THE THEORY OF PLANNED BEHAVIOR IN MESSAGE DESIGN: TESTING THE EFFECTIVENESS OF STATISTICAL EVIDENCE IN MESSAGES ABOUT GENETICALLY MODIFIED FOODS

by

KAMI J. SILK

(Under the direction of Roxanne L. Parrott)

ABSTRACT

The Theory of Planned Behavior (TPB) identifies three constructs, attitudes, subjective norms, and perceived behavioral, which are useful in predicting behavioral intentions toward an attitude object (Ajzen, 1985). A 3 (evidence type) x 4 (message topic) between-subjects design was used in this study to test the utility of the TPB in predicting behavioral intentions toward genetically modified (GM) foods and to examine the influence of statistical evidence on attitudes and behavioral intentions toward GM foods. Participants (N = 431) completed measures of math anxiety and math self-efficacy prior to a reading a risk message pertaining to GM foods or a control message. Participants then completed measures of message comprehension, attitudes, perceived behavioral control, subjective norms, and behavioral intentions toward GM foods as well as measures of their math ability and demographic information. Messages were collapsed based on pilot results that indicated they were equivalent and results supported the utility of the TPB in predicting behavioral intentions. There was not a main effect for evidence type on attitudes toward GM foods. Evidence type was significantly related to comprehension such that presentations that included a bar graph were comprehended more than the percentage formats. Significant negative correlations were found to exist
between math self-anxiety and the variables of math self-efficacy and math ability. Math ability was positively correlated with comprehension of messages. However, comprehension was not a significant predictor of negative attitudes toward GM foods, perhaps due to a sleeper effect. Overall, these and other results are discussed in terms of the importance of using theory to guide message construction and the significance of the math competency construct. Limitations of the study and implications for future research are also discussed.

INDEX WORDS: Theory of Planned Behavior, Genetically modified foods, Genetic engineering, Biotechnology, Statistical evidence, Evidence, Numeracy, Math anxiety, Math self-efficacy, Health messages, Health communication
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Prior to my dissertation proposal meeting, I had decided to recycle a couple of the printed proposal pages. The next morning I realized that the hard copy I had thrown away the night before was my only copy! I hurried over to the recycle bin in the hallway of Penn State’s Sparks Building and to my dismay the bin had already been emptied. I rushed downstairs to consult with the maintenance folks and was told that the recycling bags had already been disposed of in the dumpster outside. With the assistance of Rich, the man in charge of maintenance in my building, we hung our bodies over the side of the dumpster and pulled out the bags that could possibly contain the precious two pages of writing. By the Almighty Grace of God, we found my two pages after sorting through five garbage bags of recyclable white paper. Lesson from this story: Two pages mean A LOT when you are struggling through the dissertation process.

This incident characterizes the downright zaniness, perseverance, and support required to complete a dissertation. I have to admit that during the process, I often wondered, “Whose idea was it for me to go to graduate school anyway?” I spent many hours pondering this point while in the abyss of writing what seemed at times to be a never-ending nightmare of a project. While these words might seem harsh, atypical, and the antithesis of what an acknowledgment is supposed to entail, I believe they underscore the reality of how important it is to have a supportive network within reach during graduate school and particularly, during the dissertation process. Those around me helped me to understand why I chose the path of higher education. And they did so by lending me the confidence, advice, smiles, insight, assistance, brainstorming, venting, emotional
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It is difficult to acknowledge everyone, but similar to an awards show where Oscars, Emmys, or Golden Globes are being awarded, I want to thank everyone who has helped me out along the way. At minimum, each of you deserves a t-shirt stating, “I Survived Kami’s Dissertation.” Thank you.
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CHAPTER 1
INTRODUCTION

One goal of health communication researchers is to construct health messages that help the lay public to understand health information (Kreps & Thornton, 1992; Maibach & Parrott, 1995). At face value this seems like a straightforward goal, but creating effective health messages is a complex task that requires the incorporation and implementation of communication theory. It is often difficult for health practitioners to apply abstract communication principles and theories in their message designs. To guide the health message design process, health communication researchers need to use theory in a prescriptive way to increase the likelihood that the outcomes associated with health messages are achieved (Maibach & Parrott, 1995). In particular, theories of social influence have had a decisive impact on how health communication researchers create health messages. Social influence comprises many overlapping forms, strategies, and mediators that are often employed in combination by an influencer with the aim of changing the knowledge, beliefs, attitudes, and behavior of a nonpassive target person (Edwards, 1990). In general, social influence theories provide a framework for identifying important constructs that have explanatory and predictive power in the health realm. The Theory of Planned Behavior (TPB) is one such theoretical framework that can guide the construction of health messages (Ajzen, 1985).

The TPB is an extension of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975). The TPB states that the constructs of subjective norms, individual attitudes, and the added variable of perceived behavioral control contribute to behavioral intentions, which can be used to predict behavior (Ajzen, 1985). The theory also directly
links perceived behavioral control to behavior. The TPB is useful in the construction of health messages because it identifies the formation of behavioral intention, one major predictor of behavior. Measurable constructs of subjective norm, individual attitude, and perceived behavioral control can be operationalized to allow researchers to evaluate the relative contribution of each of the constructs in the theory to behavioral intention, which subsequently helps to predict behavior. Health communication researchers are able to take the constructs of the theory and use them in health messages to shape behavioral intention toward a specific outcome. The TPB provides a rational model and framework for the discussion of attitudes, subjective norms, and perceived behavioral control related to the topic of genetically modified (GM) foods.

**GM Foods**

Issues related to bio-engineered foods have recently made it into the minds and conversations of the public, whose concern and perceived knowledge seems to grow as each media headline forms the basis for their understanding about GM foods. GM foods are a product of biotechnology, which is defined as the use of recombinant DNA, cell fusion, and new bioprocessing techniques for research and product development (Human Genome Project, 2000). The quiet introduction of GM foods into the United States food markets provides a unique opportunity for research that examines attitudes and behavioral intentions associated with a new technology of which few are familiar. Often laden with numeric results to decipher, the presentation of information about GM foods supplies a case study of the important role of statistical evidence in health communication. Using the theoretical framework of the TPB, research pertaining to GM
foods is translated as a means to examine relationships between theoretical constructs of the TPB, statistical evidence, comprehension, and math competency.

In addition to being guided by theory, health messages also need to incorporate motivational appeals that encourage adherence to recommendations presented in the messages. Typically, motivational appeals have taken the basic forms of emotional and rational appeals. Two types of emotional appeals, fear and positive affect, have been prevalent strategies used by health campaigners in health messages to reach audience members (Witte, 1992; Witte, Cameron, Lapinski, Nzyuko, 1998; Monahan, 1995). Rational appeals, however, are the focus of this dissertation.

**Rational Appeals**

Rational appeals are defined as straightforward presentations of facts that provide audience members with evidence that typically entails reports of events and examples or statistics (Reinard, 1988). Evidence is often viewed as information used as proof by a source (Reinard, 1988). Specifically, evidence is defined as “factual statements originating from a source other than the speaker, objects not created by the speaker, and opinions of persons other than the speaker that are offered in support of the speaker’s claims” (McCroskey, 1969, p.171). The persuasive effects of evidence have received attention from numerous scholars (for review see Reinard, 1988). More recently, other research has provided meta-analyses of the persuasive effects of evidence (Allen & Preiss, 1997; O’Keefe, 1998; Reinard, 1998). While a wealth of information exists regarding evidence, there is still uncertainty concerning how evidence works in conjunction with argument and message design to produce various effects (Allen, Bruflat, Fucilla, Kramer, McKellips, Ryan, & Spiegelhoff, 2000). The goal of this research is to
begin to address this question by designing a more effective rational appeal using statistical evidence.

Statistical Evidence

Statistical evidence, also called numerical evidence, can be defined as empirically quantified descriptions of events, persons, places, or other phenomena (Church & Wilbanks, 1986, p. 108). Statistical evidence is commonplace in our culture, as newspapers, television programs, magazines, and other formal and informal information sources use it regularly to support their arguments. In the health realm, statistical evidence is also used with frequency in health messages to communicate risk and benefit information to the lay public (Kreuter & Strecher, 1995; Slovic, 1986). Numeracy, the mathematical skills that enable an individual to cope with the practical demands of everyday life (Steen, 1991), is an essential skill for the processing and understanding of information that relies on statistical evidence. Related to numeracy ability are the constructs of math anxiety and math self-efficacy, variables that have not previously been investigated by communication scholars, but form the multi-dimensional construct of math competency. Thus, strategies to communicate using statistical evidence, while considering numeracy ability, math anxiety, and math self-efficacy may increase the effectiveness of rational appeals – a long overdue endeavor.

Efforts to improve rational appeals feed directly into the health communication goals of the Healthy People 2010 initiative. Healthy People 2010 provides a set of health objectives for the nation to achieve over the first decade of the new century (United States Department of Human & Health Services, 2000). One focus area of the initiative is to improve health communication, with particular attention to making health messages
accessible and understandable to the lay public. The attention paid to health literacy by
the Healthy People 2010 initiative demonstrates that health communication researchers
are not alone in their recognition of the need for improved health messages. As a matter
of fact, the contributions of researchers from the health communication discipline are
recognized by the Healthy People 2010 initiative; for example, Maibach and Parrott
(1995) are cited as a primary resource for health message design that links theory and
practice.

This dissertation seeks to contribute to the body of literature that informs message
design by integrating the TPB into messages about GM foods and then testing their
effectiveness in predicting behavioral intentions. Additionally, different representations
of statistical evidence are considered as strategies to identify the most comprehensible
and effective method of presentation. Finally, relationships between numeracy ability,
math anxiety, and math self-efficacy are investigated to build a multi-dimensional
construct of math competency. The next chapter provides a review of relevant literature
pertaining to the TPB, message design, and numerical evidence as they relate to GM
foods.
CHAPTER 2
REVIEW OF LITERATURE

Rationale for Strategic Message Design

Bombarded with messages throughout each day, receivers of information are forced to selectively extract that which seems most relevant or important to them in a given situation. When applied to the health context, the stakes rise because understanding health information may have related benefits or conversely, serious consequences attached to it (Baker, Parker, Williams, Clark, & Nurss, 1997). Much research has indicated that individuals attending to information related to health issues do not necessarily understand what is communicated to them (Chacon, Kissoon, & Rich, 1994; Steen, 1991; Davis, Michielutte, Askov, Williams, & Weiss, 1998; Parker, Baker, Williams & Nurss, 1995), nor do they necessarily seek additional information or ask questions in health interactions (Parrott, 1994). Technological advances that have occurred in the genetics domain over the past decade -- including the recent mapping of the human genome, the production of genetically modified (GM) foods, and efforts to clone mammals of all kinds – force the public to sort through an array of complicated information they might not understand. For example, biotechnology, previously defined as the use of recombinant DNA, cell fusion, and new bioprocessing techniques for research and product development (Human Genome Project, 2000), is a scientific domain in which members of the lay public have reported minimal comprehension of the technology (Silk, Parrott, Dillow, in press; Taylor & Leitman, 2001). Specifically, Silk and colleagues examined the issue of GM foods through the theoretical lens of the Theory of Planned Behavior (TPB).
In the study, focus group participants ($N$=16; $n$=82)) were asked their views about genetically modified plants (Silk et al., in press). The researchers used a coding scheme that operationalized the constructs of the Theory of Planned Behavior (TPB) into the content categories of attitude, subjective norm, and perceived behavioral control statements to analyze the focus group transcripts. Results indicated that the lay public has little knowledge about GM foods, negative attitudes toward them, and safety concerns about unknown risks associated with them. This formative research demonstrates the use of theory as a means to understand a complex topic, revealing that more information about GM foods needs to be communicated to the lay public, who has minimal expertise pertaining to the topic (Silk et al., in press).

The information provided in messages pertaining to health and scientific topics like GM foods, often demands a high level of literacy and numeracy to understand the message content. However, illiteracy is a serious issue in the United States, with 20% of adults unable to read or understand written information (Kirsch, Jungleblut, Jenkins, & Kolstad, 1993), and the problem of low health literacy is even greater. Health literacy is defined by the National Health Education Standards as the capacity of an individual to obtain, interpret, and understand basic health information and services and the competence to use such information and services in ways which are health enhancing (Joint Committee on National Health Education Standards, 1995). Health literacy requires a complex set of skills to be able to interpret health information, and numeracy ability is one such critical skill. Numeracy, the ability to decipher numeric information, is an issue addressed less than literacy, yet low numeracy is as equally prevalent among the lay public as low literacy (Schwartz, Woloshin, Black, & Welch, 1997; Schwartz,
Numeracy is a critical skill for understanding health information. However, low numeracy skills are likely to remain a barrier for message consumers, making it necessary that message designers consider numeracy when designing health messages that physicians, health organizations, health campaigns, policy makers, and even commercial entities use to influence the lay public.

Health message designers play an important role in communicating health information to the lay public. They incorporate theory and often use empirical proof to assist in the creation of well-designed health messages. Their role as translators of health-related or scientific information is pivotal to bridge information gaps between science experts and the lay public. For example, experts discuss the issue of biotechnology in terms of health risks, environmental implications, and labeling requirements (Macilwain, 2000; Phillips, 2000; Thompson, 2000), while members of the lay public remain limited in their knowledge regarding biotechnology and GM foods (Silk et al., in press). The gap in knowledge between experts and the lay public suggests a need for messages that address issues related to the topic of GM foods. A well-designed message, for example, could be used by physicians to answer patient questions about GM foods or to provide recommendations of when GM foods might be risky for people (e.g., allergens).

