores predicted whether parents had ever refused a vaccination recommended for their children ($r = - .412$, $p < .001$), as well as whether parents elected to have their children vaccinated for the flu in the past year ($r = .358$, $p < .001$). In addition, attitude scores also predicted whether participants themselves elected to receive the flu vaccine in the past year ($r = .265$, $p < .001$, n = 399). When examining the original three conditions with the inclusion of the two extended conditions, among parents (n = 308), pretest vaccine attitude scores predicted whether parents ever refused a vaccination recommended for their children ($r = -.478$, $p < .001$), as well as whether parents elected to have their children vaccinated for the flu in the past year ($r = .232$, $p < .001$, n = 655). Compared to the original vaccine scale results produced by Horne and colleagues (2015), these results are consistent with the original findings.

Exploration of Individual Factors

Similar to the exploratory analyses of additional individual factors in Study 1, the current study wanted to further examine the potential impact political party preference (partisanship) has on vaccine related issues.

A one-way ANOVA was conducted to examine partisanship on pre-test vaccine scores (prior to receiving any intervention), results found a significant difference when looking at all six political categories (see figure 3.10), $F(5, 646) = 6.379$, $p < .001$, $\eta^2 = .047$. Specifically, Republicans significantly differed from Democrats, $t(420) = 3.859$, $p < .001$, $d = .40$, and Democrats significantly differed from Independents, $t(324) = 3.964$, $p < .001$, $d = .64$ (see figure 3.9). These results are still significant when only examining the three main political parties (Republican, Democrat, Independent), $F(2, 565) = 7.548$, $p = .001$, $\eta^2 = .026$. Specifically, Republicans ($M = 4.57$, $SD = 1.01$), significantly differed in pretest vaccine scores compared to Democrats ($M = 5.07$, $SD = .91$), $t(257) = -3.867$, $p < .001$, $d = .52$.

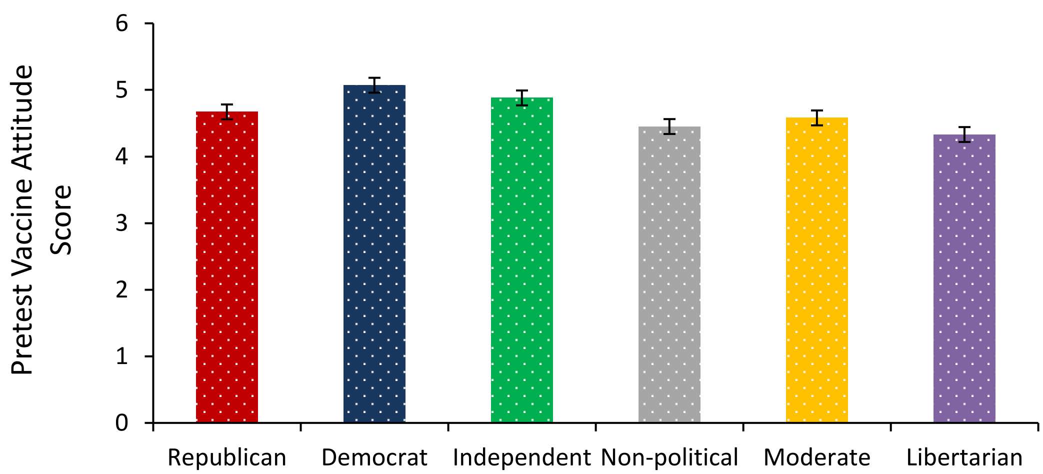

Figure 3.9. Vaccine pretest scores separated by political party preference.

Additional exploration of Republican vaccine pretest attitudes found that while on average, Republicans are slightly pro-vaccine, a surprising 44.4% of Republicans score below the group average. However, only 7.1% of Republicans held actual anti-vaccine attitudes (*score of less than or equal to three on a six-point scale*) (posttest: 7.1% held anti-vaccine attitudes), in comparison to 4.1% of Democrats (posttest: 2.4% held anti-vaccine attitudes), and 6.2% of Independents (posttest: 4.1% held anti-vaccine attitudes). We also examined partisanship on vaccine attitude change score. Results were non-significant when taking into account all six parties, $F(5, 646) = .929$, $p = .462$, and when only examining the three main political parties, $F(2, 565) = .517$, $p = .596$.

We were also curious about how partisanship (only for the three main partisanships) might play an impact the vaccine false belief *"some vaccines cause autism in healthy children."*. Despite initial findings in Study 1, a one-way ANOVA did not find significant differences in attitude change score from pre- to posttest on the false belief that vaccines cause autism, $F(2, 565) = .877$, $p = .417$, $\eta^2 = .003$. When examining partisanship in tandem with condition (disease risk, autism correction, control), on hidden question six change score, there is no main effect of partisanship, $F(2, 338) = .276$, $p = .759$, $\eta^2 = .002$; no main effect of condition, $F(2, 338) = 1.489$, $p = .227$, $\eta^2 = .009$; and no significant interaction between the two, $F(4, 338) = .920$, $p = .453$, $\eta^2 = .011$. In addition, when examining these same constructs with all five conditions, results found, no main effect of partisanship, $F(2, 553) = 1.121$, $p = .327$, $\eta^2 = .004$; a marginal effect of condition, $F(4, 553) = 2.260$, $p = .062$, $\eta^2 = .016$; with the newly extended alternate autism correction condition ($M = .55$, $SD = 1.02$) and disease risk condition ($M = .21$, $SD = 1.00$) differing significantly, $t(221) = 2.460$, $p = .015$, $d = .34$ (see figure 3.10). There was no significant interaction, $F(8, 535) = .727$, $p = .667$, $\eta^2 = .010$.

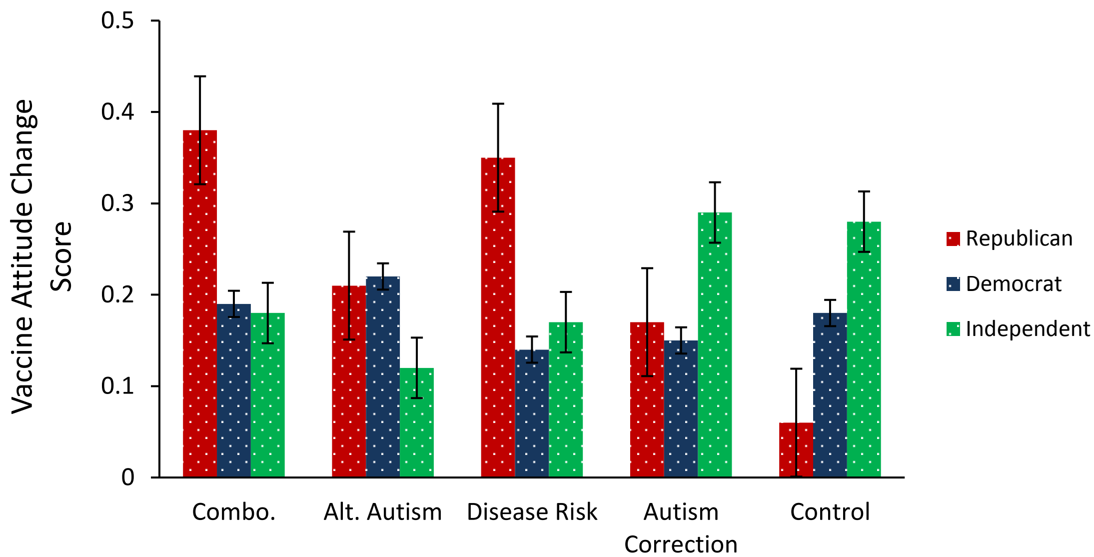

Figure 3.10. Vaccine attitude change score separated by political party preference and condition.

Discussion

In the current study, we examined an extended replication of Horne et al. (2015). When only examining the original three conditions (disease risk, autism correction, control), results failed to replicate previous findings, including the results noted in Study 1; there was no improvement in vaccine attitude change score regardless of condition. These findings persisted when comparing all five conditions.

Though the current study failed to replicate previous findings (Horne et al., 2015), there were promising results in other areas. Specifically, the newly extended autism correction condition was effective on the main false belief surrounding vaccines ("*Some vaccines cause autism in healthy children*"). These results are similar to findings presented in Study 1which showed the autism correction condition was also the most effect of the original three conditions on this vaccine misconception. It is possible that the alternate autism correction effectiveness was the result of message length and comprehensiveness (mirroring the disease risk condition) which was not altered in the original study or Study 1.

When considering why the main findings failed to replicate, one must also consider the participants themselves. The outcome of the current study could have been impacted by anti-vaxxers. It could be the case that the individuals who could have received the most benefit from the misinformation correction interventions failed to return for study session two despite qualifying for it. One potential explanation for these findings could be because these individuals are highly motivated believers that actively avoid discussing issues regarding vaccine (Epley & Gilovich, 2016). Nonetheless, we must consider that these results might have differed if more anti-vaxxers returned for study session two, or if the study were deduced to one session.

Another notable difference between the current study and Horne et al (2015) is the time allotment between session one and session two. Horne and colleagues had participants return to complete session two of the study the following day from the hours of 9am-8pm PST. The current study allowed individual a four to 78-hour time frame to complete the study. This extended window of time could account for heavy attrition rates noted in the current study. While this factor is not suspected to be very influential in the failure to replicate, it was noted as a difference between studies.

In addition, Study 2 also showed that when examining individual differences (specifically partisanship) on vaccine attitude change supported the initial findings from Study 1. When examining the three main political parties – in terms of sample size for this study – Republicans had the lowest baseline average surrounding vaccine attitudes compared to Democrats and Independents. When further exploring partisanship and vaccine attitudes, despite the findings noted in Study 1, there were no significant differences in vaccine attitude change score from pre- to posttest on the misinformation statement *"Some vaccines cause autism in healthy children"*. Additionally, the "fence-sitters" vaccine attitude pretest tercile analysis failed to show any significant findings. These results fail to support the findings by Betsch, Korn, and Holtmann (2015) which suggest more effective attitude alteration when misinformation correction approaches target larger groups of individuals with neutral vaccine attitudes rather than anti-vaxxers.

While this study failed to replicate previous findings, it does add to the debate of how exactly individuals should correct for misinformation, specifically misinformation about vaccines. Given that Study 1 was able to directly replicate the findings from Horne et al. (2015), we were optimistic about the outcome of the current study. However, given the contradictory findings presented throughout the misinformation correction literature, these results were not entirely surprising. While these results failed to replicate, they were, however, consistent with previous findings in which interventions fail to increase future intent to vaccinate (Nyhan et al., 2014).

Another potential reason for the differences in results from Study 1 to the current study could be due to the relatively small effect size the disease risk correction has (as observed in Horne et al (2015)). Perhaps, the nature of the effect size influences the ability to have robust findings therefore negatively influencing study replicability. One approach researchers could use to adjust this issue could be to re-develop the disease risk approach to include a plausible causal alternative to correct misinformation, as demonstrated in Johnson and Seifert (1994). A potential causal vaccine condition could include information about Andrew Wakefield and his fraudulent study which sparked the anti-vaxxer movement. While components of a causal model were included in the alternate autism correction condition, future studies should assess the causal aspect in isolation as a condition compared to the disease risk condition. This comparison will allow for further assessment of the effectiveness of different misinformation correction approaches. Though the findings of the current study, along with the findings in Study 1, do not offer an undisputed misinformation correction strategy for altering individual attitudes toward vaccines, it does provide a starting point for researchers and policy makers alike.