To aid in the construction of messages, health message designers have taken two rather disparate paths when integrating theory into their research. The more common path is to use theory to focus on behavioral constructs that are important outcomes of messages. The other path uses theory to focus on theoretical message constructs as the building blocks of the message. As a result, conclusions that emerge from these different uses of theory fail to provide the link between the specific micro components of the
messages and the outcomes that can be linked to these messages. In other words, message designers have focused on either message design issues OR outcomes associated with constructs of theory, without demonstrating how message design issues connect to the shaping of attitudes, subjective norms, perceptions of behavioral control, and behavioral intentions as well as other outcomes of interest. The following section provides evidence of the existence of these disparate paths by examining messages and outcomes in research that incorporates the Theory of Planned Behavior. First, the TPB will be explained, followed by applications of the theory in health related studies.

The Theory of Planned Behavior: A Rational Model of Human Action

The Theory of Planned Behavior (Ajzen, 1985), an extension of the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), has been widely used in the health literature as a means to predict behavioral intentions and subsequent behavior. Both theories assume individuals to be rational decision-makers who consider options and implications of a behavior before actually engaging in the behavior. According to the theory of reasoned action, most behaviors of social relevance are under volitional control and thus, behavioral intention is the single most important predictor of behavior (Fishbein & Ajzen, 1975). Behavioral intention refers to whether or not a person plans to perform a particular behavior. The greater a person’s behavioral intentions to perform a specific behavior, the greater the likelihood the person will actually perform that behavior.

According to the TRA, behavioral intention is determined by an individual’s attitude toward the behavior and by the subjective norm an individual perceives to exist in association with that behavior.
The Theory of Planned Behavior builds on the TRA by adding the variable of perceived behavioral control as another predictor of behavioral intention and provides a direct link to behavior. The purpose of the perceived behavioral control variable is to extend the TRA to behaviors that are not completely under volitional control, adding to the prediction of behavior beyond the effect of behavioral intention. Figure 2.1 provides a conceptual model of the TPB. Each construct of the TPB including attitude, subjective norm, and perceived behavioral control is given a weight reflecting its relative importance as a determinant of the intention under consideration (Ajzen, 1991). The individual constructs of attitude, subjective norms, and perceived behavioral control will be discussed in turn.

Figure 2.1 The Theory of Planned Behavior (Ajzen, 1985)
According to both the TRA and the TPB, attitudes are comprised of behavioral beliefs that have outcome evaluations associated with them (Fishbein & Ajzen, 1975; Ajzen, 1985). Behavioral beliefs refer to the consequences or outcomes of a behavior, while the outcome evaluations refer to the positive or negative valence assigned to each of the associated behavioral beliefs. Individual attitude toward a behavior is determined by the sum of the beliefs about performing the behavior, weighted by the evaluations of the beliefs. To calculate an individual attitude toward a behavior, the outcome evaluation (favorable or unfavorable) of each belief is multiplied by the strength of each of the beliefs (Ajzen & Fishbein, 1980). The products of each individual belief are then added together for the total individual attitude score. In general, behaviors that are thought to produce a favorable outcome have positive attitudes associated with them, while behaviors that are thought to produce negative outcomes have negative attitudes associated with them.

For example, Silk and her colleagues (in press) found that some participants recognized that food products containing genetically engineered ingredients are not labeled as such. Thus, participants who were willing to read food labels to determine whether or not a product contained genetically engineered ingredients may have associated the behavior of reading food labels with the behavioral belief of “useless,” resulting in a negative outcome evaluation. However, if participants associated reading food labels with the behavioral belief of “safety,” they might have assigned the behavior a positive outcome evaluation. Depending on the strength of each of the behavioral beliefs and the valence of the outcome evaluations, an individual may or may not develop
a positive or negative attitude toward reading food labels. In both the TRA and the TPB, attitudes are linked directly to behavioral intentions as are subjective norms.

**Subjective Norms**

Subjective norms are defined as a person’s beliefs that certain individuals or groups (referents) believe he or she should or should not perform a given behavior (Fishbein & Ajzen, 1975). Subjective norms are a function of different types of normative beliefs and are determined by the sum of the products of normative beliefs and one’s motivation to comply. Normative beliefs are the individual beliefs that underlie subjective norms; they involve specific individuals (e.g., wife, parent, or pastor) or groups (e.g., church, sorority, athletic team) that may influence how individuals perceive a particular behavior (Ajzen & Fishbein, 1980). Motivation to comply with normative beliefs can range from nonexistent to very high, depending on the importance and influence of the referent(s). In other words, a person who perceives social pressure from important referents to perform a particular behavior will be more likely to perform that behavior than if he or she perceives no social pressure to comply or if the referents are not perceived to be important.

For example, in the case of GM foods, individuals have indicated that the topic has been discussed infrequently or not at all among their peers and family members (Silk et al., in press). Infrequent discussion about GM foods might be related to low perceptions of social pressure from important others regarding the safety of these foods. Therefore, while the role of subjective norms would still be used as a predictor of behavioral intentions according to the TRA and TPB, it may have less of an influence on behavioral intentions than other constructs (e.g., attitudes in the TRA, and attitudes and
perceived behavioral control in the TPB). Overall, the TRA and the TPB both state that attitudes and subjective norms, and the weight assigned to each of them, contribute to behavioral intentions (Fishbein & Ajzen, 1975). The TPB, however, adds the variable of perceived behavioral control to the model as a predictor of behavioral intentions and behavior.

**Perceived Behavioral Control**

Perceived behavioral control refers to the perception that performance of a specific behavior is within a person’s volitional control (Ajzen, 1985). The idea of control can be seen as a continuum with easily executed behaviors at one end and more demanding behaviors (e.g., those behaviors that require more resources, opportunities, specialized skills, etc.) at the other (Conner, Warren, Close, & Sparks, 1999). According to the TPB, performance of a behavior is a joint function of behavioral intentions and perceived behavioral control. When a behavior or situation affords a person complete control over his or her behavioral performance, intentions alone should be sufficient to predict behavior (as specified in the theory of reasoned action). However, as volitional control over behavior declines, the added variable of perceived behavioral control should be useful in helping to predict behavior (Ajzen, 1991).

For example, the Federal Food, Drug and Cosmetic Act requires labeling only if an end product would be materially different from an already existing product in some respect if something else was added (FDA, 2001). Genetically modified foods are not labeled as such because the Food and Drug Administration (FDA) concludes, “Inherently there is nothing in genetically modified products that makes them materially different from their conventional counterparts” (Barclay, 1999, p.38). Based on the FDA
regulations people are unable to discern whether or not they are eating GM foods because labeling of them currently is not required. Silk and colleagues (in press) found that participants in eight of the sixteen focus groups perceived low control over their consumption of GM foods, commenting that they were unwittingly eating GM foods (e.g., “We are already eating it and we don’t really know it.”). Due to individuals’ lack of perceived behavioral control over their consumption of GM foods, the TPB might predict that individuals would be less influenced by information that points out risks of GM foods. In other words, some individuals might not be influenced by risk information because they perceive there is no action they can take to control whether or not they consume GM foods. However, other individuals might perceive greater control by attempting to influence regulations related to labeling of GM foods. Overall, the predictions of the TPB depend on the weights assigned to attitudes, subjective norms, and perceived behavioral control. The TPB predicts that the more favorable the individual attitudes and subjective norms, and the greater the perceived behavioral control, the stronger the intention should be to complete a specified behavior. Conversely, if individual attitudes and subjective norms are less favorable and perceived behavioral control is lower, intention to complete a specified behavior should be weaker.

The TPB has been used in a number of health-related studies, including smoking (Norman, Conner, & Bell, 1999), drug use (Orbell, Blair, Sherlock, & Conner, 2001), driving violations (Parker, Manstead, Stradling, Reason, & Baxter, 1992), weight loss (Armitage & Conner, 1999), exercise (Blue, 1995) and precautionary sexual activity (Boldero, Sanitioso, & Brain, 1999). All of the studies have supported the validity of the theory and its constructs. Research reviews suggest that 20-30% of the variance in future
behavior can be predicted by measures of behavioral intentions (Ajzen, 1991), demonstrating the utility of the TPB as a predictor of behavior.

Applications and Extensions of the TPB

Health-Related Outcomes Focus

The TPB has been used widely as a means to measure behavioral intentions or outcomes. For example, a considerable amount of research has used questionnaires to measure each of the constructs of the TPB (Martin, Jacobsen, Lucas, Branch, & Ferron, 1999; Orbell, Blair, Sherlock, & Conner, 2001; Parker, Manstead, Stradling, Reason, & Baxter, 1992). Parker et al. (1992) were interested in constructing safety and prevention messages and used the TPB to account for drivers’ intentions to commit driving violations. In the study, subjects read four messages that dealt with drinking and driving, speeding, close following, and overtaking another vehicle in risky circumstances. The scenarios created situations to measure the constructs of the TPB, but the TPB was not incorporated in the message content of the scenarios. Rather, the researchers were interested in using the constructs of the theory as dependent or outcome variables. The researchers employed second person scenarios that asked participants to put themselves in a particular driving situation so they could answer questions that measured their attitude, subjective norm, and perceived behavioral control regarding the driving violation depicted in the scenario. Hierarchical regression analyses were conducted to determine the contribution of attitude, subjective norm, and perceived behavioral control in predicting behavioral intention to commit each of the driving violations. All three constructs of the TPB contributed significantly to the variance in behavioral intention to commit each of the driving violations. Age and sex were then used as the between-
subjects variables with the constructs of the TPB as the dependent variables as an audience segmentation strategy. Parker et al. (1992) demonstrates a focus on operationalizing theory for the measurement of outcomes with no utilization of the theory at the message design level.

Other studies contain no scenario or message in their design and use the TPB without an experimental manipulation for strictly measurement and prediction purposes. For example, one study used the TPB to predict behavioral intention of 18 to 30-year-olds to use the drug “ecstasy” (Orbell et al., 2001). An intervention or message component was not incorporated as part of the study. The researchers used the constructs of the TPB to predict intentions and actual use of ecstasy, with a specific interest in distinguishing between two types of perceived behavioral control (i.e., perceived control over taking ecstasy and perceived control over obtaining ecstasy). Results indicated that all three constructs of the TPB contributed to intentions to use ecstasy, with 84% of the variance explained by the total model and the two types of perceived behavioral control each accounting for 7% of the total variance. Additionally, ecstasy use was directly predicted from intentions to use the substance (Orbell et al., 2001). Again the focus is not on message design, but on how well the theory predicts behavioral intentions and subsequent use of the ecstasy drug.

Martin et al. (1999) applied the theory of planned behavior to the use of sunscreen by 4th graders. The focus again was on using the constructs of the theory for measurement and prediction purposes. At Time 1, 4th graders were asked about their attitudes toward sunscreen use, subjective norms for sunscreen use, perceived behavioral control, and intentions to use sunscreen. At Time 2, they were asked about their actual
sunscreen use. After data collection was complete, the children were exposed to a 45-minute health education program about risk factors for skin cancer and behaviors that can be adopted to reduce this risk. Path analyses and multiple regression analyses supported the predictive ability of each of the constructs of the TPB for behavioral intention and actual use of sunscreen. In this study, the information received by participants in the health education program was not even part of the experimental conditions, but was instead almost an ethical imperative for the debriefing of the participants. While the study does not discuss the details of the education program, it provides implications for educational programs based on the findings of the study. In particular, it calls for messages that include rational appeals in regard to the benefits of sunscreen and messages that include subjective norms about use of sunscreen by friends and parents. Thus, as understanding of sunscreen usage increases so does the need for theory-driven messages that use the knowledge gained from studies like Martin et al. (1999).

Nguyen, Potvin, and Otis (1997) used the TPB and the stages-of-change model (Prochaska & DiClemente, 1983), a theory that describes the steps to behavior change (e.g., precontemplation, contemplation, preparation, action, and maintenance), to understand in greater detail the factors related to consistent exercise among males between the ages of 30 to 60 years of age. The study was interested in heart disease prevention and identified the determinants of the TPB that were most salient at each stage in the stages of change model (Nguyen et al., 1997). A survey method that measured each of the determinants and actual behavior was used in the study. The difference in this application of the theory from the previously cited studies is its merging with the stages-of-change model and use of a developmental viewpoint to determine which constructs of
the theory are the most salient at each stage. Results indicated that attitude, subjective norm, and perceived behavioral control related to exercise were differently associated with the stages of behavior. Specifically, perceived behavioral control was significant at all five stages, attitude was significant at stages where intention to exercise existed (e.g., contemplation and preparation stages), and subjective norm was significant at stages where no intention to exercise existed (e.g., precontemplation). Although this is an important merging and use of theory, the research continues to be interested in outcomes without incorporating theory elsewhere.

The TPB has been used in a variety of contexts for the purpose of predicting health-related behavioral intentions and behaviors. Although the TPB was not derived as a communication theory, its use by communication theorists, along with calls for interventions based on theory, has proliferated the theory’s use within the health realm. The use of the TPB as a method to inform rational message design is discussed next.

Health-Related Message Design Focus

The incorporation of constructs of the TPB at the message design level may result in favorable outcomes for message receivers. For example, one study implemented a community-based, mass media intervention to promote the purchase of low-fat milk over high-fat milk to reduce saturated fats in people’s diets (Booth-Butterfield & Reger, 2001). The campaign targeted attitudes toward milk products by incorporating specific behavioral beliefs about milk in the intervention messages. The intervention messages of the campaign were disseminated through radio, television, and written public service announcements (PSAs), and focused on behavioral beliefs about the purchase and consumption of low-fat milk. Messages consistently made the following rational appeals
about milk: (a) low-fat milk is healthier than high-fat milk because it has less saturated fat, (b) low-fat milk is not expensive compared to high-fat milk, and (c) low-fat milk tastes as good as high-fat milk. At post-test, behavioral beliefs, milk use, and demographic variables were assessed. Path model analysis revealed that behavioral intention explained the largest amount of variance, followed by intervention treatment and then direct effects from attitude, collectively accounting for almost 50% of the variance (Booth-Butterfield & Reger, 2001). The large effect sizes in this study are not typical in the health communication literature. It is possible that the large effect sizes occurred as a result of the message design process.

At closer examination, the milk campaign may have been successful because campaign message designers targeted a very specific behavior and used rational appeals to influence the target audience (Booth-Butterfield & Reger, 2001). In particular, the television PSA targeted behavior and featured a woman at the milk counter showing how easy it is to move your hand from whole milk to skim milk. The radio spots used factual, rational appeals to target attitudes that communicated that whole milk has the fat content of five strips of bacon and 2% milk has the fat content of three strips of bacon. Campaign message designers targeted attitudes over subjective norms in their message content because milk preferences were not based on subjective norms, but on personal preferences and attitudes toward what kind of milk tastes good and what is healthy. Although not measured in the study because the focus was on the influence of attitude and subjective norm, the messages also targeted perceptions of behavioral control. Specifically, message consumers were encouraged to take control of their milk intake by simply “moving your hand from one end of the milk counter to the other.” The milk
campaign messages provide an excellent example of how individual constructs of the TPB can be used to create effective messages that influence behavioral intentions and subsequent behavior. However, the multiple channels and the lack of control inherent in a field study make it difficult to calculate the level of influence exerted by specific messages on milk behavior. The control offered in an experimental manipulation of the theoretical components may provide further evidence of the utility of the TPB as a powerful tool for both constructing health messages and influencing defined outcomes.

Another study that applied the TPB extended the construct of behavioral intentions by including the variable of implementation intentions (Orbell, Hodgkins, & Sheeran, 1997). Implementation intentions were defined as the formation of plans that specify where and when the behavior will be initiated, and were used in the study as an additional variable to predict the behavior of conducting breast self exams (BSE) (Orbell et al., 1997). Women in the study were asked to complete a questionnaire about their intention, attitude, subjective norm, and perceived behavioral control to perform BSE. Following completion of the survey, women in the intervention group received a message about breast self exams and then were asked to write down where they would perform BSE in the next month and what time of day they would perform it. The intervention message provided in (Orbell, et al., 1997) read as follows:

You are more likely to carry out your intention to perform BSE if you make a decision about where and when you will do so. Many women find it most convenient to perform BSE at the start of the morning or last thing at night, in the shower or bath, or while they are getting dressed in their bedroom or bathroom. Others like to do it in bed before they go to sleep or prior to getting up. Decide
now where and when you will perform BSE in the next month and make a commitment to do so. (p. 949)

Although the methods employed in the study do not articulate details regarding the development of the intervention message, the constructs of subjective norms and perceived behavioral control were present in the message content. For example, the first and last sentences were targeted toward perceived behavioral control. The first sentence asked the women to make a decision about conducting BSE and the last sentence of the message also asked the women for specific implementation intentions, addressing two conceptually independent variables, perceived behavioral control and implementation intentions, at the same time. Subjective norms could be viewed as present in the message by pointing out the different methods that other women use to conduct BSE. However, the message is not necessarily structured to reflect the specific conceptual meanings of subjective norms. In other words, subjective norms are defined to emerge from significant others, but this message is not concerned with elaborating on the “women” that they mention. The message could easily have focused on specific significant groups to increase the immediacy of the subjective norm component, especially since immediacy has been cited as an important strategy to the construction of health messages (Parrott, 1995). For example, Orbell, et al. (1997) could easily have added phrases like “women just like you” or “mothers, daughters, sisters” to enhance the connection the reader could feel with the women mentioned in the message (Parrott, 1995).

Overall, the focus of Orbell et al. (1997) was to examine the effect of an additional variable, implementation intention, along with the effects of the other TPB constructs on women’s behavioral intentions. The TPB acknowledges that additional
variables to attitudes, subjective norms, and perceived behavioral control might contribute to more explained variance for certain behaviors (Ajzen, 1991). Results of Orbell et al. supported the addition of the implementation intention variable to the TPB as it improved the predictive validity of the behavioral intention construct to conduct BSE. In other words, implementation intention explained additional variance beyond that explained by the TPB. However, it is important to note that the study could have more systematically developed the intervention message based on the theoretical constructs already present in the message content to further increase the effectiveness of the intervention message in influencing behavioral intentions and actual BSE behavior, increasing the predictive utility of the TPB.

Research that explicates the systematic integration of theoretical constructs of the TPB into health message design is sparse, but Booth-Butterfield and Reger (2001) and Orbell et al. (1997) demonstrate the great potential related to the inclusion of attitudes, subjective norms, and perceived control in the message design process. A relatively recent domain of research, biotechnology, provides a unique opportunity and context for health communicators to integrate constructs of the TPB in messages.

A TPB Framework to Understand Outcomes of Public Responses about Genetically Modified Foods

The Theory of Planned Behavior provides a rational framework for the discussion of genetically modified foods. In this next section, the science of GM foods is defined and the constructs of the TPB are discussed in relation to the formative research that exists about GM foods.
Genetically Modified Foods

Genetically modified foods are often called by other names including, “genetically altered crops,” “modified varieties,” and of course, the media’s favorite, “Franken-food.” All of the previous terms are used to describe the biotechnology of modern agriculture. As defined earlier, biotechnology is the use of recombinant DNA, cell fusion, and new bioprocessing techniques for research and product development (Human Genome Project, 2000). Biotechnology has the ability to break down genetic barriers by combining, within and between species, the genes of plants, animals, and even humans for the production of seeds, foods, fiber, and medical products. For example, scientists have been able to inject tomatoes with a gene of a flounder to guard against freezing and are developing crops that are created with genes that make them more able to withstand pesticides (Woodworth, 2000). Although the ability to break down genetic barriers is a new technology, agricultural biotechnology is not new; the food industry has used mutation and selection techniques for the production, processing and preservation of food for centuries (Harlander, 1990). However, the “new” biotechnology compared to the “old” biotechnology enables the exchange of genetic information between related and unrelated organisms for the creation of GM foods, allowing for an even greater impact on agriculture by increasing food supply, quality, and resistance (Smith, Skalnik, & Skalnik, 1997). While most scientists are fundamentally in favor of the new biotechnology, many believe that the human race is proceeding much too quickly on the basis of too little knowledge (Worth, 2000). The caution perceived by some experts on GM foods is also felt by members of the lay public.
Formative research has demonstrated that the lay public has minimal knowledge about GM foods and that they are concerned about their influence on human growth patterns, the environment, and on the economy (Silk et al., in press). It seems that while the lay public recognizes the potential benefits of genetically engineered plants, they are not convinced that enough testing has been conducted to indicate that genetically modified products are completely safe. The lay public may not be as informed about GM foods as possible due to the relative novelty of biotechnology and the related technical information that may require some translation by experts for comprehension by non-experts. Enough expert knowledge exists about GM foods that health communicators can translate it into messages that strive to form and shape attitudes, subjective norms, and perceived behavioral control. The gap between what experts know and what the lay public has available to them for decision making needs to be bridged. It is time for health communicators to become involved in this new arena, by creating messages that address current health issues related to GM foods. The TPB provides a rational model and framework for the discussion of attitudes, subjective norms, and perceived behavioral control related to GM foods.

**Attitudes and GM Foods**

Issues related to bio-engineered foods have recently made it into the minds and conversations of the public, whose concern and perceived knowledge seems to grow with each media headline, forming the basis for their attitudes about GM foods. The lay public’s attitudes toward GM foods are marked by uncertainty due to unknown consequences related to human growth patterns and the environment that they associate with GM foods (Silk et al., in press). While the lay public has expressed uncertainty,
most scientists have focused on the benefits of biotechnology. Genetically engineered
crops in particular are lauded because they increase productivity and crop resistance to
disease, insects, drought, or other natural pests as well as enhance taste and nutritional
content (Hoban, 1995). Many researchers also point to the successes and future of
biotechnology for being more cost-effective, efficient compared to conventional breeding
techniques, and advantageous to poorer nations (Datta & Bouis, 2000; Philips, 2000;
Vasal, 2000). However, other research supports some of the uncertainty expressed by the
lay public, pointing to long-term risks associated with human consumption and the
environment (e.g., Ewen & Pusztai, 1999; Falci, 2001; Cummins, 2000; and Woodworth,
2000).

Opponents have also pointed to concerns of biotechnology as it relates to food
safety. They cite statistics indicating that 80 million people are estimated to become sick
from food-caused illness each year and nine thousand of them die (Teitel & Wilson,
1999, p.44). Although these deaths are not directly linked to GM foods, critics call for
increased requirements for testing and labeling of genetically modified foods to better
ensure product safety and consumer knowledge of products. Labeling, in particular, has
been a focus for individuals who seek tighter regulation of GM foods. Findings from Silk
et al. (in press) demonstrate that the lay public supports increased testing and labeling of
GM foods. Additionally, a Harris poll concluded that the lay public would be more
knowledgeable, and that attitudes to GM food might be more positive, if the food
industry had decided to label GM food as such from the beginning (Taylor & Leitman,
2001).
One study examined the social issues related to attitudes surrounding two biotechnologically engineered food products introduced in 1994, bovine somatotropin (BST) and Flavr-Savr tomatoes (Hoban, 1995). Based on early public reaction to the two food products and the public policy direction, Hoban (1995) concluded that “food biotechnology will not become much of a social problem” (p. 206), and “overall, the majority of people demonstrate little interest in or concern for technology until the benefits or risks are brought close to home” (p. 193). Since the publication of Hoban (1995), the risks have been “brought close to home” due to the onslaught of popular media addressing agricultural biotechnology (Barboza, 1999; Gates, 2000; Heinrichs, 1999; Kieckhefer, 1999; Nash, 2000; Weiss, 1999). Stories about feeding third world countries and curing world hunger (Gates, 2000) mixed with articles about allergic reactions (Hopkin, 2001) and environmental risks (Brown, 2001), provide pieces of information on a complex topic from which individuals are beginning to form their understanding and attitudes about GM foods.

According to a recent survey, only 11% of those polled said they follow the news about biotechnology and 30% perceive the news to be a hazard (Saad, 2001). Only about half of the Americans polled support the use of biotechnology in food production and 38% said they opposed it (Saad, 2001). Thus, some individuals fully embrace the benefits of agricultural biotechnology and weight their behavioral beliefs more positively, applying the TPB framework, whereas others perceive risks and weight their behavioral beliefs toward GM foods more negatively. Even more likely to exist are individuals who are uncertain of how to weight their behavioral beliefs about GM foods because of the complex nature of the information associated with them. It is a prudent step for health
communication researchers to examine what the lay public perceives and understands to be true about agricultural biotechnology, in order to assist in the design of rational appeals that address health risks that might be associated with GM foods.

**Subjective Norms and GM Foods**

The TPB states that subjective norm, in addition to attitude, is also an important determinant of behavioral intentions. Subjective norms toward GM foods are currently unclear to the lay public as discussions about them have been minimal (Silk et al., in press). This may be partly due to the fact that the introduction of GM foods into the United States market went virtually unnoticed, as no specific regulations for genetically modified foods are in place in the United States (Halsberger, 2000). Until recently, the theme in the United States was one of quiet acceptance combined with low awareness of GM food products, which does not facilitate discussions about them. Thus, it is difficult to assess what normative beliefs might exist as research has indicated that the American lay public has rarely, if ever, talked about GM foods with friends and family (Silk et al., in press). However, subjective norms associated with behaviors are based on what individuals perceive significant persons or groups believe about a given behavior. Thus, European attitudes and American farmer attitudes might provide insight into the important influences on individuals’ normative beliefs pertaining to GM foods.

In European countries, attitudes toward biotechnology are increasingly negative, with more than half of Europeans consistently ranking biotechnology as not useful and risky (Boy, 2000). European restaurants routinely post whether or not they use genetically modified organisms in their food products, making the issue a visible, everyday decision for consumers. The cautious attitude toward GM foods epitomized by
European countries provides a contrast to American consumers who comparatively have been less concerned and informed about GM foods. However, as Americans learn more about the varying attitudes and regulatory differences that exist between European countries and the United States, the information may serve to promote discussion or even more directly, serve to influence normative beliefs about GM foods. For example, focus group participants discussed European attitudes toward GM foods (Silk et al., in press), perhaps weighting European countries as a significant influence on their subjective norm toward GM foods.

Heinrichs (1999) discusses the differences in regulatory and scientific perspectives on GM foods between the United States and Europe. Whereas the United States remains the leader in biotechnology applications as evidenced by the more than double number of people (100,000) working in biotechnology than Europe (39,000) (Heinrichs, 1999), researchers in Europe believe risks are not yet known and that assertions about minimal risks are premature because it seems the more scientists discover about DNA, the more complex and unknown DNA becomes (Worth, 2000). For example, scholars from Britain have met to discuss risks and hazards associated with GM foods (Worth, 2000), pointing to the need for more information about the effects of GM foods before they should be allowed on the market. One researcher stated, “It is impossible to predict what will happen to all forms of life on this planet if experiments in genetic engineering continue unchecked” (Worth, 2000, p.163). Claims such as the previous one from individuals considered as “experts” by the lay public could contribute to individuals’ normative beliefs that comprise their subjective norm about GM foods.
American farmers may also serve as an important referent group for shaping subjective norms associated with GM foods because they might be perceived as experts on the topic. Farmers were some of the first individuals to gain information about GM foods because they had the task of using GM seeds to grow GM crops. However, despite their arguable expert status, it seems that consumers are not relying on the actions of farmers as a signal to embrace biotechnology. Phillips (2000) notes that, “consumer reaction to the first generation of transgenic crops is not enthusiastic, even though farmers have rapidly adopted the technology” (p.457). Likely outweighing the influence of farmers’ attitudes and behavior, is the fact the lay public has seen no direct benefit to the cost and quality of food due to the technology thus far (Phillips, 2000). The potential for farmers to be a strong referent group and influence on subjective norm exists as more and more individuals begin discussing the topic of GM foods and relate their use back to farmers (Silk et al., in press).