While the disease risk condition was not as effective in the current study as it was previously in Study 1a and in Horne and colleagues 2015 study, the newly extended autism correction condition was highly effective at altering vaccine attitudes on the misconception that "*Some vaccines cause autism in healthy children*". Additionally, the findings demonstrated that a combined disease risk – extended autism correction condition may be effective at altering vaccine attitudes. Furthermore, future studies would benefit from examining a combination correction condition which allows for a direct correction of misinformation while also highlighting potential harmful aspects of not obtaining vaccines.

One important aspect to note about this study is the extensive examination of the vaccine scale parsed into different items, specifically examining the vaccine false belief *"some vaccines cause autism in healthy children"* intentions. While these data failed to replicate the main findings of Horne et al (2015) (i.e., the disease condition was the most effective at altering vaccine attitudes), it also demonstrated some interesting findings. Specifically, these results suggest that a direct misinformation correction approach as seen in the autism correction condition may be a more influential approach to use when looking at vaccine beliefs. The main misconception about vaccines – *"Some vaccine cause autism in healthy children"* – was mostly impacted by the autism correction condition. When considering these results, one must also consider the possibility that these findings are the outcome of a correction approach that presents information counter to the belief in question. In addition, one must also entertain the possibility of a backfire effect as noted by Nyhan and Reifler (2010, 2014), however these results do not support that effect.

These interesting findings propelled us to explore this topic more but within different contexts. Specifically, we wanted to further test the misinformation correction approach in a context examining misconceptions about the safety of genetically modified organisms (GMOs) for human consumption. This GMO context allowed us to draw theoretical connections to vaccines such as the individual and environmental/societal impact of whether one engages in a certain behavior. In addition, the results of the current study further demonstrated that attitudes and intentions will not always be influenced in the same manner by the same correction approach. In the proposed study of this "disease risk" misinformation correction approach using a GMO context, we generated a series of different scales assessing attitudes and intentions, as well as implications toward GMOs. This development of subscales will also allow us to further explore how individual differences require different misinformation correction approaches.

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Appendix

Newly Constructed Comprehensive Autism Correction Condition

Introduction

Please examine the following information about measles, mumps, and rubella carefully.

Introduction

You might worry that childhood vaccines can cause autism, but research has actually found that being vaccinated is in no way connected to developing autism.

There are several reasons that some people think vaccines cause autism. First, children are more likely to be vaccinated today, and autism is also more prevalent. However, this is likely a coincidence and the increased prevalence in autism is due to increased awareness. Second, children are often diagnosed around the same age that they are vaccinated; this is probably because parents and doctors notice autism symptoms when children are supposed to be learning language.

Anecdote

True Story

In 1998, Dr. Andrew Wakefield published an alarming study linking autism to the vaccine that prevents measles, mumps, and rubella (MMR). Wakefield—who has **no formal pediatric qualifications**—"found" in his **uncontrolled study of only 12 children** that the three vaccines taken together could "alter immune systems, causing intestinal woes that then reach, and damage, the brain." His findings, of which he offered **no causal mechanism**, were later debunked and rejected, The British Medical Journal called his work "fraudulent". In addition, the British journal Lancet retracted Wakefield's originally published works and had his medical license stripped due to **ethical violations** and **scientific misconduct**.

Following Wakefield's initial study, numerous large-scale scientific studies have concluded that there is no relationship between vaccines and autism. These studies have been conducted by scientists from around the world. A recent meta-analysis combined the results of these studies that together included over 1,266,327 children found absolutely no relationship between vaccination and autism, the MMR vaccine and autism, or thimerosal and autism (Taylor, Swerdfeger, & Eslick, 2014).

Research

Research

Vaccinating your children has been found to have no influence on the development of autism. Please look over the following graphs displaying the truth behind vaccinations.

Jain et al. (2015)
This graph shows that in a large sample of children with older siblings, getting the measles, mumps, rubella (MMR) vaccine was not associated with increased risk of autism.

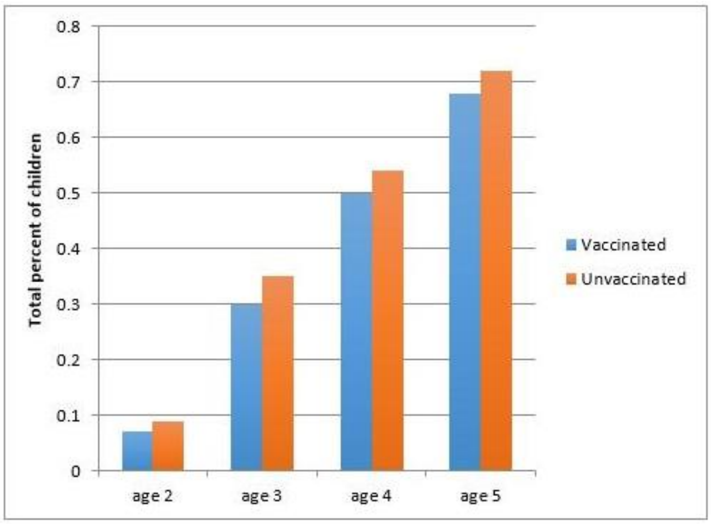

Figure 3.A1. Illustration of the research by Jain et al. (2015) presented to participants in the newly extended autism correction condition.

Kaye (2001)
This graph shows that while autism risk rates have gone up over the years, measles, mumps, rubella (MMR) vaccines have stayed constant.

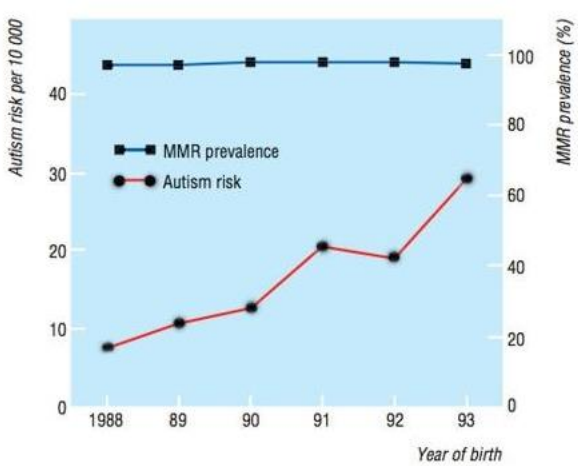

Figure 3.A2. Illustration of the research by Kaye (2001) presented to participants in the newly extended autism correction condition.

<u>Taylor, Swerdfeger, & Eslick (2014)</u>
These two charts demonstrate the results of a meta-analysis examining two different types of observational studies: risk-factor studies and disease outcome studies. Results found that there is no evidence of a relationship between vaccinations and autism spectrum disorders.

Figure 3.A3. Illustration of the research presented to participants in the newly extended autism correction condition.

Control (Horne et al., 2015)

Please examine the following information about bird feeding carefully.

Q: What are the costs and benefits of bird feeding?

A: It is difficult to assess the costs and benefits of bird feeding because it is difficult to compare the health of birds without access to feeders with birds that frequent feeders. Only one study was able to obtain some sound results. That study found that any benefits of feeding only appear to occur sporadically under extreme climactic conditions. No research has been able to demonstrate a cost. Aside from costs and benefits to birds, there is a cost and benefit to humanity. The costs are obvious – the expense of bird feeding supplies.

The benefits include learning more about birds and the joy of connecting with the natural world. Bird feeding provides a direct, intimate view of the natural world for more than 50 million Americans who feed the birds in their yards. It is most popular in winter, when birds seem to need the most help. Some people worry that birds will suffer unless they make great efforts to the feeder filled, but research indicates that most birds do not depend on feeders.

Chapter 4

Study 3: Genetically Modified Organisms

Introduction

According to the Center for Food Safety (2018), genetically modified organisms (GMOs) account for 92% of United States grown corn, 94% of soybeans and cotton. Furthermore, 75% of supermarket stocked shelf items contain some sort of GMOs. Despite the prevalence of GMOs in US food, many individuals and groups (including the Center for Food Safety) oppose the use of GMOs because they believe that GMOs are hazardous to human health (Mannion & Morse, 2012). On the contrary, other organizations such as the World Health Organization (WHO), American Medical Association (AMA), National Academy of Sciences, and the American Association for the Advancement of Science all agree that there is no reasonable evidence to support that GMOs are harmful to human consumption (Saletan & Union, 2015). Because this issue is heavily debated, some researchers have stated there is “no scientific consensus on the safety of GMOs” (Hilbeck et al., 2015). However, most researchers have found GMOs to not only be safe for human consumption but also beneficial for the environment (Nicolia, Manzo, Veronesi, & Rosellini, 2013; Mannion & Morse, 2012). Specifically, GMOs presented in food are said to improve food production, food quality and safety, all while positively influencing social and economic growth (Qaim & Kouser, 2013).

Previous studies of GMOs have typically had one goal in mind: understanding public perceptions of GMOs. This goal has resulted in several typical study designs in the GMO literature such as: (1) the use of focus groups to gather more information about the public knowledge of biotechnology, (2) the use of a series of questionnaires designed to access individual knowledge and level of acceptance of GMOs, and (3) the use of a combination of both focus groups and surveys (Sorgo & Ambrozic-Dolinsk, 2009; Chen & Raffan, 1999; Lewis & Leach, 2007; Silk, Parrott, & Dillow, 2009). Typically, the questionnaires noted above, are used to access individual attitudes and level of acceptance toward GMOs. Some of the examples of attitude assessments included in those questionnaires include: “All mutations are harmful”, “Bread rising is a biotechnical process”, and “Products from GMOs (genetically modified organisms) must be labeled as containing GM components” (Sorgo & Ambrozic-Dolinsk, 2009).

Studies have suggested that anti-GMO attitudes may be rooted in heuristic thinking (Blancke et al., 2015). Specifically, individuals view plant and crop modification and introduction of new plant organisms as an “unnatural”, contaminated, or unhealthy process (Blancke et al., 2015) and therefore reject them. Initial emotional reactivity and an individual’s level of knowledge about GMOs can also influence whether an individual holds negative perceptions about GMOs.

One factor that seems to impact individuals’ feelings toward GMOs is that it is difficult to actually avoid them. Because of weather conditions, insect life, proximity to other farms, and cross-pollination, it is possible one may be unknowingly consuming GMOs that have contaminated non-GMO farms (Silk, Parrott, & Dillow, 2009; Myhr & Traavik, 2001). Meat eaters who are opposed to GMOs are concerned that they may be eating meat from animals who have previously consumed foods made with GMOs. This lack of one's ability to control consumptions seems to add to people's fears.

The prior research focuses on attitudes toward GMOs rather than addressing or altering these attitudes. So, what can be done to effectively alter attitudes about GMOs?

A Novel Study

Currently, there is only one study in the literature that I am aware of that focuses specifically on altering GMO attitudes (i.e., Bode & Vraga, 2015). Instead, most studies examine public knowledge – or lack thereof – about the safety of human consumptions of GMOs, in addition to assessing individual perceptions of GMOs, while examining the origin of those beliefs. Given that the one study that has examined altering GMO attitudes specifically focused on the role of social media in misinformation correction, we designed misinformation correction approaches – paralleled after the interventions used in the vaccine correction literature – to examine the degree to which we can alter negative GMO attitudes and beliefs while improving future intentions of using GMOs.