The formative research conducted by Silk et al. (in press) suggests that a message could contribute to the formation of a subjective norm related to GM foods by addressing the subjective norm construct within the content of a message about GM foods. In other words, the message could encourage individuals to think about and discuss the topic of GM foods with family members and friends, increasing the value of the subjective norm determinant in predicting behavioral intentions.

**Perceived Behavioral Control and GM Foods**

Perceived behavioral control is the final determinant of the TPB that contributes to the prediction of behavioral intention of performing a behavior and also contributes directly to behavior according to the model depicted on p.12. Perceived behavioral
control in the case of GM foods refers to consumers’ ability to discern whether or not foods are genetically engineered. One study found that the overwhelming majority of the lay public believed that they had not eaten GM foods; only 20% believed they had eaten them (Taylor & Leitman, 2001). Relatedly, another study reported that one-third of its participants reported that they were unwittingly eating GM foods (Silk et al., in press). It is estimated that in the year 2000 more than 60% of food in the supermarket contained some sort of the genetically engineered material (Chase, 2000). Consumers’ lack of perceived control over their consumption of GM foods is a result of the proliferation of GM foods that are not required by law to be labeled.

A “genetically-friendly” economic and political environment impedes consumers’ ability to ascertain whether food products have been genetically altered or not because labeling is not required. In other words, lack of labeling requirements for GM foods removes much of the actual control people have in deciding whether or not to eat GM foods. Labeling of GM foods is not mandatory; instead, labeling of GM foods is voluntary (Macilwain, 2000). The Federal Food, Drug and Cosmetic Act, requires labeling of GM foods only if an end product is materially different in some respect with an added ingredient than it would have been without the additional ingredient (FDA, 2001). For example, a combination of broccoli and cauliflower called “brocciflower” is labeled as such because it is no longer simply broccoli or cauliflower, but a combination of the two. Genetically modified foods are typically not labeled as such because they are not considered materially different than their non-GM counterparts (Barclay, 1999).

Proponents of labeling point out consumers’ right to know the ingredients in food as well as the fact that the United States maintains the most strict standards for food
labeling in the world – why would GM foods be exempt? As a response to large advertising dollars invested by the GM industry to eliminate the labeling threat, proponents of labeling have designed their own mock advertisements. For example, one group designed an advertisement that changed a Campbell’s soup label to “Campbull’s Experimental Vegetable Soup,” with the advisory, “Warning: This Product is Untested” (Roosevelt, 2000). Messages like the Campbell’s soup label identify perceived inadequacies in current regulations of GM foods, highlighting the idea that consumers’ control of GM food consumption would increase if the government would more strictly regulate GM food products as they do other products. On the other side of the labeling issue are those who complain that labeling GM foods would not be cost-effective and that too many consumers would consider a mandatory biotech label as a warning that it is unsafe (Roosevelt, 2000). These opponents of labeling argue that labeling GM foods as such would increase consumer perceptions of unwarranted risk and perhaps decrease sales of GM foods. Messages from proponents and opponents who support or oppose labeling, increased testing, and/or regulation of GM foods respectively, serve to influence individuals’ perceptions of behavioral control. Labeling, in particular, is a mechanism that would enable consumers to choose whether or not to consume GM foods, thereby increasing the level of perceived behavioral control they associate with GM foods.

Formative research from Silk et al. (in press) suggests that individuals are concerned about their ability to control their intake of GM foods due to risks they associate with GM foods. Health messages could influence perceived behavioral control within the content of a message about GM foods. Specifically, the message could provide
information about current FDA regulations for labeling and also suggest that individuals engage information seeking behavior by contacting the FDA about GM foods.

**Behavioral Intentions and GM Foods**

It is the case that much scientific information and related research is available to influence the lay public’s behavioral intention toward GM foods. The TPB predicts that attitudes, subjective norms, and perceived behavioral control about GM foods will contribute to the formation of behavioral intentions toward them. A rational approach to the design of messages might integrate available knowledge about GM foods that pertain to attitude, subjective norm, and perceived behavioral control for the purpose of influencing behavioral intentions toward GM foods. According to the TPB, the effectiveness of each of the integrated message constructs to influence behavioral intention is based on the weights assigned to attitude, subjective norm, and perceived behavioral control. In other words, message designers will need to consider each construct of the TPB because one construct may be more influential than another. The weighting process is critical to the influence of each of the determinants of behavioral intention.

For example, consider a woman who reads a health message pertaining to the importance of eliminating GM foods from her diet. If the woman holds a positive attitude toward eating GM foods, perceives a positive subjective norm, and believes she is able to control her eating of GM foods, she will likely ignore the message and not form the intended behavioral intention or enact the behavior in the message. On the other hand, if her individual attitude and subjective norm are both negative toward GM foods, and she believes that she is able to easily distinguish between GM and non-GM foods, she would
be more likely to form the intention to eliminate GM foods from her diet. However, if she had a negative attitude toward GM foods and her subjective norm was positive toward GM foods, her behavioral intentions would be determined by the stronger of the two influences as well as her perceptions of behavioral control. That is, if the strength of her negative attitude was greater than the strength of her positive normative beliefs, her negative attitude would be the more important predictor of her behavioral intention toward GM foods than the subjective norm she associates with GM foods. Alternatively, if the woman felt completely in control of her ability to distinguish between GM and non-GM foods, her perceived behavioral control may be the most important and direct predictor of behavioral intention to eliminate GM foods from her diet. Overall, the importance of each of the constructs of the TPB will vary from person to person.

This research aims to incorporate constructs of the TPB in the message content as a method to influence behavioral intention toward GM foods. According to the TPB, the following prediction can be made in regard to the constructs of the theory:

H1: Attitudes, subjective norms and perceived control toward the attitude object (GM foods) will predict behavioral intentions toward the attitude object.

A TPB Framework to Guide Message Design Associated with Public Responses to GM Foods

The few studies that have used the TPB to guide message design have not focused on the micro message design components of message construction. In view of the fact that the TPB depends on a rational model of human behavior, rational appeals are often used to shape attitudes, subjective norms, and perceived behavioral control to affect behavior intentions and actual behavior. However, formation of an attitude, subjective
norm, or perception of control is dependent on message comprehension (McGuire, 2001). Comprehension, in turn, will depend on the presentation and understanding of arguments used to support the beliefs associated with the message. Although it may seem intuitive that comprehension is a critical consideration in message design, many messages intended to influence an audience contain numerical information that is inaccessible to many individuals. Specifically, low numeracy skills may serve as a barrier to understanding messages that incorporate statistical information as evidence. Thus, message designers need to consider how to best communicate statistical information within health messages so that a maximum number of people can understand information within them. Often laden with numeric results to decipher, the presentation of information about GM foods supplies a case study of the important role of statistical evidence in health communication.

Use of Statistical Evidence in Rational Appeals: Shaping Public Attitudes About GM Foods

A great deal of literature exists regarding the use of evidence in persuasive messages. Researchers have compared types of evidence, amount of evidence, use of evidence, evidence quality as well as other dimensions of evidence. In general, evidence has been categorized into two types: testimonial assertions and factual information (Reinard, 1988). Factual information can be classified as either reports of events or statistics. Report evidence refers to examples, stories, opinions, case studies, and other similar types of narrative information (Baesler & Burgoon, 1994), and as previously defined by Church and Wilbanks (1986), statistical evidence refers to empirically quantified descriptions of events, persons, places, or other phenomena.
A review of the literature indicates that, in general, there is agreement on the following points about evidence: (a) evidence is the basis from which logical argument is developed, (b) usually, the broader this basis (i.e., the more evidence presented) the more likely it is that proof will be generated, (c) evidence that has been evaluated empirically is more likely to be valid, and (d) evidence that has been carefully documented is generally more acceptable than undocumented evidence (Cathcart, 1955). A more current review supports these same general assertions (Reinard, 1988), demonstrating the strength of the support generated from decades of research. However, while general assertions provide a broad stroke for what appears to be the case for the use of evidence, there exist some inconsistent findings regarding what types of evidence will bolster the effects of a message. The inconsistent findings emanating from the empirical literature may be a result of an “inability to adequately isolate, limit, and define evidence as a construct as well as the use of questionable methodological procedures” (Kellerman, 1980, p.159). The need to understand a complete and clear picture of the effects of evidence is necessary as communication scholars continue to offer advice in textbooks and as consultants to practicing communicators (Allen & Preiss, 1997). Research regarding statistical evidence provides one example of contradictory findings in the realm of evidence.

**Statistical vs. Narrative Evidence**

A large body of extant literature suggests that narrative evidence is more memorable and persuasive than statistical evidence (see Reinard, 1988, for a comprehensive review of literature on evidence). However, recent research has indicated just the opposite (Allen & Preiss, 1997; Baesler & Burgoon, 1994; Kazoleas, 1993). For
example, Allen and Preiss (1997) conducted a meta-analysis that revealed that statistical evidence was more persuasive than narrative evidence. However, Allen and Preiss (1997) only included research that focused on the persuasive effects of different forms of evidence, while previous meta-analyses included research that was also concerned with the accuracy of message interpretation (Reinard, 1988). Thus, the difference in outcomes may be a result of differences in criteria for sampling methodology employed in the meta-analyses.

Baesler and Burgoon (1994) found that statistical evidence (simple percentage of odds, e.g., 80% or “8 out of 10”) is generally more persuasive than narrative evidence (e.g., paragraph with a story line) over time and that statistical evidence, when combined with vividness, produced immediate, moderate, and long-term persuasive effects on beliefs toward juvenile delinquents (p.596). In the study, four different messages about juvenile delinquency crossed evidence type (story or statistical) with vividness (vivid or nonvivid) (Baesler & Burgoon, 1994). Message vividness was operationalized by manipulating low and high levels of emotiveness (e.g., low: “he failed school” vs. high: “the star athlete failed miserably in school”); concreteness (e.g., low: “a bad grade” vs. high “a D or F grade”); and imagery (e.g., low: “use of force” vs. high: “fistfight”) (pp.588-589). The written messages controlled for message valence, organization of argument, themes, details of information, readability, and message features other than the independent variables. In other words, a very controlled manipulation of statistical versus narrative evidence was conducted that had less chance for confounds than previous research efforts. While Baesler and Burgoon (1994) found empirical support for the usefulness of statistics as influential in messages, they did not manipulate types of
numeric representations. The study supports the use of numbers as evidence and as a method for retention of information when vivid statistical evidence is used (Baesler & Burgoon, 1994), but it does not attempt to assess different methods for presenting statistical/numeric information within messages. Often times, information that is important to our health may not be “vivid” in nature, but is still valuable for us to understand and remember. The question of how to most effectively communicate important, but less “vivid” statistical information still remains to be answered.

Other research also provides support for the impact of statistical information (Boster, Cameron, Campo, Liu, Lillie, Baker, & Yun, 2000). Boster et al. (2000) paired a set of constant exemplars with consistent and inconsistent statistical evidence. Similar to Baesler and Burgoon (1994), Boster et al. (2000) found that quantitative information does indeed impact judgments directly, and attitudes indirectly. Instead of using written messages, participants listened to three-minute, audiotaped messages (Boster et al., 2000). The audiotaped messages presented statistical information about cafeteria food (e.g., “77% of persons participating in a survey believed that cafeteria food was good and nutritious”) along with five exemplars from students, four that asserted the food was good and one that asserted the food was not good. In the consistent condition, the exemplars matched the statistical information given; in the inconsistent condition, the exemplars did not match the statistical information. The control condition offered exemplars only, with no statistical information provided in the audiotaped message. As with Baesler and Burgoon (1994), the message manipulation of Boster et al. (2000) controls for certain message variables, which allows the researchers to conclude that statistical information can be used effectively to increase conformity to message recommendations and to
influence attitudes. However, while both studies provide critical support for the influence of statistical evidence, neither of them informs message designers of how to present statistical information in the most effective manner.

Some research has identified when it is appropriate to use statistical evidence as a strategy to affect health outcomes (Kopfman, Smith, Yun, & Hodges, 1998). Kopfman et al. (1998) examined reactions to statistical and narrative evidence about organ donation to understand cognitive and affective processes. Prior thought and behavioral intention pertaining to organ donation was measured. Participants then read one narrative message and one statistical message followed by survey questions that measured cognitive and affective variables. Messages in the study urged readers to become potential organ donors by signing donor cards. The messages contained the same major premise, differed in terms of the evidence offered for support, and emphasized in the last sentence that lives could be saved due to signed organ donor cards (Kopfman et al., 1998). Other message features were not controlled. Participants who entered the research with prior thought about organ donation and a behavioral intention to become an organ donor reported a greater likelihood of becoming an organ donor. Additionally, the study demonstrated that when the desired health behavior is distant in time from the receipt of the message (as most are), statistical evidence should be used to support claims, because this type of evidence has been shown to “generate more thoughts, greater causal relevance, and greater use of heuristic cues such as credibility and effectiveness than does narrative evidence” (Kopfman et al., 1998, p.295).

Researchers also hypothesized that narrative evidence would provide more causal relevance in terms of problem solving and similarity than would statistical evidence
(Kopfman et al., 1998). The opposite occurred. A greater sense of causal relevance was perceived by subjects when they read the statistical evidence as compared to the narrative evidence. These results are an interesting finding because similar to Kazoleas (1993), Kopfman et al. (1998) believed narrative evidence would be more effective because it is more readily available and accessible in the receivers’ cognitive processes as compared to statistical evidence. In other words, they theorized that the format of narratives is easier for receivers to comprehend because it is more vivid and concrete. Narratives may also provide specifics that foster greater perceptions of self-efficacy if a reader perceives similarity between the character in the narrative and him/herself (Kopfman et al., 1998). However, one explanation of why narrative evidence was not more effective than statistical evidence in Kazoleas (1993) and Kopfman et al. (1998) may be due to the simplicity of the statistical message content included in each of the messages.

For example, the organ donation message provided in Kopfman et al. (1998) offered two percentages (e.g., “In 1991, a total of 16,003 people received kidney, heart, or liver transplants in the United States. This may seem like a large number of transplants until you consider that 26,463 people in the United States were in need of kidney, heart, or liver transplants.”) as the manipulation of evidence type for the statistical evidence condition. Similarly, Kazoleas (1993) presented quantitative evidence that consisted of straightforward percentages that were not difficult to grasp either (e.g., “A recent investigation has found that persons are 50% more likely to be injured in a nonfatal automobile crash, if they are not wearing a seatbelt.”). Therefore, one explanation of why people were persuaded by the quantitative information used in the studies might be because the information was easily accessible to readers due to its relative simplicity. It
is possible that narrative evidence would be more influential than statistical evidence, as theorized by Kazoleas (1993) and Kopfman et al. (1998), if more complicated or technical numeric information was presented within a message. It is unclear whether statistical evidence would remain more persuasive than narrative evidence in messages that deal with more complex presentations of numeric information. Likely to be related to the effects of statistical evidence is how message designers organize and present evidence in a message.

Organization of Messages

Important to the presentation of statistical evidence in messages is the organizational structure of the message. Message organization in print contexts typically relies on deductive or inductive reasoning for its logical structure. In the written context, research has found that inductively organized messages are more effective than deductively organized messages in persuading individuals with no behavioral intention to perform a behavior (Buller, Borland, & Burgoon, 1998). Deductive messages are more effective when individuals are unsure about their behavioral intention to perform a behavior (Buller et al., 1998). Thus, when communicating about a new topic such as GM foods where people have yet to form a behavioral intention toward them, messages may want to take an inductive approach to communicate findings associated with the topic by starting with a particular issue that may influence an attitude in a more general way. For example, a message may use statistical evidence from a scientific study about potential allergens associated with a specific GM food with the goal of influencing a behavioral intention to seek more information about the labeling of GM foods.
Presentation of Statistical Evidence

The presentation of statistical evidence in a message plays a significant role in the comprehension of a message as well as its persuasive effect. The lack of clear empirical proof regarding complex statistical evidence makes decisions about channel selection, risk introduction, and modes of evidence presentation critical considerations for the presentation of statistical information. Each topic will be discussed in the following sections.

Channel Selection for Statistical Evidence. Messages that contain statistical evidence may be best communicated in written or print form, especially if the evidence presented is complicated, as might be perceived about GM foods. Research has indicated that written messages like pamphlets, brochures, or newsletters are more appropriate for communicating complex information (Chaiken & Eagly, 1976). Print messages also promote greater cognitive processing of information than oral messages (Rubin, Hafer, & Arata, 2000). Moreover, according to Chaiken and Eagly (1976), people expend more cognitive effort to process print messages than television or radio messages. The reading of messages promotes greater retention, and an increase in the ability to extract salient information from a message than does listening to messages because people can refer back to message content when necessary (Rubin et al., 2000). Additionally, individuals report a preference for print information (Fisher, King, Epp, Brown, & Maretzki, 1994).

In Fisher et al., 1994, different channels for receiving information about food risks were tested. The researchers compared paper and computer versions, hypothesizing that subjects would learn more from the computer version and that individuals prefer electronic media for receiving information. Neither hypothesis was supported; subjects
learned equally well in both the paper and computer version conditions, and pamphlets were ranked as a preferred medium for receiving information. Specifically, participants reported a preference for pamphlets because they could more easily skim and refer back to a pamphlet of information than a computer version of the same information (Fisher et al., 1994). This research provides support for selecting a written channel for messages that present statistical evidence pertaining to risks associated with GM foods.

**Introducing Statistical Evidence.** Messages in communication campaigns typically rely on one of two strategies to structure message content, using either fear appeals or straightforward presentations of fact. As demonstrated in one content analysis of AIDS public service announcements, approximately one-fourth of the PSAs used fear appeals to persuade individuals to change risky behaviors, and half of the PSAs were affectively neutral with straightforward presentations of facts (Freimuth, Edgar, Hammond, & Monahan, 1990). Messages pertaining to GM foods follow the neutral approach by presenting the results of the scientific research in the form of statistical evidence. Some research suggests that statistical evidence should be introduced in a familiar fashion (e.g., within the context of a known metaphor, analogy, belief, etc.) because it will be easier for receivers to process information that is built from familiar elements (Kintsch, Jungleblut, Jenkins, & Kolstad, 1975; Schwartz et al., 1999). For example, it might be easier for a person to understand the risk of allergens in GM foods if it were compared to a more familiar, readily known risk such as the risk of being in a car accident or being hit by lightning. However, the risks associated with a new technology such as GM foods are not easily quantified or compared, due to conflicting findings and/or constantly emerging information regarding the technology (Hoban, 1995). Proponents and opponents of the
technology focus on different aspects of it, highlighting those issues that promote their specific agendas. For example, supporters of biotechnology will tend to stress economic and other benefits, while opponents raise concerns about health risks and ethics. The ongoing flood of information about GM foods from different stakeholders makes it difficult to present information to readers about potential risks.

When considering potential risks to their health, consumers of information indicate they would like to know definitions of “normal” to use as a standard by which they can interpret information, allowing them to make better sense of health information as it pertains to their own health (Adelsward & Sachs, 1996; Parrott, Silk, Dorgan, & Daniels, 2000). Related to the consumers’ need for definitive parameters, is the idea that individuals often prefer to be told what to do rather than deciphering statistical evidence for their own evaluation. For example, consumers have reported that they would rather be told directly of consequences associated with performing a behavior (e.g., “Should I stop drinking the water?”) than told scientific information (e.g., level of contaminant in the water) that might influence their decision to perform the behavior (Halverson & Burton-Radzely, 1999). In the case of GM foods, directive information based on scientific findings is not possible because as a new technology, long-term risks associated with GM foods have not been assessed. The end result is that the introduction and interpretation of potential risks has been left to stakeholders (e.g., members of the GM industry or organic crop growers) whose interests in GM foods are not defined by public health interests. Health message designers need to take on the task of creating rational messages that focus on the available empirical evidence that addresses risks associated with GM foods.
Modes of Presentation for Statistical Evidence. While channel selection refers to the mode in which information is delivered, the mode of presentation refers to the actual form that statistical evidence will take within the content of the message. For example, research on message presentation tested the effectiveness of two different versions of a brochure on comprehension, perceived ease of understanding, and overall rating of the two brochures (Michielutte, Bahnson, Dignan, & Schroeder, 1992). One version used text only with simple sentences and a bullet-type format and the other version was a narrative text with illustrations. Participants comprehended more from the illustrated narrative version and found it easier to read (Michielutte et al., 1992). Additionally, the illustrated narrative version was preferred more than the text only version. Michielutte et al. (1992) also support a rational approach for message-designers that promotes a clear, straightforward message style complemented by visual presentations to maximize chances for understanding by audience members. These findings are critical when applied to the realm of GM foods because the information surrounding findings about GM foods is typically technical and novel to most receivers and thus, may be more accessible to intended audience members if communicated in a print context.

There has been recognition among message designers that individuals, especially those with low literacy skills, will find material more easier to read when pictorial representations of information are present (Davis, Holcombe, Berkel, Pramanik, & Divers 1998; Dunn, Buckwalter, Weinstein, & Palti, 1985; Schwartz et al., 1987). For example, Davis et al. (1998) tested different versions of an informed consent form and found that participants found the simplified form easier to read than a more complex version, but that they did not necessarily comprehend more information in the simplified version.
Participants in the study who had higher literacy levels also preferred the simplified version, indicating an overall preference for easy-to-read information by all participants regardless of their literacy level. Limited research exists regarding how to effectively present statistical evidence that pertains to complex topics like GM foods, but much research points to message receivers’ inability to decipher statistical evidence.

The work of Schwartz et al. (1997) on how women understand the risk of breast cancer provides an example specifically focused on the comprehension of statistical evidence. Women in the study were exposed to different numeric representations of risk. Results indicated that participants had difficulty with simple probability and conversions from percentages to probability expressions. Researchers found that evidence might be expressed and comprehended more easily in frequencies rather than probabilities, and in visual displays like histograms, graph formats, or line graphs (Schwartz et al., 1997). Additionally, Schwartz et al. (1997) concluded that messages should focus on better numeric formats, combining numeric and verbal formats, using visual displays, and using frequency formats rather than probabilities (e.g., 10 out of 1000 rather than 1%) to address problems with numeracy and literacy.

Also interested in comprehension of statistical evidence, Halverson and Burton-Radzely (1999) conducted focus groups that asked individuals to interpret water quality data in bar graphs and charts. Findings indicated that participants were confused by terms used in the bar graphs and charts (e.g., maximum contaminant level and maximum contaminant goal), which made it difficult for them to understand the significance of the presence of certain substances (e.g., nitrate and mercury) in drinking water. Even though the water charts given to participants were confusing to them, they consistently
responded positively to illustrations, and to bar graphs and charts that presented material in a clear, simple manner (Halverson & Burton-Radzely, 1999). The lesson to be learned from the previous research is that literacy and numeracy skills need to be taken into consideration regardless of the format in which statistical evidence is presented. Thus, it is critical that presentations of statistical evidence be pre-tested on intended audience members so that message designers can effectively address channel selection, numeracy issues, and content issues like framing of statistical evidence.

**Presentation of Multiple Forms of Evidence.** Allen et al. (2000) note that a perspective appears to exist that one form of evidence precludes the use of another form of evidence, although in reality, types of evidence are combined in messages. Allen et al. (2000) reasoned that it would be beneficial to discover whether a combination of evidence is more effective than a single type of support. Four versions of 15 messages were used in the study, including messages with: (a) neither statistical nor narrative evidence (no evidence condition), (b) narrative, but no statistical evidence, (c) statistical, but no narrative evidence, and (d) both statistical and narrative evidence. The published research does not provide examples of the messages used in the study, but indicates that graduate students created the messages across a variety of topics (e.g., the validity of the Scholastic Aptitude Test, and the use of cosmetics by women). The omission of message manipulation details is perhaps due to page length restrictions of the periodical and the editorial process. It is, therefore, difficult to assess the methodological issues regarding message construction, which are pivotal in understanding the results of the study. 

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1 The lack of methodological detail in published research reports has been reported in the past as a barrier for assessing the impact of the messages (Kellerman, 1980). Consumers of research articles are often unable to comprehensively assess messages and results because important details are often not readily available within published work. To obtain further information about the study, the first author was
Overall, Allen et al. (2000) showed that a combination of statistical and narrative evidence maximizes the effects of a message on receivers.

Some research also recommends that messages be constructed with quantitative information presented in multiple ways within the same health message (e.g., demonstrate the probability of 1 and 3 as a fraction, and a pie chart, and in some form of picture format) to recognize the different proficiencies of individuals in understanding quantitative information (Steen, 1991). In other words, multiple formats of quantitative information within the same message may lead to greater understanding by more people because it accommodates for the different abilities of individuals. Perhaps multiple representations could also afford an individual stronger comprehension of the message, due to the reinforcement of the information being presented twice. Communication research on message repetition effects suggests that multiple exposures to a message will facilitate message elaboration (Petty & Cacioppo, 1979). Applied to the GM context, multiple types of statistical evidence within the context of a message may serve to increase comprehension of the message as well result on more persuasive effects on attitudes about GM foods. Some researchers, however, might caution the use of multiple representations because individuals may have difficulty attending to several sources of information simultaneously (Sweller, Chandler, Tierney, & Cooper, 1990). Thus, it is unclear whether a message that uses both visual and text presentations of statistical information will be more effective than a visual-only presentation.

In general, while research demonstrates that visual representations are favorable and helpful to readers, there is little research that tests different presentations of statistical

contacted. The first author was kind enough to search for them, but was unable to locate the messages used in this particular study. (Allen, Bruflat, Fucilla, Kramer, McKellips, Ryan, & Spiegelhoff, 2000).
evidence within the context of a controlled experimental message. Thus, a second goal of this research is to test the effectiveness of different presentations of statistical evidence, using biotechnology as the message context. The following hypotheses are posited:

H2a: Presentation of statistical evidence about risks associated with GM foods shapes negative attitudes of risk about GM foods.

H2b: Participants who receive graphic forms (bar graph or combined format) of statistical evidence will have more negative attitudes of risk toward GM foods than those participants who receive textual forms (percentage) of statistical evidence.

H2c: Participants who receive multiple forms of statistical evidence (combined format) will have more negative attitudes of risk toward GM foods than those participants who receive textual or bar graph only forms of statistical evidence.

The previous hypotheses are related to the effects of statistical evidence on attitudes toward GM foods. However, to investigate the effects of statistical evidence on comprehension, it is not necessary that the topic be related to GM foods as comprehension of statistical evidence can be related to an infinite number of topics. Thus, the following hypotheses pertain to all messages used in the study:

H2d: Participants who receive graphic forms (bar graph or combined format) of statistical evidence will have greater comprehension of a message than those participants who receive textual forms (percentage) of statistical evidence.