Expected Utility of GMOs

The current study used a cognitive approach to examine the impact different GMO misinformation correction interventions had on individual attitudes, beliefs, and behaviors/intentions surrounding GMOs. Similar to Studies 1 and 2, the current study used a series of intervention strategies that highlighted various aspects of the expected utility formula to further examine potentially altered attitudes and beliefs toward GMO concerns. Emphasizing the beneficial societal and environmental properties of GMOs while discussing the research on the harmlessness of GMOs for human consumption, is analogous to the strategic approach the extended alternate autism correction condition used in Study 2. This approach allows for further comparison of the effectiveness of similar intervention tactics in different domains.

Here, we applied an expected utility formula for GMOs (as applied to vaccines by Horne and colleagues, 2015):

$\Sigma[U(\text{GMOs})] = [P(\text{positive consequences})U(\text{positive consequences})] + [P(\text{negative consequences})U(\text{negative consequences})]$.

While individuals seem to be aware of the vaccine debate, people have less knowledge about the positive and negative consequences of GMOs aside from a general fear of the "unnatural" plus the knowledge that more expensive and organic foods are often labeled as non-GMO and that therefore there may be negative consequences of consuming GMOs. Even a tiny risk without knowledge of a benefit yields a negative utility function. In that case, it may be possible that a misinformation correction approach that addresses the potential risks – or lack thereof (GMO correction condition) – may not be effective.

An alternate approach, akin to the disease risk approach proposed by Horne et al. (2015), would be to highlight either the negative consequences of not having GMOs or the positive environmental and societal impact of GMOs. In other words, this can easily be converted into an expected utility formula to assess the potential risks and outcomes associated with GMOs:

$\Sigma[U(\text{GMOs})] = [P(\text{negative consequences if no GMOs exist})U(\text{negative consequences if no GMOs exist})] + [P(\text{negative health consequences})U(\text{negative health consequences})]$.

When applying a similar expected utility formula to GMOs as was used prior for vaccines, there are essentially two expected utility and decision-making outcomes one must consider: (1) the impact of the use and consumption of GMOs at the individual level, and (2) the influence of GMO usage on the environment and society. The misinformation correction approaches proposed in this study address these concerns in more depth. The interventions proposed were similar to intervention tactics used in Studies 1 and 2 (*see* Procedure).

The misinformation correction condition addressing the beneficial aspects of GMOs (GMO Explanation condition) parallels the disease risk condition from Horne et al. (2015), as well as Studies 1 and 2. This GMO explanation condition specifically focused on the environmental and societal benefits of GMOs (e.g., higher crop yield, more resilient plants, increase in global food production). Additionally, the GMO correction condition paralleled the extended alternate autism correction condition developed for Study 2. The GMO correction condition used scientific research and evidence to highlight the safety of human consumption of GMOs. Addressing the benefits GMOs provide at the societal and environmental level rather than solely focusing on how GMOs impact the individual, allowed us to further extend upon the previous studies (Study 1 and 2). Specifically, the proposed study examined the effectiveness of different misinformation correction approaches on altering individual attitudes, beliefs, and behaviors/intentions as well as implications toward GMOs.

Method

The current study compared how different messages impact participant attitudes toward GMOs. Participant inclusion and exclusion criteria and statistical analyses were similar to the previously described methodology in Studies 1 and 2. One noticeable difference in methodology between the current study and the previously mentioned studies, was that the entire study was completed in a single session. We selected this approach as an initial test due to levels of attrition noted in the previous studies and the relative lack of robustness of the earlier previous findings.

Participants

Similar to Studies 1 and 2, all participants were recruited through Amazon Mechanical Turk (MTurk) (i.e., including native English speakers in the US, and participants who correctly answered all attention check items). Participants were provided with a consent form prior to completing any portion of the study. An initial pilot study (Study 3a) was conducted prior to the full collection of data noted in Study 3b. Using the initial findings for Study 3a, a power calculation was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007), detecting effect sizes of $d = .25$ or greater. After correcting for multiple comparisons, 1000 participants were needed to complete Study 3b (n = 692). Participants were paid $1.35 for their participation.

GMO Scales

The primary measure of attitude change for GMOs was a series of self-generated GMO items comprised of several subscales. These self-generated scales assessed specific stances individuals may have about GMOs (e.g., beliefs and attitudes about the safety of GMOs, beliefs and attitudes about the environmental influence of GMOs, and behaviors/intentions toward GMOs. All newly generated GMO scales consisted of six-point items ranging from "*Strongly Disagree*" to "*Strongly Agree*". The GMO behaviors/intentions scale assessed items such as *"I would be willing to pay more to* *avoid consuming genetically modified organisms"* (seven items: α = .94). The attitudes and beliefs about GMO safety subscale contained items such as *"Genetic modification of food products is unnatural"* (three items: α = .89). Given that the proposed misinformation correction interventions discuss the environmental aspect of GMOs, participants were asked about their attitudes about the environmental impact of GMOs (e.g., *"Genetically modified organisms are beneficial to the environment*") (three items: α = .76). In addition to validity tests, all GMO scales were piloted in a small sample study (*see* Study 3a Findings).

While the generation of an entirely new scale can bring about a host of reliability and other statistical concerns, currently, only one scale in the literature exists that allows for the examination of the alteration in individual attitudes (e.g., Bode & Vraga, 2015) but this only exists in the context of how influential social media can be and only assesses attitudes toward GMOs. Currently published scales on GMO attitudes merely assess individual beliefs surrounding the nature of the given topic, however, we are primarily interested in the correction of misinformation that allows for the altering of attitudes and beliefs and for further examination of effect misinformation correction intervention approaches. Additionally, all self-generated scales had a reliability of α >.75. The proposed scales (*see* Appendix) measure individual attitudes and beliefs toward GMOs using similar approaches from previous studies (Linnhoff, Martin, & Smith, 2017) while accounting for potential attitude and belief changes. Many of the items featured in the scales were reverse-coded. This scale was administered once at the beginning of the study session and again after condition randomization, at the end of the study.

Procedure

Study 3 followed the same general procedure seen in Studies 1 and 2. A noticeable difference between the current study and the previous two studies is the session administration time. Given previous attrition rates associated with administering multiple-session studies via MTurk and the results of the pilot studies, Study 3 was administered in one study session. Another difference in procedure between Studies 1 and 2 and the current study was the primary dependent measure. Study 1 and 2 used one overall vaccine attitude scale that had to be parsed into subscales to further assess individual changes in views towards vaccines. For the current study, we generated a series of GMO scales assessing: behaviors/intentions toward GMOs, attitudes and beliefs about the safety of GMOs, and attitudes and beliefs about the environmental impact of GMOs. Additionally, all items were examined under one overarching GMO scale in a series of exploratory analyses (*see* Results).

Participants were asked to provide demographic information (age, sex, income, political preference, etc.), rate the frequency in which they engage in certain shopping behaviors (e.g., "*I buy food made with genetically modified organisms*"), and to rate the level of agreement on three different six-point GMO scales in addition to rating their pre-existing beliefs on various morality scales including: euthanasia, abortion, and consequentialism (*see* Appendix). Attention checks were randomly placed throughout these scales to ensure participants were paying close attention to the questions. An example of an attention check question was as follows: "*For this statement, please select agree"*. Participant responses that failed to pass all attention checks were excluded from data analysis.

After completing a series of behavior/intentions, and attitudes and beliefs questionnaires, participants were then randomly assigned to one of three conditions: (1) GMO correction condition modeled after the extended alternate autism correction condition introduced in Study 2, (2) GMO explanation condition (modeled after the disease risk correction condition proposed by Horne et al. (2015) and used in Studies 1 and 2, (3) the same control condition used by Horne and colleagues (2015) and as seen in Studies 1 and 2. Participants assigned to the GMO correction condition were given three pieces of information: (1) a brief paragraph that highlights the research organizations that argue GMOs are safe for human consumption, (2) a fictious anecdotal story about a new parent who only buys organic non-GMO food despite scientific findings, and (3) graphical information from previous researchers highlighting the safety of human consumption of GMOs. Similar to the GMO correction condition, the GMO explanation condition also consisted of three pieces of information: (1) a brief paragraph about the safety of GMOs for human consumption, (2) a story about a fictious woman who is concerned about food safety despite the many benefits of GMOs, and (3) graphical information from previous researchers displaying the benefits of GMOs for the environment and society at large. Participants assigned to the control condition read an unrelated scientific article used previously by Horne et al. (2015) and Nyhan et al. (2014).

Study 3a Findings

A GMO pilot study (Study 3a) was conducted to test the effectiveness of GMO misinformation correction approaches on altering attitudes and beliefs, and behaviors/intentions toward GMOs. Results were analyzed using SPSS 25. Incomplete data were not included in data analysis nor were participant responses that failed to pass attention checks. One-hundred fifty participants were recruited to complete the pilot. After accounting for exclusions, 116 participant responses were analyzed.

GMO Behavior/Intentions & Attitudes and Beliefs about Safety of GMOs

A one-way ANOVA examining condition on behavior/intentions toward GMOs change score found significant results, $F(2, 113) = 4.442$, $p = .014$, $\eta^2 = .07$, with the most effective condition being the GMO explanation intervention. Specifically, the GMO explanation condition significantly differed from the control, $t(78) = 2.994$, $p = .004$, $d = .67$ (see figure 4.1). Additionally, the GMO explanation condition significantly differed from the GMO correction condition, $t(75) = -2.110$, $p = .038$, $d = .46$. The findings testing the impact of condition on GMO attitude change score ($F(2, 113) = 1.346$, $p = .264$), failed to meet significance (see table 4.1).

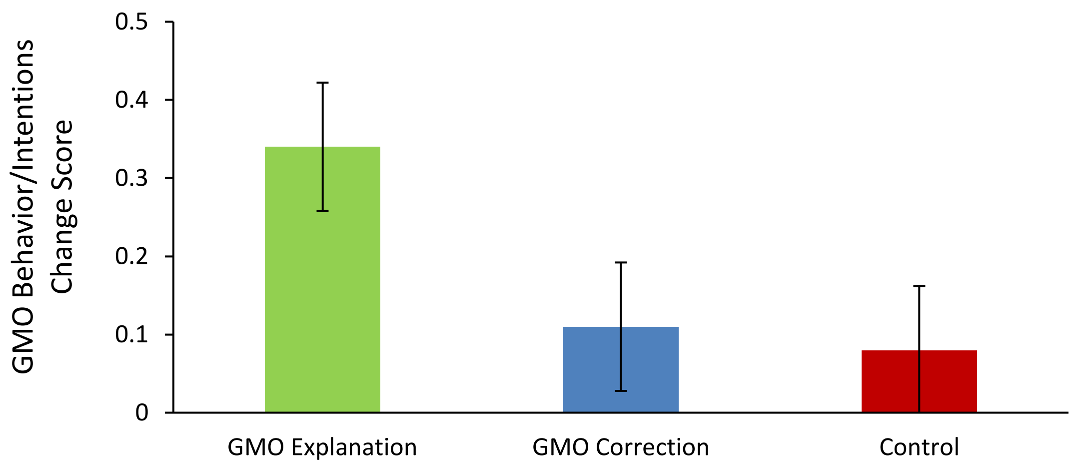

Figure 4.1. GMO behavior/intentions change score by condition.

Table 4.1

Attitudes and beliefs about safety of GMOs change scores based on condition.