H2e: Participants who receive multiple forms of statistical evidence (combined format) will have greater comprehension of a message than those participants who receive textual or bar graph only forms of statistical evidence.
**Audience Characteristics Associated with Efficacy of Evidence**

Audience characteristics pertaining to “math competency” should also be taken into consideration when designing messages that include statistical evidence. In American culture, message receivers rely on statistical evidence as a source of accuracy and authority from which to derive much public policy. Although statistical evidence is helpful at a macro-level for assisting organizations, legislators, and other government agencies in determining the emphasis of time, energy, and money for investments relating to health, it is often less helpful at the individual level. Individuals are inundated daily with number presentations, including weather forecasts, financial calculations, time estimates, and of course, health information, among other types of everyday information. All of the previous number presentations presume a certain level of numeracy ability. However, the reality is that although people have a level of familiarity and certainty they associate with some numbers, many individuals have limited ability to critically assess how numbers are presented to them (Baker et al., 1997; Steen, 1991). There is a need for the lay public to be competent consumers of statistical evidence because numbers are a critical component of message content used to communicate estimates, probability, and risks, especially within the health context (Steen, 1991). The construct of math competency, however, should not be limited to actual numeracy ability because when presented with more technical information, individuals may also experience challenges with math self-efficacy and math anxiety, two potential barriers for the communication of statistical evidence.

This research aims to provide additional insight for message designers by considering three possible dimensions of math competency, specifically numeracy
ability, math anxiety, and math self-efficacy within the context of biotechnology.

Numeracy ability, math anxiety, and math self-efficacy have not been explored previously by health communication scholars and may collectively represent a larger, multi-dimensional construct of math competency with behavioral (numeracy/math ability), affective (math anxiety), and cognitive (math self-efficacy) dimensions. A closer examination of the relationships between math-related variables could significantly contribute to explaining why some messages containing statistical evidence fail to influence receivers. The audience characteristics of numeracy, math anxiety, and math self-efficacy will be discussed next.

**Numeracy**

As previously defined, numeracy ability includes those mathematical skills that enable an individual to cope with the practical demands of everyday life (Steen, 1991). Numeracy and literacy requirements have increased as technological advancements in medicine and other domains are presented in complex ways. The use of numbers in medical encounters to communicate about bodily functions, health risks, and health benefits is commonplace, even though individuals are daunted by the use of numeracy, avoid the use of numbers, invent methods for coping with numeric information, and invent their own methods for computing and understanding math (Steen, 1991). In effect, people are rather uncomfortable when they are presented with statistical evidence and often struggle to make sense of it. For example, much research has demonstrated that many patients leave health encounters with much less than a complete understanding of what has been communicated to them or at best, a general understanding (Adelsward & Sachs, 1996; Chacon et al., 1994; Fain, 1994; Schwartz et al., 1997), nor do they
necessarily seek additional information or ask questions in health interactions (Parrott, 1994). Extend the lack of understanding experienced by patients in medical encounters to situations where individuals independently consume quantitative health information and one might expect an even greater lack of understanding. For example, a health brochure picked up at the local supermarket or an on-line article might offer statistical evidence that is difficult to understand. The message may have little impact or meaning as the reader does not have the resources or expert available to fully determine the meaning of the message. Research has documented the difficulties associated with low numeracy ability.

Adelsward and Sachs (1996) conducted a study of twenty-eight men and their health conversations with a nurse. The nurse used three strategies to present results of a cholesterol test, including: (a) presenting results according to an ideal curve; (b) adapting results to the individual; and (c) adapting the results to a global setting. Regardless of the strategy employed by the nurse, participants in the study were unable to recall their exact cholesterol count, but did remember whether or not it was within “normal” limits. The result seemed only to matter in its relation to being within the boundaries of “normal” (Adelsward & Sachs, 1996). Additionally, patients considered the results of the cholesterol test as facts, despite caution from the nurse to interpret the results with moderation. It seems patients often accept whatever information a health practitioner communicates, without necessarily comprehending what the health information actually means.

Numeracy has also been related to accurately gauging the benefits of health interventions. Schwartz et al. (1997) found accuracy in the application of risk reduction
information and numeracy to be poor in judging the benefits of screening mammography. Even individuals who are more “savvy” as consumers of health information are affected by numeracy and the method used for the presentation of the health information. For example, Forrow, Taylor, and Arnold (1992) found that clinicians gave different responses to information about a disease in terms of relative changes in outcomes when they were presented with differently worded information. These findings imply that numeracy is as salient to health experts as it is to their patients who rely on health experts for understanding of health information (Forrow et al., 1992).

Although the presentation of statistical information may be difficult for many individuals, people still are drawn to numbers and are challenged to think about and “solve” mathematical problems as evidenced by their attraction to games of strategy, lotteries, and puzzles (Steen, 1991). If we combine people’s attraction to numbers with the fact that some research has demonstrated that it is a very effective way to influence individuals (Allen & Preiss, 1997; Baesler & Burgoon, 1994; Kazoleas, 1993), it is not surprising that message designers continue to use numbers as evidence in their message appeals. Nonetheless, numeracy skills seem likely to impact message effects.

Numeracy and GM Food Risks. Rational decision-making about GM foods depends on one’s receiving comprehensive information about GM foods and one’s ability to comprehend the information provided about the topic. In situations where health risks might be present, the lay public is often presented with probabilities, proportions, and other statistics that ask them to calculate their individual risk for a specific disease or condition (Marteau, Drake, & Bobrow 1994; Rothman & Kiviniemi, 1999). In the case of GM foods, consumers might be presented with information that discusses risks for
themselves, others, the environment, or perhaps risks associated with the production and consumption of specific types of organisms. For example, a message about GM foods might read that there is a 12 to 14 percent drop in phytoestrogens (plant-based estrogens that are associated with protection against heart disease, osteoporosis, and breast cancer) in soybeans that were genetically engineered with the herbicide “Roundup” (Teitel & Wilson, 1999). What does a 12 to 14 percent decline of phytoestrogens mean for an individual? Are the soybeans of less nutritional value? Do these results really mean anything important at all? The mere presence of a statistic might be cause for other questions or worries as individuals subjectively interpret the meaning of the statistic. If consumers should seek information about GM foods, they may have difficulty comprehending it due to its complexity as well their minimal knowledge regarding GM foods (Silk et al., in press).

There is a sparse but existing literature about the effects of GM foods, enabling an investigation of numeracy issues within that context. For example, some studies reveal through statistical evidence that individuals can experience allergic reactions from eating GM foods and that the immune system can weaken as a result of eating GM foods (Ewen & Pusztai, 1999, Falci, 2001, Nordlee et al., 1996). The literature suggests that some GM foods can pose a risk to people, especially those with known allergies to certain foods. While these risks may be small or may apply to only a small percentage of the population, it is important to note that for the most part, the lay public in the United States is seemingly unaware that these risks exist at all. Yet, the lay public is consuming GM foods without any critical thought being given to the possible consequences associated with such consumption. Health communicators need to examine how to best
present statistical evidence in messages so that individuals have the greatest opportunity for comprehension of the information presented to them.

Numeracy ability is a variable that should be considered within the context of messages that present statistical evidence about risks related to GM foods. Individuals who are high in numeracy ability are likely to interpret from the statistical evidence that risks associated with GM foods are small. To investigate the relationships between numeracy, comprehension, and attitudes toward GM foods the following hypotheses and research question are posited:

H3a: Numeracy ability is positively related to comprehension of statistical evidence.

RQ1: How does numeracy ability relate to comprehension of different presentations of statistical evidence?

H3b: Numeracy ability will covary with comprehension of statistical evidence such that greater numeracy ability is associated with less negative attitudes of risk toward GM foods.

Math Anxiety

Math anxiety is defined as the tendency to feel tension or anxiety when attempting to manipulate numbers and solve mathematical problems in a wide variety of ordinary life and academic situations (Lussier, 1996; Richardson & Suinn, 1972). Math anxiety may contribute to tensions during routine or everyday math activities such as handling money, balancing bank accounts, evaluating sales prices, or dividing workloads (Richardson & Suinn, 1972). Individuals who experience high levels of math anxiety may have difficulty comprehending statistical evidence presented in the context of a health
message like GM foods. Math anxiety may also be related to the method by which statistical evidence is presented and communicated in health messages. For example, a person who is high in math anxiety may experience less anxiety when examining quantitative information presented in bar graphs as compared to straight percentages.

Math anxiety has been conceptualized as both a state and trait anxiety. Trait anxiety refers to “relatively stable individual differences in anxiety-proneness, that is, to differences between people in how they perceive stressful situations as threatening and how they respond to stressful situations in their state anxiety reactions” (Leso & Peck, 1992, p.469). State anxiety is situational; “it results directly from some stress-producing situation during a finite period of time” (Leso & Peck, 1992, p. 469). It is unclear whether math anxiety should be considered as a state or trait anxiety when considering it in the realm of statistical evidence pertaining to scientific topics like GM foods.

Previous research regarding math anxiety has typically taken place within the context of testing situations for the purpose of examining gender differences (Betz, 1978; Harriss-Dew et al., 1983; Lussier, 1996). Research on math anxiety has resulted in mixed findings. In some studies, math anxiety was more likely to occur among women than men and among individuals with lower-level mathematical background (Betz, 1978; Harriss-Dew, Galassi, & Galassi, 1983; Hunsley & Flessati, 1988; Flessati & Jamieson, 1991). Contrary to these findings, Cooper and Robinson (1991) found no differences between gender and math anxiety in college students who chose math-oriented college majors. In order to address the discrepancy between the findings, Lussier (1996) controlled for mathematical background and found no sex differences. Overall, individuals who are dealing with the translation of numbers in a scientific message have
not been the focus of previous research. While it seems certain that math anxiety can be operationalized as an affective construct, its conceptualization as state or trait may inform how to best present information about GM foods.

For example, if math anxiety is conceptualized as a trait anxiety there is little that health message designers can do to craft messages that try to minimize it. If, however, math anxiety is conceptualized as a state anxiety, it is possible that the level of math anxiety experienced by an individual might be affected by the presentation mode of the statistical evidence in a message about GM foods. Thus, if math anxiety is a trait variable health message designers might be able to present statistical evidence that minimizes the effects of math anxiety.

Individuals who are high in math anxiety may have more negative attitudes toward attitude objects like GM foods because their anxiety interferes with their ability to comprehend the statistical evidence about risks associated with GM foods. The following research question and hypotheses are forwarded about the relationships between math anxiety and statistical evidence:

H4a: Math anxiety is negatively correlated to numeracy ability such that greater math anxiety is related to lower numeracy ability.

H4b: Math anxiety is negatively correlated with comprehension of statistical evidence such that greater math anxiety is related to lower comprehension of statistical evidence about GM foods.

H4c: Math anxiety is negatively correlated with attitudes of risk toward GM foods such that greater math anxiety is related to more negative attitudes of risk toward GM foods.
RQ2: How do different presentations of statistical evidence affect levels of math anxiety?

Math self-efficacy

Another construct related to math anxiety, math self-efficacy refers to an individual’s confidence in her or his ability to successfully perform or accomplish a particular math task or problem (Hackett & Betz, 1989). Conceptualizing math self-efficacy as a cognitive construct would be helpful toward the goal of creating a multi-dimensional variable of math competency. Research has demonstrated that the constructs of math anxiety and math self-efficacy are negatively correlated with each other (Betz, 1978; Cooper & Robinson, 1991). Overall, men have been found to report higher scores on mathematics self-efficacy than women, and individuals with backgrounds in mathematics have reported higher mathematics self-efficacy than those individuals with less mathematical background (Lussier, 1996). Other studies on math self-efficacy have demonstrated that it is positively correlated with attitudes toward mathematics (Hackett & Betz, 1989), and selection of math-related career paths (Betz & Hackett, 1983). If individuals are high in math self-efficacy, their confidence in their ability may translate into higher actual math achievement. For example, a person high in math self-efficacy who reads a message about GM foods may actually have high comprehension of the statistical evidence presented in the message, which may lead to a clear understanding of risks associated with GM foods. Thus, math self-efficacy may play an important role in individuals’ ability to understand statistical evidence in a health message about GM foods.
Based on the previous literature, the following hypotheses are forwarded regarding math self-efficacy:

H5a: Math self-efficacy is negatively correlated with math anxiety and positively correlated with numeracy ability.

H5b: Math self-efficacy is positively correlated with comprehension in presentations of statistical evidence such that greater math self-efficacy leads to more comprehension of statistical evidence.

H5c: Math self-efficacy is negatively correlated with attitudes in presentations of statistical evidence such that greater math self-efficacy leads to less negative attitudes of perceived risks toward GM foods.

Finally, it is critical to investigate the links between math competency variables (math self-efficacy, math anxiety, and numeracy ability) and the theoretical variables of the TPB (attitudes, subjective norms, and perceived behavioral control) on behavioral intentions. To examine the relationships between the math constructs, comprehension, and the theory of planned behavior, the following hypotheses are posited:

H6a: Math self-efficacy, numeracy ability, and math anxiety are significant predictors of comprehension of statistical evidence.

H6b: Math self-efficacy, numeracy ability, math anxiety, and comprehension of statistical evidence are significant predictors of attitudes toward GM foods.

H6c: Math self-efficacy, math anxiety, numeracy ability, comprehension, attitudes, subjective norms, and perceived behavioral control are significant predictors of behavioral intentions toward GM foods.
Summary of Evidence and Numeracy

Much research has demonstrated that many individuals are not confident in their ability to decipher information presented to them in numerical form (Adelsward & Sachs, 1996; Schwartz et al., 1997; Schwartz et al., 1999; and Steen, 1991). This lack of confidence experienced by many people may explain the inconsistent findings long associated with the use of statistical evidence in persuasive messages. It also provides one explanation for the findings in health communication literature that rational appeals are less effective than other types of appeals. Low numeracy is quite likely to be an even greater problem when the content deals with scientific information such as biotechnology, which creates a challenge when communicating information about the topic. As indicated in the literature review, a multitude of research exists that suggests how to most effectively communicate health information (e.g., Adelsward & Sachs, 1996; Chacon et al., 1994; Dee-Lucas & Larkin, 1988; Fain, 1994; Jackson, 1992; and Michielutte et al., 1992), but none seems to focus on the effectiveness of visually and numerically presenting information, and certainly not within the content domain of genetically modified foods. As the public sifts through more and more information about GM foods, they may begin to feel more or less confident in this new technology based on how quantitative information is presented to them. Health communicators can play a key role in how information about biotechnology is presented to the lay public.

Overall Summary

The Theory of Planned Behavior like the Theory of Reasoned Action is based on the assumption that human beings prefer to be quite rational and make systematic use of the information available to them (Ajzen, 1975). The constructs of the TPB can be
operationalized within the content of a health message to influence attitudes and behavioral intentions toward GM foods. The assumption of rationality by the TPB supports the idea that statistical evidence in health messages could be a useful strategy to communicate risk information about GM foods to individuals. The previously reviewed literature supports the idea that statistical evidence pertaining to GM foods can exert influence on message consumers’ attitudes toward GM foods. The addition of math competency variables, including numeracy ability, math anxiety, and math self-efficacy may also help message designers in understanding how to best present complex statistical evidence to increase comprehension and influence attitudes toward scientific topics like GM foods. Results of previous research have provided guidance in regard to some aspects of health messages, however, further research is necessary to inform message designers of how to better present statistical evidence to readers.

The overriding purpose of this dissertation is to help message designers to design more effective rational appeals that use statistical evidence. This goal is targeted by: (a) systematically incorporating the theory of planned behavior into message content; (b) investigating how to most effectively present statistical evidence within the context of biotechnology; and, (c) including numeracy issues as variables for consideration when presenting statistical evidence. The next chapter outlines the methods used in this research.
CHAPTER III

METHODS

Development of Experimental Messages

The messages used in this study were systematically constructed to: (1) incorporate constructs of the Theory of Planned Behavior (TPB); and (2) vary the type of statistical evidence used within the content of each message. The use of multiple messages increases the external validity of the findings because the ability to collapse messages for analyses eliminates message topics as possible explanations for effects. To create messages that incorporated the TPB, findings from formative research based on the theory were used to structure and create message content (Silk et al., in press). For the second goal of communicating statistical evidence within the context of the same messages, statistical evidence about possible personal risks associated with eating GM foods was included in the message content. Research that provides recommendations for the writing of health messages was also used to guide message construction (Parrott, 1995).

The messages used in both the pilot study and the larger study pertain to three topics about GM foods (e.g., rats, Brazil nut, food recall) and a control message about book preservation. Messages were adapted from scientific studies that examined the effect of GM foods as an allergen or toxin (Ewen & Pusztai, 1999; Falci, 2001; Nordlee et al., 1996). The control message was adapted from a study about costs related to book preservation (Rhys-Lewis, 2001). Within each of the message topics, one of three forms of statistical evidence were included (e.g., text only, graph only, both text and graph) to present the results of the study being discussed, resulting in a 3 (statistical evidence type)
x 4 (message topic) design. Please refer to Appendices A-L for each of the twelve messages. The development of experimental messages will be discussed in relation to the organization of theoretical constructs of the TPB in the message content and message controls.

**Theoretical Construction of Messages Using the TPB**

Much of the content of the experimental messages integrated into a TPB message framework emerged from qualitative formative evaluation research (Silk et al., in press). Results from the study revealed findings that stemmed from each of the constructs defined by the TPB, contributing to the content of each message to be used in this study. Each construct will be discussed as it relates to its use in messages in this research. Whereas the following paragraphs address GM foods specifically, it should be noted that the control messages also follow the explicated parameters of the TPB as closely as possible, but within the context of costs related to book preservation.

**Attitudes**

According to Silk et al. (in press), participants did not have fully formed attitudes about GM foods. Overall, participants were mostly neutral or negative in their beliefs about GM foods and believed that continued testing of them was essential. These neutral to negative attitudes were stated in the study messages by pointing out that risks may be associated with GM foods. Messages in this study targeted attitude formation by indicating that most people did not know a lot about GM foods, and that the information in the message was being supplied to assist people so they may form attitudes about risk associated with GM foods. All messages attempted to directly stimulate attitude formation by alerting readers that they might “want to decide for yourself” about GM
foods. The transition from the first paragraph to the second paragraph in each of the messages used the following statement to indicate the goal of the message: “This information is intended to help you begin talking about GM foods with your friends and family because eating them might affect your health.” Information provision is important for people to form an attitude about a topic of which they have little knowledge. Therefore, the message defined what genetic engineering of food involves (e.g., “GE allows the crossbreeding of genes between both related and unrelated plants and animals.”) and then provided results of a specific study as statistical evidence that there may be some risk associated with GM foods.

Subjective norms

Subjective norms regarding GM foods have yet to emerge as the topic has not been discussed much or at all by the general public (Silk et al. 2001). As a result of this finding, the statistical evidence provided in each of the messages was aimed at attitudes rather than subjective norms. However, the construct was incorporated in the first paragraph of all messages via the following statements: “Research has found that most people in the United States do not know a lot about GM foods. People do not often discuss them with their friends and family.” Although not the key influence on behavioral intentions at this time because participants are unaware of what their significant family and friends believe about GM foods, the construct of subjective norm was included as part of the message to parallel all of the constructs of the TPB as well as to define the current reality that there has not been much communication about GM foods.
Perceived Behavioral Control

Research has indicated that individuals do not perceive themselves to have a lot of control over whether or not they eat GM foods and believe they are probably eating them and do not even know it (Silk et al., 2001). Currently, the FDA does not require mandatory labeling of GM foods. However, the lay public needs to be able to read food labels that contain genetically engineered ingredients so they can protect themselves against potential allergens or toxins.

The construct of perceived behavioral control is relevant to labeling of GM foods and was included in the following statement of the last paragraph in all of the messages: “The FDA does not call for labels on GM foods because they are not thought to differ in content from other foods… If you have questions about GM foods, you may want to contact the FDA about how the public can detect GM foods and why labeling is not required.” In other words, the last paragraph in each message informed the lay public that they are not able to always detect allergens or toxins in their foods on food labels. The last paragraph also informed the lay public of whom to contact for more information regarding GM foods, perhaps influencing their perceptions of control and subsequently, their behavioral intentions.

Behavioral intentions

One goal of the messages was to influence behavioral intentions toward GM foods. Research has found that individuals do not have specific behavioral intentions toward GM foods because they are still in the process of developing an understanding of them and have not had many discussions with friends and family about GM foods (Silk et
The messages were designed to influence behavioral intentions by
influencing attitudes and perceptions of behavioral control as they relate to GM foods.
The primary behavioral intention suggested in the content of each of the messages is that of information seeking. In other words, the behavioral intention targeted by each message is to gain more information about GM foods, perhaps by contacting the FDA.

Message Design Variables within TPB Messages

In addition to the theoretical constructs of the TPB providing a framework for message content, each message was constructed similarly according to the following message design variables: (a) organizational pattern, (b) title, (c) source credibility, (d) novelty, (e) definitional (f) message clarity, (g) literacy and readability, (h) length, and (i) typeset. Each of the message design variables will be discussed in turn.

Organizational pattern. An inductive presentation pattern was used to present information as the message asked individuals to take a look at the results of a specific study from which to draw greater implications. The first two paragraphs in all of the messages were exactly the same. The first two sentences tried to capture reader interest by pointing out the saturation of GM foods in our food supply. The next sentence incorporated findings from the formative research that individuals really do not know a lot about GM foods and they are not really talking about the issue much. The lack of dialogue about GM foods underscores the assertion that subjective norms have not emerged yet, perhaps due to lack of discussion amongst family and friends as well as the newness and complexity of the topic. The following sentence pointed out the FDA’s position that GM foods are an acceptable product with no more risks associated with them than non-GM foods, framing the context in which GM foods have entered the
market. The next sentence instructed readers to pay attention to the message by asking them to “decide for yourself,” priming them to think about the message that is to come and to form their own attitudes. The last sentence in paragraph one explained that the purpose of the message is informational and advised readers to think cautiously about GM foods.

The second paragraph of the text-only evidence type message remained the same in all messages. The first few sentences defined genetic engineering (GE) and the last sentence of the paragraph pointed to the possibility that the transfer of genes with GE may lead to the transfer of unwanted allergens or toxins. Additionally, the last sentence transitioned the reader into the next paragraph by preparing them for the presentation of statistical evidence that was derived from quantitative, scientific research pertaining to GM foods.

The third paragraph of each message comprised the evidence manipulation. The paragraph indicated that according to a particular study, some risk has been associated with GM foods. The risk is then presented in percentage, bar graph, or both percentage and bar graph formats. The manipulation of statistical evidence will be discussed in greater detail further on in the methods section.

The last paragraph of the experimental messages explained the FDA’s policy about the labeling of GM foods, pointing out that labeling is not required of manufacturers. The next sentence stated that individuals who have food allergies need to be able to determine whether or not allergens are in their food. Additionally, based on the unknown consequences, people may want to decide whether or not to eat GM foods. Both the allergy and unknown consequences are representative of control issues that aim to
incorporate the perceived control construct of the TPB. The last sentence provides readers with information on how to address their concerns.

**Title.** Each of the messages used the same opening title as an attention getting device. Each of the titles used the following question, “Should Labeling of Genetically Modified Foods be Required?,” to begin the title. The second part of the titles was the same across evidence type and specific to the particular study discussed in the message. For example, the second half of the titles read, “Allergic Reactions to Genetically Modified Soybeans,” “A Recent History of FDA Food Allergen Recalls,” and “The Effects of a Lectin Gene on Rat Organs.” All of the control messages were titled the same: “Should Preservation be a Priority?: The Costs Associated with Different Types of Preservation.”

**Source credibility.** All of the messages included a reference to an expert source. For example, each GM message referenced scientists and the control message referenced librarians (a perceived expert source when it comes to books). At the bottom of the page each message also provided the citation of the study being discussed.

**Novelty.** Novelty of information is one prerequisite for piquing interest about a topic (Parrott, 1995). The topic of GM foods met the novelty requirement because it is a new topic that individuals currently do no know much about (Silk et al., 2001). Additionally, the specific topic of “allergens and toxins” was considered relevant to individuals because many individuals themselves are allergic to foods or know others who are allergic. The idea of book preservation in the control message was also considered a novel topic to which individuals have given little attention.

**Definitional.** The messages were created in a denotatively specific manner so that readers were provided with a definition of the technology being discussed. In particular,
the messages provided a definition of genetic engineering, which stated, “GE allows the
crossbreeding, or joining and transfer, of genes between both related and unrelated plants
and animals.”

**Message clarity.** Messages were crafted in a straightforward, easy to understand format. Efforts were made to make sure that statements were accurate, supported, relevant, and well explained. For example, simple sentence structure was used and the average sentence length was 16 words with most words having two or less syllables. Additionally, information provided in each of the messages was taken from scientific sources to ensure accuracy.

**Literacy and readability.** Literacy and readability level were held constant across all messages at an 8th grade level. The Flesch-Kincaid index was used to assess readability and grade level. Message titles and source information were not included in the literacy and readability assessment.

**Message length.** Message length was also held constant across evidence type. The number of words in each message was the same around a 5% median interval for each evidence type. Across text-only messages, word length ranged from 428 to 451 words with a median score of 440 words. Across graph-only messages, word length ranged from 361 to 380 words with a median score of 371 words. Across messages with both text and graph presentations, word length ranged from 434 to 458 with a median score of 446. Titles, citations, and bar graph content were not included in calculations of message length.

**Message typeset.** The following message format variables were held constant as well: (a) *Times New Roman* was used as the font-type in all of the messages, and (b) font-size
for titles (18 point), message content (14 point), and source (12 point) were consistent throughout the messages.

**Statistical Evidence Manipulation within TPB Messages**

The statistical evidence manipulation occurred in the third paragraph of each of the messages. Specifically, the third paragraph pointed to research that suggested that some risk has been associated with GM foods. The results of the research were presented either in percentage, bar graph, or both percentage and bar graph formats. The number of numeric representations was constant across messages. Specifically, the statistical evidence manipulation included 6 numeric representations based on the sample and results of the study presented in the message. For example, in the message dealing with allergens associated with a Brazil nut, the statistical evidence presented information about the size of the allergic reaction (e.g., size of hives in millimeters) to doses of a Brazil nut allergen. The food allergen message provided statistical evidence about the number of product recalls for a series of years. The statistical evidence was presented in a text format with percentages, a bar graph format, OR a percentage and bar graph format where the manipulation consists of both of the previous formats. Bar graph representations were also presented as similarly as possible across messages.

**Validity Check of Messages**

Before messages were piloted, a face validity check was conducted by an expert in biotechnology. The messages were reviewed by the expert to ensure their accuracy and provide any insights to their presentation (N. Ostiguy, personal interview, June 20, 2001). Messages were found to be accurate and ready for piloting.
Pilot Study Methods

The purpose of the pilot study was to assess message clarity across topics, test the evidence manipulation in messages, and review the pilot instrumentation. It was important that participants perceived the messages to be clear and similar, but that they perceived differences in the type of statistical evidence provided in the messages. Thus, the goals of the pilot study were to check for message clarity, evidence manipulation, and overall effectiveness of experimental materials and data collection procedures to promote the validity and reliability of the study.