	M	SD	N
GMO Correction	.04	.60	36
GMO Explanation	.25	.61	41
Control	.15	.51	39

GMO Attitudes & Beliefs about Environmental Impact

A one-way ANOVA assessing attitude and belief change scores about the environmental impact of GMOs and condition, results were significant, *F*(2, 113) = 25.416, $p < .001$, $\eta^2 = .31$ (see figure 4.3). The GMO correction condition (*M* = -.15, *SD* = .60) significantly differed from the GMO explanation condition (*M* = .79, *SD* = .74), *t*(75) = 6.029, $p < .001$, *d* = 1.40. Additionally, the GMO explanation condition significantly differed from the control (*M* = -.01, *SD* = .52), *t*(78) = 5.559, $p < .001$, *d* = 1.25.

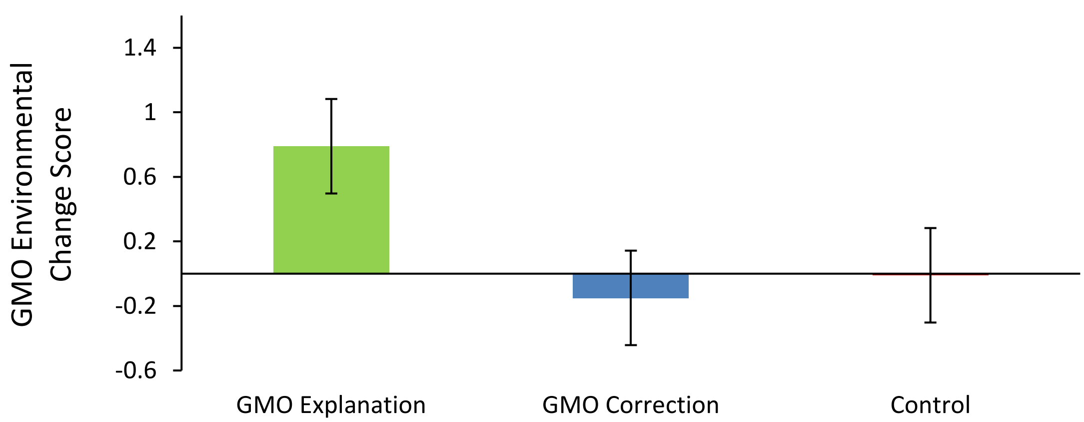

Figure 4.2. Change scores for attitudes and beliefs about environmental impact of GMOs by condition.

All GMO Scale Items

Given that previous research does not always parse apart belief, attitude, and behavior/intention scales, we conducted a one-way ANOVA examining all 13 GMO belief, attitude, and behavior/intention scale items by condition (GMO correction, GMO explanation, control). Results were significant, $F(2, 113) = 16.141$, $p < .001$, $\eta^2 = .22$ (see figure 4.4). Post hoc tests revealed the GMO correction condition ($M = .03$, $SD = .33$), significantly differed from the GMO explanation condition ($M = .43$, $SD = .43$), $t(75) = 4.460$, $p < .001$, $d = 1.04$. Additionally, the GMO explanation condition also significantly differed from the control group ($M = .08$, $SD = .21$), $t(78) = 4.588$, $p < .001$, $d = 1.03$.

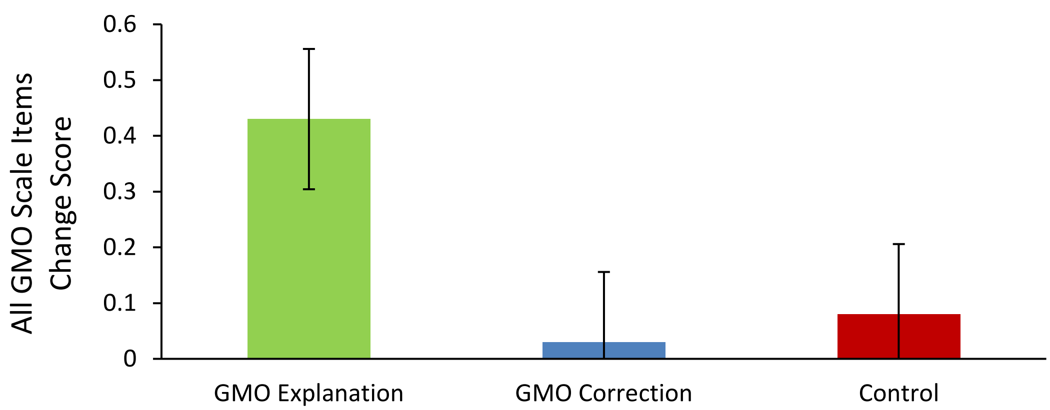

Figure 4.3. Average change score for all GMO subscales (beliefs, attitudes, beliefs about environmental impact of GMOs, implications and intentions of GMOs combined by condition.

Exploration of Individual Factors

Additionally, a series of factorial ANOVAs examining political party preference (partisanship) and the various GMO scales (behavior/intentions toward GMOs, GMO safety, environmental impact) were all non-significant at $p > .10$ (see table 4.2), with the exception of the 3 X 3 factorial ANOVA examining partisanship (broken down into the three main parties as reported in the sample: Republican, Democrat, Independent) and condition (GMO correction, GMO explanation, and control) on the GMO perceived environmental impact scale in which the findings for partisanship were not significant, $F(2, 91) = .940$, $p = .395$, nor was the interaction, $F(4, 91) = 1.529$, $p = .200$, however the condition variable was significant, $F(2, 91) = 20.557$, $p < .001$. These preliminary pilot findings suggested that while the Horne et al. (2015) extended replication was not effective, the disease risk approach proposed by Horne and colleagues (also used in Study 1) might apply to a GMO domain.

Table 4.2
GMO attitudes and beliefs about safety of GMOs, environmental impact attitudes and beliefs, and behavior/intentions change scores based on political party preference.

GMO Scale	partisanship	M	SD
Beh./Intent.	Republican	.19	.53
	Democrat	.16	.44
	Independent	.06	.35
GMO Safety	Republican	.20	.83
	Democrat	.10	.53
	Independent	-.05	.26
Envi. Impact.	Republican	.16	.78
	Democrat	.27	.68
	Independent	.27	.77

Results

Results were analyzed using SPSS version 25. Participants who failed to answer all scale items or pass all attention checks were not included in data analysis. After excluding participants for failure to pass attention checks – 1000 participants were initially recruited – 692 participant responses were analyzed.

GMO Behavior/Intentions

A one-way ANOVA was conducted examining the impact of condition (GMO correction, explanation condition, control) on GMO behavior/intentions change scores (from pre to posttest). Results were significant, $F(2, 689) = 27.099$, $p < .001$, $\eta^2 = .07$

(see figure 4.5) Specifically, the GMO correction condition (*M* = .32, *SD* = .57) compared to the control group (*M* = .03, *SD* = .33) showed significant group differences, *t*(461) = 6.771, $p < .001$, *d* = .62. There were also significant group differences between the GMO explanation condition (*M* = .36, *SD* = .64) and control group, *t*(464) = 6.999, $p < .001$, *d* = .65.

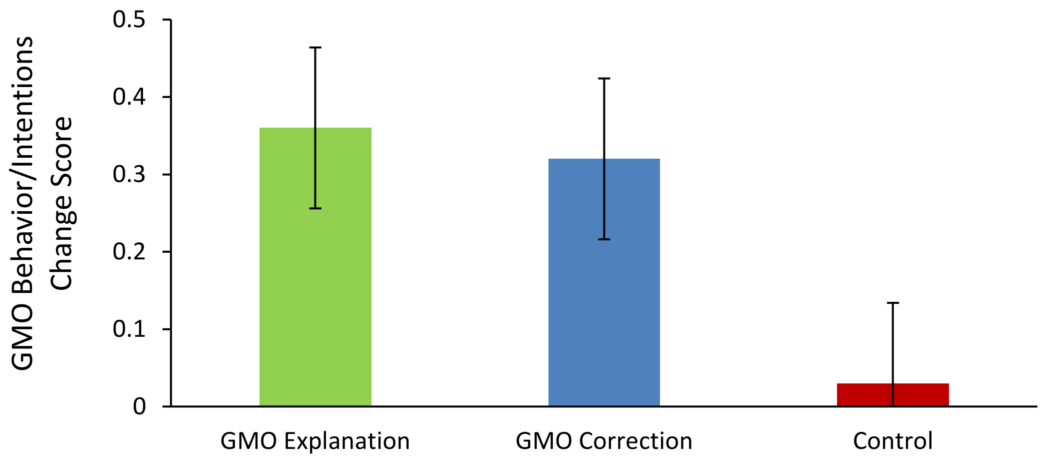

Figure 4.4. GMO behavior/intentions change score by condition.

Attitudes and Beliefs about Safety of GMOs

A one-way ANOVA examined the impact of condition on GMO attitude change scores from pre to posttest. Results were significant, $F(2, 689) = 31.033$, $p < .001$, $\eta^2 = .08$ (see figure 4.5). Specifically, the GMO correction condition (*M* = .27, *SD* = .75), and control group (*M* = -.09, *SD* = .49), *t*(461) = -6.153, $p < .001$, *d* = .57. There were also significant differences between the GMO explanation condition (*M* = .38, *SD* = .78), and the control group, *t*(464) = -7.942, $p < .001$, *d* = .72. Finally, an Independent samples t-test found a marginal difference between the GMO explanation and GMO correction conditions on GMO attitude change scores, *t*(453) = -1.653, *p* = .099, *d* = .14.

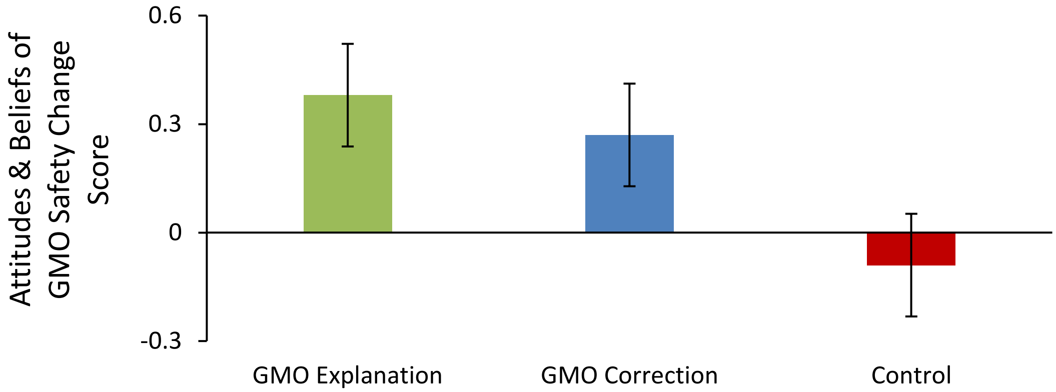

Figure 4.5. Average change score for attitudes and beliefs about safety of GMOs by condition.

Attitudes and Beliefs about Environmental Impact of GMOs

A one-way ANOVA was conducted to test the influence of condition on attitudes and beliefs about environmental impact of GMOs change score. Results were significant, $F(2, 689) = 66.790$, $p < 001$, $\eta^2 = .16$ (see figure 4.6). The GMO explanation was the most impactful ($M = .73$, $SD = .92$), compared to the GMO correction condition ($M = .36$, $SD = .71$), $t(453) = -4.799$, $p < .001$, $d = .45$, and control ($M = -.06$, $SD = .53$), $t(464) = -11.355$, $p < .001$, $d = 1.05$. Additionally, an Independent samples t-test found a significant differences between the GMO correction and control group, $t(461) = 7.188$, $p < .001$, $d = .67$.

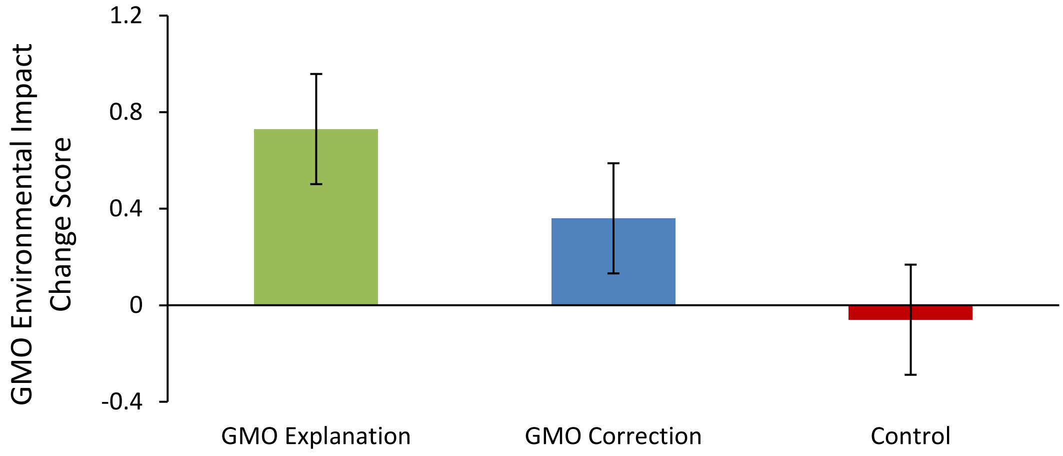

Figure 4.6. Average change score for attitudes and beliefs about environmental impact of GMOs by condition.

Influence of Condition on all GMO Scale Items

When examining all GMO beliefs in tandem (beliefs, attitudes, beliefs about environmental impact, and behavior/intentions), results were still significant, $F(2, 689) = 54.825$, $p < .001$, $\eta^2 = .14$ (see figure 4.7). The GMO explanation condition ($M = .45$, $SD = .63$), was the most effective in altering GMO beliefs, attitudes, and behavior/intentions, compared to the GMO direct correction ($M = .32$, $SD = .54$), $t(453) = 2.408$, $p = .016$, $d = .22$, and the control group ($M = -.02$, $SD = .26$), $t(464) = 10.545$, $p < .001$, $d = .98$. Additionally, there were significant group differences noted between the GMO correction condition and the control group, $t(461) = -8.664$, $p < .001$, $d = .80$.

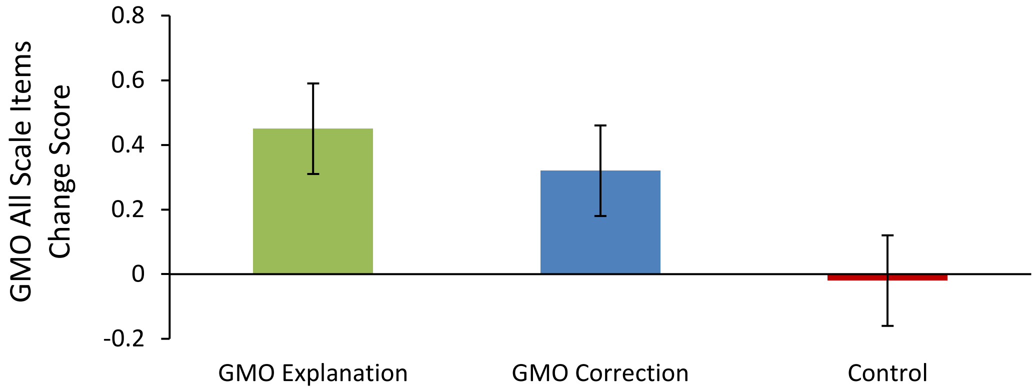

Figure 4.7. Average change score for all GMO subscales (beliefs, attitudes, beliefs about environmental impact of GMOs, and implications and intentions) combined by condition.

Tercile Analyses

Similar to Studies 1, 2, and Horne et al. (2015), we examined the effect of GMO change score for all GMO subscales combined based on condition and terciles generated from participant pretest scores. A 3 X 3 Factorial ANOVA was conducted to examine tercile (bottom, middle, top) and condition (GMO correction, GMO explanation, control) on GMO belief, attitude, and behavior/intentions full scale change score. As noted above, results found a significant main effect of condition, $F(2, 683) = 54.397$, $p < .001$, $\eta^2 = .14$. There was also a significant main effect of tercile, $F(2, 683) = 4.772$, $p = .009$, $\eta^2 = .02$ (see figure 4.8). The bottom pretest tercile group ($M = .32$, $SD = .67$), significantly differed from the middle tercile ($M = .22$, $SD = .48$), $t(470) = 2.035$, $p = .042$, $d = .17$, as well as the control group ($M = .19$, $SD = .41$), $t(453) = 2.573$, $p = .01$, $d = .23$. Finally, results demonstrated a significant interaction between the two, $F(4, 683) = 3.754$, $p = .005$, $\eta^2 = .02$.

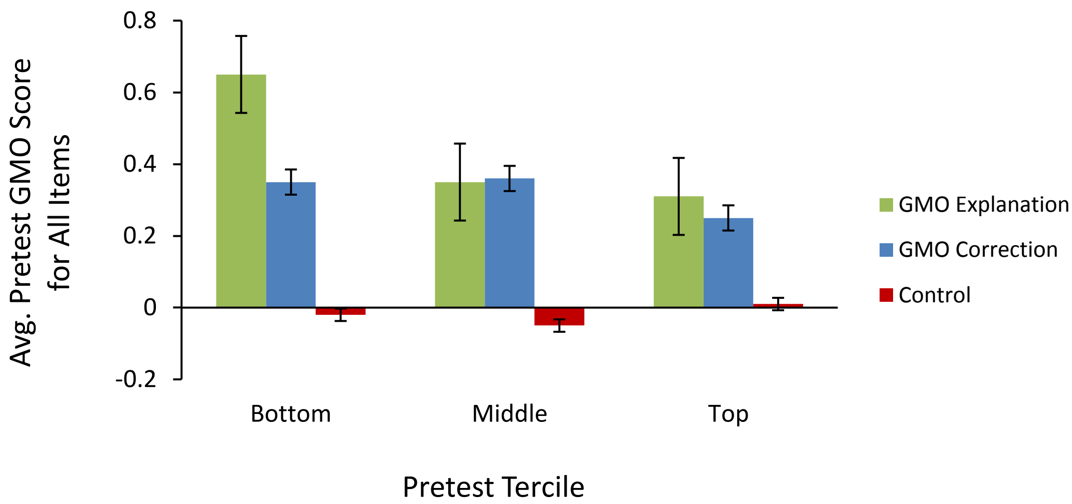

Figure 4.8. GMO pretest tercile for all subscales (belief, attitude, environmental impact beliefs, and behavior/intentions) in tandem based on condition.

Exploration of Individual Factors

Similar to the previous studies, results were also analyzed on the basis of political party preference (partisanship). Given the findings of the previous chapters, it was no surprise that the three most prevalent political parties were: Republican (n = 199; 28.8%), Democrat (n = 286, 41.3%), and Independent (n = 129, 18.6%). All other political parties (Libertarian, Moderate, non-political) contained less than 45 participants per group. All analyses examining partisanship only tested the three main political parties. A series of factorial ANOVAs examining partisanship and the various GMO scales (attitudes and beliefs about GMO safety, attitudes and beliefs about environmental impact of GMOs, and behavior/intentions) were conducted.

A one-way ANOVA was conducted to examine any potential differences in GMO belief pretest measures for all GMO subscale items combined by partisanship. Results were significant, $F(2, 611) = 5.846$, $p = .003$, $\eta^2 = .02$ (see figure 4.9). Specifically, Republican pretest GMO scores ($M = 3.18$, $SD = .99$), significantly differed from

Democrats (*M* = 3.52, *SD* = 1.13), *t*(483) = 3.500¸ *p* = .001, *d* = .32. There were no significant group differences involving Independents (*M* = 3.40, *SD* = 1.19).

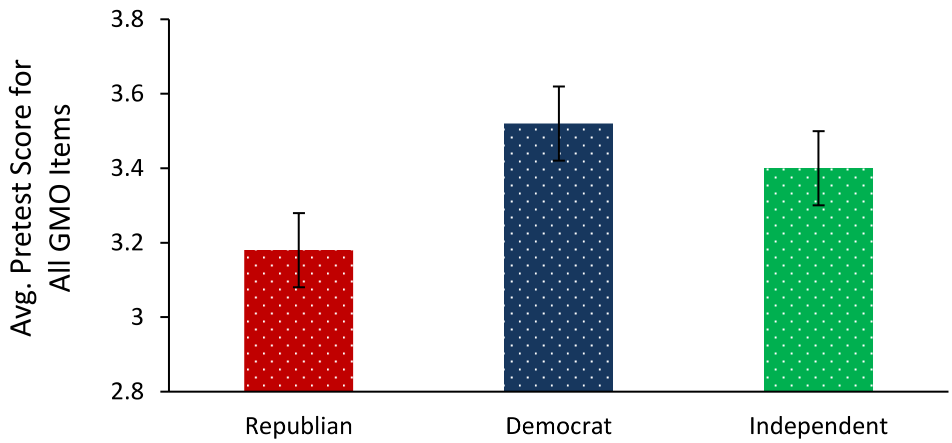

Figure 4.9. GMO pretest tercile for all subscales (GMO safety, environmental impact of GMOs, and behavior/intentions) in tandem based on condition.

GMO Behavior/Intentions

A 3 X 3 factorial ANOVA was conducted to examine the impact of partisanship (broken down into the three main parties as reported in the sample: Republican, Democrat, Independent) and condition (GMO correction, GMO explanation, and control) on the GMO belief subscale change score. Results found a main effect for partisanship, $F(2, 605) = 3.380$, $p = .035$, $\eta^2 = .01$ (see figure 4.10). Specifically, there were significant group differences between Republicans (*M* = .16, *SD* = .46), and Democrats (*M* = .27, *SD* = .61), *t*(483) = -2.235, *p* = .026, *d* = .20. There were marginal group differences when comparing Republicans to Independents (*M* = .26, *SD* = .52), *t*(326) = -1.883, *p* = .061, *d* = .20. Results also found a main effect of condition, $F(2, 605) = 25.728$, $p < .001$, $\eta^2 =.08$, but no significant interaction, $F(4, 605) = .293$, $p = .883$.

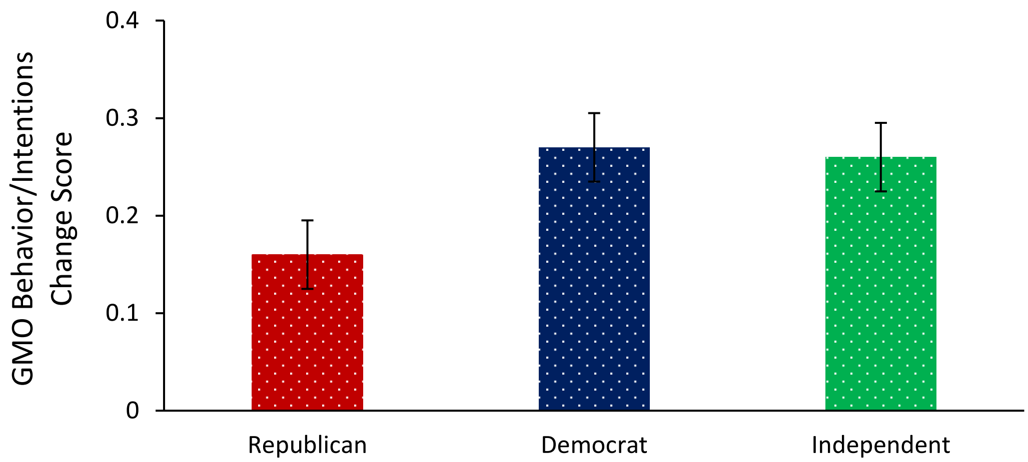

Figure 4.10. GMO behavior/intentions by political party preference.

Further examination of partisanship and belief change scores, results found an initial 47.7% of Republicans held anti-GMO beliefs (scored less than or equal to three of the six-point GMO belief scale) (posttest: 40.1% of participants held anti-GMO beliefs). Consistent with initial prior findings, on average, Republicans displayed the lowest change score from pre to posttest compared to Democrats and Independents. Results found 53.3% of Democrats held anti-GMO beliefs prior to receiving any intervention. This number dropped to 48.7% in posttest. Finally, 48.8% of Independents held anti-GMO attitudes, a number that dropped to 38.8% in posttest.

Attitudes and Beliefs about Safety of GMOs

Similar findings were found when examining partisanship and condition on attitudes and beliefs about the safety of GMOs change scores from pre to posttest. A 3 X 3 factorial ANOVA found a marginal effect of partisanship, $F(2, 605) = 2.432$, $p = .089$, $\eta^2 = .01$ (see figure 4.11). There were marginal group differences between Republicans ($M = .11$, $SD = .68$), and Independents ($M = .25$, $SD = .65$), $t(326) = 1.853$, $p = .065$, $d =$

.21. There were no significant group differences involving Democrats (M = .20, SD = .75).

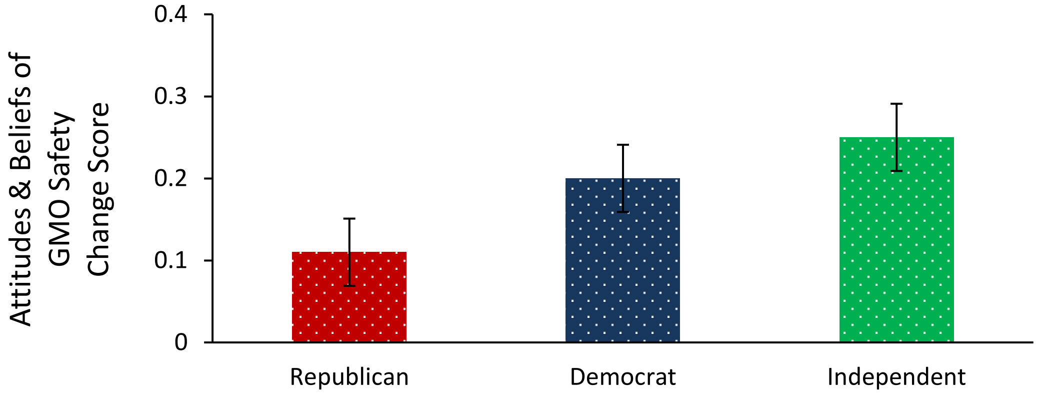

Figure 4.11. Average change score for attitudes and beliefs about safety of GMOs by political party preference.

Results also found a main effect of condition, $F(2, 605) = 25.251$, $p < .001$, $\eta^2 = .08$, but no significant interaction between the two, $F(4, 605) = 1.123$, $p = .345$, $\eta^2 = .01$. Furthermore, on average, Republicans again showed the smallest change in attitude from pre to posttest, with 44.7% displaying anti-GMO attitudes at pretest and posttest. Of Democrat pretest scores, 37.8% held anti-GMO scores while 30.1% of Democrats reported anti-GMO attitudes at posttest. For Independents, 41.9% of pretest scores were considered anti-GMO, compared to 36.4% of participants posttest.

Attitudes & Beliefs about Environmental Impact of GMOs

Repeating the previous analysis apart from using the change score on beliefs about environmental impact of GMOs. Unlike previous subscale findings, there was no main effect of partisanship, $F(2, 605) = .043$, $p = .958$, however, there was a main effect of condition, $F(2, 605) = 51.205$, $p < .001$, $\eta^2 = .15$, and no significant interaction, $F(4, 605) = 1.916$, $p = .106$. These results may at first glance seem surprising given the previous literature on partisanship and concern for the environment (Van Bavel & Periera, 2018; Rutjens, Sutton, & van der Lee, 2018). However, it is possible that individuals at pretest were entirely unaware of how GMOs might impact the environment.

On average, at pretest, 32.2% of Republicans held anti-GMO attitudes at pretest while 22.1% reported those attitudes at posttest. Of Democrat pretest scores, 29% held anti-GMO views while 18.2% of Democrats reported anti-GMO attitudes at posttest. For Independents, 35.7% of pretest scores were considered anti-GMO, compared to 25.6% of participants posttest.

Discussion

The goal of the present study was to examine the effectiveness of a GMO explanation condition – designed to parallel the vaccine disease risk condition – on altering individual beliefs, attitudes, and behavior/intentions toward GMOs. The initial pilot findings reported in Study 3a found GMO change scores for attitudes and beliefs about GMO safety, attitudes and beliefs about the environmental impact of GMOs, and behavior/intentions toward GMOs were significantly impacted by the GMO explanation condition. Additionally, when examining all GMO scale items in tandem, the GMO explanation was the most effective at altering individual attitudes, beliefs, and behavior/intentions toward GMOs. Given the most effective condition in the current study was designed to parallel the vaccine disease risk model proposed by Horne et al (2015), these results further support the argument that the most successful misinformation correction approach is to focus on the risks posed to the individual and society when people fail to engage in a certain behavior. Furthermore, not only do these findings support the proposed correction intervention of Horne and colleagues (2015), it also demonstrates that similar misinformation correction approaches may be applicable in different contexts.

Study 3b, with its larger sample size, showed similar findings. The GMO explanation condition – designed to be equivalent to the vaccine disease risk condition – was the most effective at altering GMO attitudes and beliefs about GMO safety, and attitudes and beliefs about the environmental impact of GMOs. Additionally, when all GMO scale items were grouped together, the GMO explanation condition was still the most effective at altering individual attitudes, beliefs, and behavior/intentions toward GMOs. The GMO behavior/intentions scale was the only measurement in which the explanation condition was just was effective as the GMO correction condition (designed to parallel the alternate autism correction condition generated in Study 2).

Further exploration of individual factors and GMO measurements – specifically, partisanship and its influence on GMO attitudes, beliefs, and behavior/intentions – found that with the exception of attitudes and beliefs about the environmental impact of GMOs, there was a consistent marginal effect of partisanship on all GMO subscale change scores from pre to posttest. Specifically, when examining the three main political parties in isolation (Republican, Democrat, Independent) Republicans consistently demonstrated lower change scores from pre to posttest compared to Democrats and Independents. Furthermore, Democrats demonstrated the highest GMO baseline scores, a finding that was a bit surprising given the push for some groups of Democrats to label and identify GMO foods (Berning & Campbell, 2017).

Finally, results of a tercile analysis found an interaction between condition and tercile, suggesting that the ability for individuals to alter their attitudes, beliefs, and behavior/intentions toward GMOs may impacted by which misinformation correction approach one is exposed to, in addition to their baseline values without intervention. While the results are very clear and the GMO explanation condition is the most effective, the results of the tercile analyses should be considered in the future when generating additional GMO misinformation correction approaches.

Overall, these findings suggest that: (1) a condition designed to parallel the disease risk condition developed by Horne et al. (2015) is effective in multiple contexts, (2) when using an expected utility approach, misinformation correction tactics that highlight the negative consequences of not engaging in a particular behavior – in this case human consumption of GMOs – are successful at altering attitudes, beliefs, and behavior/intentions toward GMOs. While Studies 3a and 3b were not designed to address the GMO debate one way or another, these findings further support the argument that the use of a "disease risk" framework is an effective and successful approach to alter individual attitudes and correct for misinformation for individuals who oppose the human consumption of GMOs.

Future studies should also consider a more extensive examination of the degree to which partisanship influences general GMO attitudes and beliefs. As mentioned previously, there are notable differences in individual beliefs when partisanship is examined. Specifically, there are differences in a number of scientific issues, including climate change, on which political parties differ (Van Bavel & Periera, 2018; Rutjens, Sutton, & van der Lee, 2018). Given these findings, future studies that wish to continue the exploration of GMO misinformation correction approaches should also consider including more political viewpoints about GMOs.

Overall, both the environmental explanation and the GMO correction conditions were effective in altering beliefs and attitudes (though there was some benefit for the explanation condition on some outcomes). GMO beliefs and attitudes may be easier to alter than vaccine beliefs and attitudes. One possible explanation for this difference is that people may have less knowledge about GMOs and thus less entrenched beliefs about them. Supporting this idea is that most people scored in the “neutral” range on the initial survey of GMOs. In contrast, the vaccine-autism debate is well known and is commonly discussed in the media. This is not the case for GMOs. Genetically modified organisms in food have been prevalent in crops for the past several decades, yet the non-GMO movement is relatively new (Roff, 2009). Future researchers wanting to further pursue misinformation correction approaches, whether they be for GMOs, vaccines, or something else entirely, should consider the indirect impact that topic novelty may have on participants.

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Appendix

<u>Assessment Scales used for Studies 3a & 3b:</u>
For the following scale, participants were asked to rate the frequency with which they engage in the following behaviors with each of these items on a five-point Likert scale from Never to Always (never, rarely, sometimes, often, always).

Please respond with how frequently you participate in the following behaviors:

1. I avoid consuming genetically modified foods.
2. I read packaging labels to avoid buying genetically modified items.
3. I buy food products made with genetically modified organisms.

For the following scales, participants were asked to rate their agreement with each of these items on a six-point Likert scale ranging from Strongly Disagree to Strongly Agree.

GMO Behavior/Intentions Scale

1. I believe it is important to avoid consuming genetically modified foods.
2. I believe that it is important to read packaging labels to avoid buying genetically modified items.
3. I believe that it is good to buy food products made with genetically modified organisms.
4. I would be willing to pay more to avoid consuming genetically modified organisms.
5. I am concerned about consuming items made with genetically modified organisms.
6. I think there should be labels on genetically modified organisms in food.
7. I think genetic modification of foods should be made illegal in the U.S.

GMO Attitudes and Beliefs about Safety Scale

1. Genetically modified organisms in food pose a threat to human health.
2. Genetic modification of food products is unnatural.
3. Genetically modified organisms are safe for human consumption.

GMO Attitudes and Beliefs about Environmental Impact Scale

1. Genetic modification of food products is harmful to the environment.
2. Genetically modified organisms are beneficially to the environment.
3. Genetically modified foods reduce human exposure to pesticides.

In addition to the GMO scales provided, the morality distractor scales (consequentialism, abortion, and euthanasia) previously used in Horne et al. (2015) will also be included in this study.

<u>*GMO Correction Condition*</u>

Please examine the following information about genetically modified organisms (GMOs) carefully.

You may worry that human consumption of foods made with genetically modified organisms (GMOs) is harmful, but research has actually found that consuming GMO foods is safe for human consumption. Indeed, the World Health Organization, the American Medical Association, and the National Academy of Sciences all agree there is ***"no good evidence to suggest GMOs are unsafe."***

The idea of genetically-modified plants sounds scary to many consumers. As a new parent, Jacob Sanders wants the best for his toddler. He buys organic, non-GMO foods as often as possible. He cooks her healthy meals with minimally processed ingredients and many vegetables. He says "why take a chance on GMOs when non-GMO food is clearly labeled and wouldn't have the risk of GMOs?".

Why are people so concerned about GMOs? First, it seems as though modifying genes is "unnatural" and therefore potentially dangerous. Why mess around with plants that have been safely eaten for hundreds of years by changing their genetic characteristics? Furthermore, why trust agribusiness – the same industry responsible for rampant use of pesticides and herbicides, overuse of antibiotics, soil erosion, water contamination, and tomatoes that taste like cardboard? In general, the idea of genetically modified foods sounds potentially risky.

Decades of research, however, has found that GMOs are completely safe for human consumption; in many ways, they are even safer than non-GMO foods. For example, GMO foods are frequently being engineered to be resistant to common pests and therefore require fewer pesticides. At the same time, some agribusinesses actually benefit from consumer concerns. If these businesses can convince consumers to pay more to buy non-GMO foods, they can increase their sales and profits.

Given that both sides – pro-GMO and anti-GMO businesses – have skin in the game, what is the truth?

Research has found no evidence to suggest that foods made with GMOs are unsafe for human consumption. Please look over the following graphs displaying the truth behind GMOs.

<u>National Academy of the Sciences</u>
The National Academies of the Science, Engineering, and Medicine conducted a review of over **900** studies and publication found that consuming foods made with GMOs is just as safe as consuming foods made without GMOs.

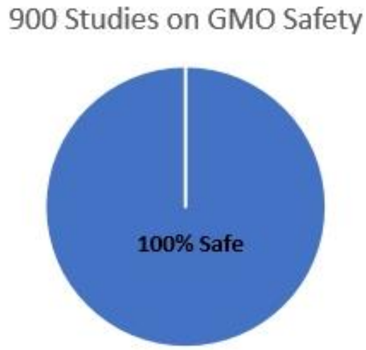

Figure 4.A1. Illustration of GMO safety research presented to participants in GMO correction condition.

Norris
Researchers are working to develop genetically modified foods that produce more health benefits, such as: golden yellow rise that contains more vitamin A to combat vision ailments and other deficiencies, pineapples that contain lycopene (a tomato-based pigment) which is an antioxidant that may prevent cancer, and the antioxidant properties noted in blueberries is being engineered in tomatoes. Despite these many genetic modifications, research has found no health and or toxicity concerns for human consumption of GMOs.

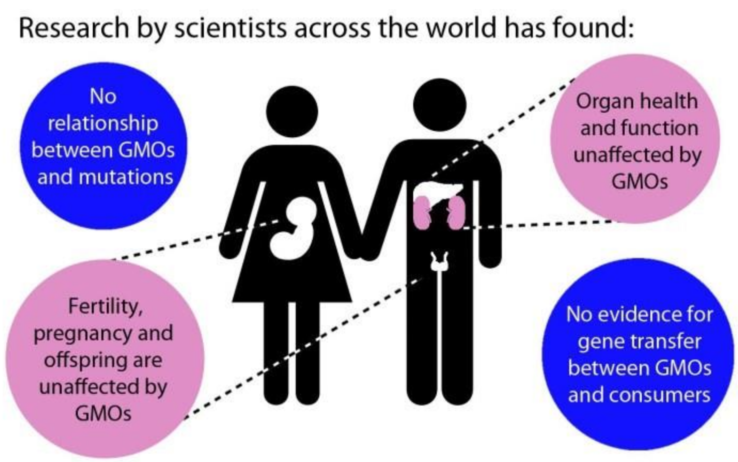

Figure 4.A2. Illustration of lack of human harm from consuming GMOs presented to participants in GMO correction condition.

GENetic Engineering Risk Atlas (GENERA) 2014
The following graph displays data from GENERA of 197 peer-reviewed scientific studies that address the safety of foods made with genetically modified ingredients. A vast

majority of the studies found no difference in foods made with GMOs compared to non-GMO foods.

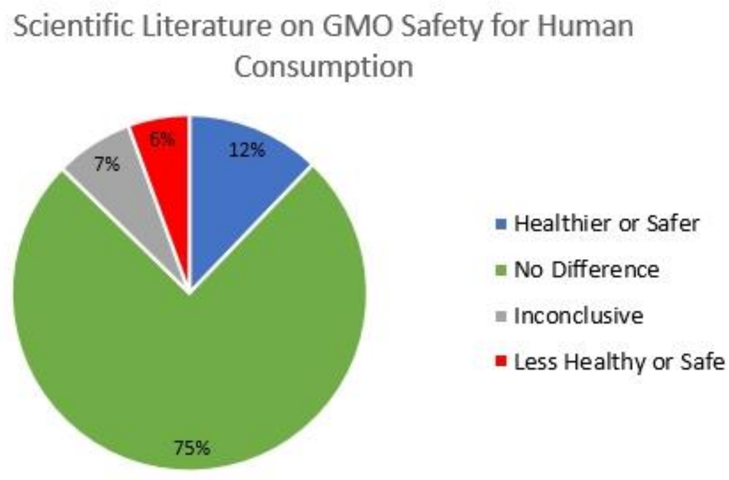

Figure 4.A3. Illustration of GMO scientific literature on safety of GMOs research presented to participants in GMO correction condition.

GMO Explanation Condition

Please read the following information about genetically modified organisms carefully.

While there are fears surrounding genetically modified organisms (GMOs), there is resounding evidence that GMOs are completely safe for human consumption. In fact, not only are GMOs safe, but they also have significant benefits due to increased crop yields, increased plant resiliency, reduction in use of pesticides and herbicides, and reduced exposure to diseases.

Adequate and safe food is a concern for Cecilia Ramirez. As a new parent, she wants the best for her toddler. Corn is a major part of her family's diet, and she is very concerned that the corn be safe, and used to avoid foods that were labeled as having GMOs or pesticides. Her niece died of liver failure after consuming corn containing mycotoxin, a fungus called *Aspergillus*. She later learned that GMO corn, which she had previously avoided, actually reduces the prevalence of mycotoxins because GMO corn is more resistant to pests such as the corn borer. In turn, the corn requires fewer pesticides to be grown and also is less likely to be infested with corn borers that in turn would make them susceptible to mycotoxin growth. Now, she knows that GMO foods are not only safe, but also reduce her child's exposure to known toxins such as fungi and pesticides.

Humans started farming over 10,000 years ago. Throughout these millennia, the population has continued to increase and with this population growth has been a corresponding increase in crop production. Since 1950, the world's population has more than doubled and to feed all of the world, and all Americans, it is necessary to either increase farmland (by destroying the wilderness) or to increase crop yield. GMOs have been a key approach to increasing crop yield.

Furthermore, many species of plants have been destroyed, or nearly destroyed, by disease and pests. The Hawaiian papaya, for example, was nearly extinct due to infestation by the ringspot virus. If not for the genetic engineered version. However, genetic engineering has led to the creation of a version of the papaya that can destroy the virus. Other plants at risk include the common Cavendish banana, which is slowly being destroyed by a fungus throughout the world.

Foods made with GMOs are not hazardous for human consumption. However, there are many benefits of GMOs for the environment as well as for the individuals. Please read the descriptions of some GMO benefits and carefully view the pictures.

Higher Crop Yield & Resiliency
Foods made with GMOs are less susceptible to the potential damages that arise with weeds, insects, and other crop damaging factors; this naturally leads to a higher crop yield in crop production for GMO-based plants (James, 2014). In addition, foods made with GMOs also tend to be more resilient to harsh and adverse weather patterns than non-GMO crops (Font, 2011; Mintz, 2017). The higher crop yield that GMOs promote, which is a direct result of a reduction in losses due to the pest and weed control, further supports the notion that GMOs have positive environmental benefits (Mannion & Morse, 2012).

Figure 4.A4. Illustration of comparison of GMO to non-GMO crops presented to participants in GMO explanation condition.

Carter and Greene (2014)
The following graph shows that global hunger has been slowly declining in the past decades. Due to the higher crop yield and increased resiliency GMO crops have, the decline in global hunger is often attributed to the use of GMOs in foods.

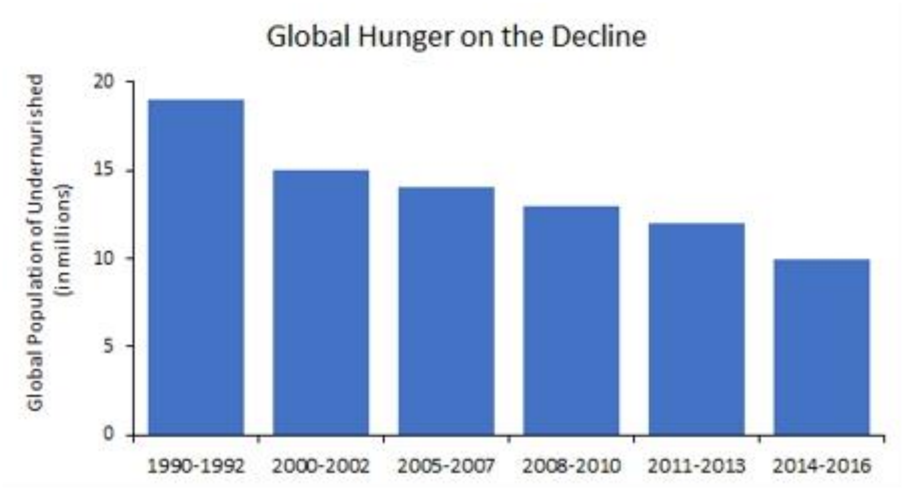

Figure 4.A5. Illustration of benefit of GMOs on global hunger decline presented to participants in GMO explanation condition.

<u>University of California Division of Agriculture and Natural Resources</u>
The following highlights the many beneficial environmental impacts that arise due to the use of GMOs on crops, such as a reduction in CO_2 emissions, less use of pesticides, and a reduction in the amount of land needed to produce the same amount of food.

Figure 4.A6. Illustration of the benefits of GMOs on the environment presented to participants in the GMO explanation condition.

<u>*Control (Horne et al., 2015)*</u>

Please examine the following information about bird feeding carefully.

Q: What are the costs and benefits of bird feeding?

A: It is difficult to assess the costs and benefits of bird feeding because it is difficult to compare the health of birds without access to feeders with birds that frequent feeders. Only one study was able to obtain some sound results. That study found that any benefits of feeding only appear to occur sporadically under extreme climactic conditions. No research has been able to demonstrate a cost. Aside from costs and benefits to birds, there is a cost and benefit to humanity. The costs are obvious – the expense of bird feeding supplies.

The benefits include learning more about birds and the joy of connecting with the natural world. Bird feeding provides a direct, intimate view of the natural world for more than 50 million Americans who feed the birds in their yards. It is most popular in winter, when birds seem to need the most help. Some people worry that birds will suffer unless they make great efforts to the feeder filled, but research indicates that most birds do not depend on feeders.

Chapter 5

Conclusions

The goal of my dissertation was to examine the effectiveness of various misinformation correction approaches to alter individual attitudes, beliefs, and future intentions toward specific topics. Specifically, this dissertation addressed approaches to correct the false belief “vaccines cause autism”, and the false belief that genetically modified organisms (GMOs) are hazardous for human consumption. Across a series of studies, I found framing misinformation correction tactics that focused on how vaccines and GMOs reduce risks posed to the individual, environment, and society is, for the most part effective at altering individual attitudes, beliefs, and intentions toward a given topic and has the ability to transcend contexts However, this effect is not very robust in certain contexts and it is not clear how replicable the current findings might be.

Summary of Key Findings

Study 1 further supported previous findings by Horne et al. (2015) that suggested altering attitudes is possible when posing information in terms of a disease risk – posing arguments in terms of the risks the vaccine preventable diseases pose to the individual if they fail to vaccinate. This disease risk condition was more effective than a direct autism correction approach. Additionally, a comparison of the autism correction condition against the control found a marginal effect of condition on vaccine attitude change score. These findings suggest that while an autism correction condition may not be as effective at altering individual vaccine attitudes as a disease risk approach, it is somewhat impactful when examined in isolation. In other words, a direct misinformation correction condition may be better than no misinformation correction condition. After parsing the vaccine scale in to separate subscales measuring different vaccine values, marginal effects of condition on vaccine intention were found. Similar to Horne et al. (2015), Study 1 found no significant differences in vaccine attitude change score when taking into account parent status. An exploratory analysis on hidden question six, the main misconception surrounding vaccines and autism (*"Some vaccines cause autism in healthy children")*, found significant group differences, with the autism correction condition showing the most change from pre to posttest. Furthermore, additional analyses found Republicans consistently displayed the lowest vaccine attitude score average when compared to Democrats and Independents.

While the results of Study 1 found the disease risk condition to be the most effective at altering vaccine attitudes, extended replication Study 2 failed to replicate those same findings; rather the was no effect of condition on vaccine attitude change score. None of the proposed misinformation correction conditions, including the previously effective disease risk condition as demonstrated in Study 1 and Horne et al. (2015), were effective at altering individual vaccine attitudes compared to the control condition. For Study 2, the examination of hidden question six by condition was significant when considering all five conditions, with the most effective condition for this scale item being the newly extended alternate autism correction condition. One similarity in findings from Horne and colleagues (2015), Study 1, and Study 2 was that there was no significant impact of parent status on vaccine attitude change score. Other exploratory analyses of Study 2 yielded interesting findings. Specifically, there were significant differences in partisanship in baseline vaccine attitudes. Consistent with previous exploratory findings, Republicans – while still slightly pro-vaccine – demonstrated the lowest baseline vaccine attitudes compared to Democrats and Independents.

While the findings from Studies 1 and 2 were inconclusive, Studies 3a and 3b were designed to examine a paralleled disease risk misinformation correction approach in a different context than vaccines. Initial results for Study 3a suggested that a disease risk parallel GMO condition (i.e., GMO explanation condition) that highlighted the detrimental impacts on society and the environment intervention strategy was effective at altering some aspects of beliefs, attitudes, and behavior/intentions about human consumption of GMO foods. Specifically, Study 3a found a marginal effect of condition on GMO behavior/intentions, with the GMO explanation condition being the most influential. While there was no significant impact of condition on GMO attitudes and beliefs about GMO safety change score, results demonstrated when examining condition and change score of GMO behavior/intentions as well as beliefs about the environmental impact of GMOs, there were significant group differences. Though exploratory partisanship analyses in the previous two studies showed interesting differences, Study 3a found no differences in GMO beliefs, attitudes, and behavior/intentions as a function of partisanship. Finally, Study 3b found the GMO explanation condition to be effective at altering GMO attitudes and beliefs about GMO safety, beliefs about the environmental impact of GMOs, and behavior/intentions toward GMOs. Additionally, within a GMO specific context, direct misinformation correction approaches – designed to parallel the vaccine autism correction approach seen in Study 1 – were also effective at altering GMO attitudes and beliefs about GMO safety, environmental impacts, and behavior/intentions when compared to a control. Further exploratory analyses of individual factors – specifically partisanship – found that while on average Republicans held more anti-GMO attitudes and beliefs, these individuals were also the least likely to show change in those attitudes and beliefs compared to Democrats and Independents.

Overall, these findings seem to suggest the misinformation correction approach proposed by Horne et al. (2015) may be the most effective at altering individual attitudes, beliefs, and future intentions. Furthermore, these findings may appear to be more robust and therefore more easily replicated in certain contexts than others. Specifically, in contexts that are newer – newer in terms of how readily available information is – individual attitudes toward those topics may not be as polarized as other topics such as: capital punishment, gun control, and abortion (Lord, Ross, and Lepper, 1979; Wolpert & Gimpel, 1998; DiMaggio, Evans, & Bryson, 1996)

Theoretical Practical Implications & Limitations

One very noticeable characteristic of the misinformation correction literature in general, and the findings of this dissertation specifically, is inconsistency of results. One possible reason for inconsistent findings may have to do with the assessment of attitudes, beliefs, and intentions used in many studies. It is possible that interventions have very specific impacts, and overall scales may fail to capture these specific outcomes; scales need to be better designed to have multiple items that separately assess different beliefs, attitudes, and behaviors. In addition, individual differences in prior knowledge about topics may interact with the effectiveness of interventions and they are not always assessed. And unfortunately, not all assessments directly assess misinformation. The brief five-item scale in the Horne et al. (2015) study, for example, did not include the question about vaccines causing autism (hidden question six). If individual interventions address different beliefs, but beliefs are only assessed by a single scale, then how these interventions specifically impact beliefs is not addressed. This is problematic in the vaccine literature, as the current findings suggest that direct correction of the misconception that vaccines cause autism may actually reduce that specific belief (rather than resulting in a backfire effect) but not other beliefs about vaccines.

Previous research has also demonstrated the effectiveness of different misinformation correction approaches on different assessments of individual items or subscales (e.g., attitudes, beliefs, intentions) (Nyhan & Reifler, 2013; Betsch, Korn, and Holtmann (2015)). This could also explain why researchers such as Nyhan, Reifler, Richey, and Freed (2014) obtained different results when parsing out vaccine-autism survey questions compared to the results demonstrated by Horne et al. (2015).

In addition to more subscales, the inclusion items assessing participant knowledge and experience could aid in determining effective misinformation correction approaches. Specifically, these items should include assessments of: what participants already know about the vaccine-autism debate, if they have a close family member who holds anti-vaccine beliefs, and do they personally know an individual who has been diagnosed with autism. These items may help researchers identify potential reasons behind pretest vaccine attitudes and beliefs. Furthermore, having that information could help researchers investigate if individual exposure and knowledge of issues about vaccines is related to the ability to alter individual attitudes and beliefs. The newly self-generated attitude, belief, and intention subscales created for Studies 3a and 3b capture different aspects of an individual's values. This formation of subscales may explain why the results of the two GMO studies in this dissertation were robust and replicated while the vaccine studies using similar misinformation correction approaches yielded different results (such as seen in Studies 1, 2, and Horne et al., 2015).

The vaccine-autism "link" has been incorrectly believed since its introduction in the early 1990s. It could be that over time, individuals have less malleable views of vaccines and autism, affecting the replicability of previous findings (as seen in Study 1, 2, and Horne et al., (2015)). Although only four years have passed since the initial Horne et al. (2015) study was published, it is possible that beliefs are more entrenched than they were.

The relatively large effect size and robustness of the GMO interventions in this dissertation could be due to the fact that individuals hold less entrenched beliefs about GMOs. As the use of GMOs in food products is being discussed more in the media and news, GMOs are becoming more prevalent in people's minds. As the discussion surrounding this topic increases so does the possibility of encountering misinformation about GMOs (Linnhoff, Martin, & Smith, 2017; Maghari & Ardekani, 2011). Perhaps it is the case that novelty of a topic is influential in altering attitudes, beliefs, and intentions.

Future Directions

One future direction would be to continue to examine misinformation correction approaches that focus on highlighting the positive aspects of engaging in different behaviors in different contexts. For example, one could use a similar misinformation correction approach in an airplane safety scenario to alter individual attitudes, beliefs, and future intentions about flying. Roughly about 10-25% of the population has a fear of flying based on an inaccurate underestimation of the safety of flying (Rothbaum, Hodges, Smith, Lee, & Price, 2000). Though airplanes are routinely checked for safety concerns and flying is a mode of transportation many individuals rely on, some people are still fearful of flying, with some avoiding it entirely. If the correction approach proposed by Horne et al. (2015) remains consistent across contexts outside of GMOs, then it may be possible to alter attitudes, beliefs, and intentions toward a number of issues such as correcting fear of flying beliefs.

Additionally, future studies of misinformation correction should also include individual difference factors such as dogmatism and degree of openness of participants. Dogmatism can be thought of as a personal bias that can influence decision-making. Rokeach (1954, p. 195) describes dogmatism as a "a relatively closed cognitive organization of beliefs and disbeliefs about reality". In other words, it is the degree to which an individual displays belief rigidity. Future examination of these individual differences should consider tailoring these scales such as the dogmatism scale based on the topic one is investigating. For example, a future study of misinformation correction of GMOs may benefit from knowing more about individual levels of participant dogmatism toward GMOs. I predict that, individuals who possess high traits of dogmatism would be less likely to alter their attitudes, beliefs, and future intentions regardless of misinformation correction approach. On the contrary, individuals who possess high levels of openness may be more easily influenced by misinformation correction approaches. An assessment of participant levels of openness, researchers would have a better comprehension of participant thoughts attitude alteration.

A recent meta-analysis examining the factors that underly effective misinformation correction approaches provides further recommendations (Chan, Jones, Jamieson, & Albarracin, 2017). Firstly, the detailed account of reasons why misinformation may have been spread may in fact make it difficult for individuals to process new information countering those initial beliefs. Instead, reports of misinformation correction should address the misinformation with a reduction in the elaboration surrounding that topic. Under this recommendation, the retraction of misinformation should be discussed in ways that "reduce detailed thoughts in support of the misinformation". Secondly, counter-arguments are not effective. Rather than arguing from an oppositional standpoint (i.e., counter-argument), researchers should develop misinformation correction approaches that from level of skepticism. While counter-arguments may not be effective for topics in which people may be more entrenched in their thinking (e.g., vaccines), instances in which individual stance toward a topic is more neutral – as seen in the GMO studies – counter-arguments may be just as effective as other correctional approaches. Finally, counter-arguments that are direct in their approach – as demonstrated with the autism correction condition – make individuals less likely to accept those correction messages (Chan, Jones, Jamieson, & Albarracin, 2017).

Closing Remarks

Altering beliefs and attitudes is quite a complex endeavor. On one hand, the findings of the present series of studies suggest that a disease risk approach may be the most effective in multiple contexts for correcting misinformation and altering attitudes, but it is not always successful. One possibility is that different misinformation correction approaches may need to be applied to different misinformation correction topics or for different individuals. Perhaps there are misinformation correction tactics yet to be explored or discovered.

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