Design of Pilot Study

A 3 (evidence type: text only, graph only, both text and graph) x 4 (message topic: rats, Brazil nut, food recall, control) between subjects design was used for the pilot study. Each message condition was manipulated to contain one of three versions of statistical evidence about one of the three message topics related to genetically modified foods or a control message so that evidence type AND message topic were balanced across the design. Messages were ordered using a random numbers table and participants were assigned to one message condition.

Participants and Procedures

Participants (N=58) for the pilot study were recruited from a basic course in the Department of Communication Arts & Sciences, Pennsylvania State University. Participants ranged in age from 18 to 27 years and were predominantly European Americans. All participants (N=58) received extra credit for their participation in the study. Participants for the pilot study were told that the purpose of the research was to examine knowledge, attitudes, and beliefs about genetically modified foods. The
researcher asked participants to read the consent form, sign it, and keep a copy for themselves.

Participants read one experimental message and then answered open-ended questions asking their opinion about the clarity of the messages. Message clarity was then assessed via semantic differential scales as was the manipulation of statistical evidence. Participants also completed measures of math self-efficacy, math anxiety, numeracy ability, comprehension, attitudes, subjective norms, perceived behavioral control, and behavioral intentions. A control group underwent all of the same procedures, but was given an alternative message that did not pertain to genetically modified foods. The survey took anywhere from 15 to 35 minutes for participants to complete and the researcher remained available at all times to answer any questions that participants had regarding the message, survey instrument, or procedures. The few questions that were asked simply verified that the control message was indeed the correct message (e.g., participants wondered what book preservation had to do with GM foods) and to clarify directions (e.g., three participants needed clarification for how to complete the semantic differential scales). Upon completion of the survey instrument, participants were asked if they had any questions regarding the study. Finally, participants were then thanked for their involvement in the research.

Measures for Pilot Study

The primary purpose of the pilot study was to complete manipulation checks for message clarity and statistical evidence. The other measures (e.g., math self-efficacy, math anxiety, numeracy ability, comprehension, attitudes, subjective norms, perceived behavioral control, and behavioral intentions) completed by participants in the pilot study
are discussed in detail later in the methods of the larger study. They were examined in the pilot study for clarity, comprehension, and order effects.

Message clarity

The pilot study assessed message clarity by asking three open-ended questions about participants’ understanding of message content (e.g., *What information is missing/included that made it hard for you to understand the message?* and, *what suggestions do you have to help design better messages?*). Clarity was also assessed by two questions measured on 5-point semantic differential scales that asked whether the information in the message was *well explained* or *unclear* and *understandable* or *confusing*. Items to measure message clarity were included to demonstrate that all messages were understandable and equally clear in their use of language and organizational structure.

Evidence manipulation

The pilot study assessed the evidence manipulation by asking participants questions about the type of evidence used in each message. For example, participants were asked whether the information in the message depended on *visual graphics* or *no visual graphics*, *facts* or *emotions*, and *statistics* or *stories*. Items to measure the evidence manipulation were included to demonstrate that participants are indeed perceiving differences between the types of numeric information that were presented to them.

Order effects

The pilot study also looked for order effects. The first part of each questionnaire packet was ordered in the following way: (1) message; (2) open-ended questions; (3)
evidence manipulation; (4) message clarity; and (5) comprehension. To control for order effects, three versions of the second part of the questionnaire were compiled to include the following measures: (1) numeracy ability; (2) attitudes; (3) subjective norms; (4) perceived behavioral control; (5) behavioral intentions; (6) math anxiety; and (7) math self-efficacy. Demographic information consistently remained the last measure across versions.

**Survey content**

The pilot instrument included the aforementioned manipulation checks as well as questions that measured numeracy ability, comprehension, subjective norms, perceived control, behavioral intentions, and demographic information. Questions measuring these constructs were included primarily to pilot for order effects as well as for their wording and understanding by participants.

**Results of Pilot Study**

**Results of Message Clarity**

Data for the pilot study were collected during the last week of a public speaking class, which likely increased the critical assessment of the messages as students had just completed a course that focused on the effective construction and presentation of messages. Students provided constructive feedback to improve the presentation of the messages. Overall, students understood the messages and offered suggestions to increase the clarity of the messages. All suggestions were considered, but only those suggestions that were within the goals and parameters of the study were implemented. For example, several word changes were suggested and students also indicated the need for a more elaborate definition of genetic engineering. However, some suggestions were
inappropriate (e.g., more information about the effects of GM foods on human organs) and beyond the scope of this particular study. Thus, while all suggestions were considered equally, some were applied and some were not based on the goals of the study.

Messages were compared to each other based on participants’ perceptions of message clarity. Two one-way ANOVAs were conducted using message topic as the independent variable and the two message clarity items as the dependent variables. There was no significant difference between message topics on message clarity at the .05 level. Table 3.1 provides descriptive statistics for message clarity.

<table>
<thead>
<tr>
<th>Clarity</th>
<th>M</th>
<th>n</th>
<th>SD</th>
</tr>
</thead>
<tbody>
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<td>15</td>
<td>1.10</td>
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<tr>
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<tr>
<td>Food Recalls</td>
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</tr>
<tr>
<td>Book</td>
<td>2.57</td>
<td>14</td>
<td>.94</td>
</tr>
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</table>
Results of Message Affect and Involvement

Messages were also compared to each other based on participants’ perceptions of message affect and involvement. A series of six one-way ANOVAS was conducted using message topic as the independent variable and the four message affect items and the two involvement variables as the dependent variables. There were no significant differences between message topics on the message affect or message involvement variables at the .05 level. Table 3.2 provides descriptive statistics for message affect and involvement.

Table 3.2

Means and Standard Deviations for Message Topic by Message Affect

<table>
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<tr>
<th></th>
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</thead>
<tbody>
<tr>
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<td>.83</td>
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<td>Food Recalls</td>
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<td>Fearful vs. Confident</td>
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</tr>
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<tr>
<td>Rat</td>
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<td>.83</td>
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<td>Food Recalls</td>
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<tr>
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Table 3.2 Continued

Means and Standard Deviations for Message Topic by Message Affect

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<td></td>
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<tr>
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<td>14</td>
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<td></td>
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</tr>
<tr>
<td>Book</td>
<td>3.00</td>
<td>14</td>
<td>1.04</td>
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</table>

Results of Manipulation Check of Evidence

A manipulation check for the type of statistical evidence presented in the message was conducted as part of the pilot study (N=58). The manipulation check was conducted to test whether individuals could perceive the difference between the three types of statistical evidence (bar graph, percentage, or both) provided in the messages. In other words, participants needed to be able to discern that the statistics provided in the message were presented primarily as a percentage in the text of the message, within a bar graph, or
using a combined approach to ensure that the manipulation of statistical evidence was effective. Results indicated that the wording of the question for this manipulation check was unclear to participants. Specifically, participants seemed to be confused by the wording of the semantic differential question that asked, “The information presented in this message depends on: visual graphics ____1 ____2 ____3 ____4 ____5 no visual graphics.” After revising several more versions of the question, a separate manipulation check for evidence type was conducted. The questionnaire read more clearly and asked participants (N=37) to read one of the twelve messages in the study and answer three questions based on the information presented in the message. The revised semantic differential scales read as follows:

The information presented in this message depends on:

Bar Graph ____1 ____2 ____3 ____4 ____5 No Bar Graph
Bar Graph ____1 ____2 ____3 ____4 ____5 Percentages
Text ____1 ____2 ____3 ____4 ____5 Bar Graph

Three one-way ANOVAs were computed to compare evidence type (text-only, bar graph-only, both text and bar graph) on the three dependent variables (bar graph, percentages, text). Table 3.3 provides descriptive statistics for the manipulation check for statistical evidence.

Presence of bar graph. Results of a one-way ANOVA indicated significant differences between evidence types on the “no graph” variable (presence of a bar graph) ($F_{(2,35)} = 34.71$, $p < .001$, Adj. $R^2 = .65$). Post-hoc analyses revealed that the text-only message was rated much higher on not having a bar graph ($M = 4.21$, $SD = 1.48$) as compared to the graph-only ($M = 1.46$, $SD = .88$) and text-plus-graph versions ($M = 1.09$, $SD = 1.09$).
Table 3.3
Manipulation Check: Means and Standard Deviations for Presentations of Statistical Evidence

<table>
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<th>Evidence</th>
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</thead>
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<td></td>
<td></td>
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<td>Graph Only</td>
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<td>.88</td>
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<td>Text &amp; Graph</td>
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<td>.30</td>
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<td><strong>Graph vs. Percentage</strong></td>
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<td>.79</td>
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<td><strong>Text vs. Graph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text Only</td>
<td>1.36</td>
<td>14</td>
<td>.75</td>
</tr>
<tr>
<td>Graph Only</td>
<td>2.85</td>
<td>13</td>
<td>1.28</td>
</tr>
<tr>
<td>Text &amp; Graph</td>
<td>2.55</td>
<td>11</td>
<td>1.13</td>
</tr>
</tbody>
</table>

SD = .30). As expected, no significant differences existed between the graph-only and text-plus-graph versions on the bar graph variable at the .05 level. In other words, results indicated that the message without a bar graph was rated as not having one, and that the
two messages with bar graphs were rated as having the bar graphs present. The manipulation of bar graph evidence was successful.

**Percentages.** Results indicated significant differences between the three types of evidence on the bar graph vs. percentage variable ($F_{(2,30)} = 30.41, p < .001, \text{ Adj. } R^2 = .64$). Post-hoc analyses revealed that individuals who received a text-only message rated the messages more closely to percentages than individuals who received the text-plus-graph version (Mean difference = 1.16, $p = .02$) or the graph-only message (Mean difference = 2.95, $p < .01$). Additionally, significant mean differences were found between the text-plus-graph message and the graph-only message (Mean difference = 1.78, $p < .01$). As expected, the results indicated that the percentage-only message was rated as relying on percentages to present the statistical information, whereas the combined evidence was rated as containing both kinds of evidence, and the bar graph-only message relied on a bar graph to present statistical information. The manipulation of percentage evidence was successful.

**Text.** Results indicated a significant difference between type of evidence on the text vs. bar graph variable ($F_{(2,35)} = 7.37, p < .01, \text{ Adj. } R^2 = .26$). Post-hoc analyses revealed that individuals who received the percentage-only message rated the message as having more text than the combined evidence (percentage-plus-graph) version (Mean difference = 1.49, $p < .01$) or the bar graph-only message (Mean difference = 1.19, $p = .02$). As expected, no significant differences existed between the combined version and the bar graph-only message at the .05 level. Differences between these latter two versions would not be expected because both versions have text and a graph present within the message content. In other words, participants saw that the percentage-only version of the
statistical evidence as based primarily on text (because the percentages are embedded in the text rather than in a bar graph), and saw the other versions as based on both text and bar graphs (because both messages contained both text and bar graphs). Overall, based on the results of these manipulation checks, the manipulation of evidence was considered successful.

Results of Order Effect

Due to the length of the survey, three versions of the survey were created to control for any order effects. Eight one-way ANOVAs were conducted, using survey version as the independent variable (three types) and items that measured attitudes, subjective norms, perceived behavioral control, intentions, math anxiety, and math self-efficacy as the dependent variables. Two items were found to be significantly different at the .05 level, “toxins can be passed on to people if they eat GM foods” and “food labels are often wrong.” The Bonferroni correction (.05 significance level divided by eight comparisons) was used to set the significant level to .004. Using this correction, the first item regarding toxins was no longer significantly different between versions (p = .04). However, significant differences between versions of the survey on the item, “food labels are often wrong,” still remained even with the significance level set at .004 using the Bonferroni correction $F_{(2,57)} = 5.88, p < .004$. These findings suggest that this item should be placed elsewhere in the survey because it is possible that the ordering of the questions affected individuals’ responses to that question.

Pilot Summary

The pilot study demonstrated effective manipulations of evidence and indicated equivalence among the different messages on message clarity, affect, and involvement.
Based on these findings, the messages can be collapsed for this study, thus increasing the generalizability of findings as message effects will not be dismissed as an artifact of message topics. Based on the results of the pilot study, the messages used in the study were considered appropriate experimental materials for the larger study. The experimental material and methods for the larger study remain predominantly the same as in the pilot study. Methods for the study and survey measures are discussed next.

Methods for Study

A 3 (evidence type: text only, graph only, both text and graph) x 4 (message topic: rats, Brazil nut, food recall, control) between subjects, pre-test/post-test design was used in this study. Participants were exposed to one message that was manipulated to contain one of the three types of statistical evidence pertaining to information about one of three topics related to genetically modified foods or a control message. Participants completed measures of math self-efficacy and pre-math anxiety prior to reading a message, read one of the four possible messages, and then completed measures of post-math anxiety, comprehension, attitudes, subjective norms, perceived behavioral control, behavioral intentions, math ability, and demographic information. The control group underwent all of the same procedures, but was given an alternative message about book preservation.

Sample size

According to Glass and Hopkins (1996), a small effect size in the field of communication is .18 (p.303). Using an effect size of .18 and power (β).80, with a one-tailed alpha of .05, the minimum number of cases per cell should be a minimum of (n = 30) for a total of (N=360).
Participants

Participants (N=431) were recruited from a basic course in the Department of Communication Arts and Sciences, Pennsylvania State University. Participants included 221 female students (51.3%), 201 male students (46.6%), and nine students who did not report their sex (2.1%). Most students were of European American descent (84.2%), while other ethnic and racial backgrounds were also represented, [Asians (6.5%), African American (2.6%), Hispanic (1.9%), Other (2.6%)]. Ten participants did not report their ethnic/racial background (2.3%). The age of participants ranged from 18 to 40 years (M = 19.88; SD = 2.64), with the vast majority (95.8%) between the ages of 18 to 22 years. Participants’ college majors were a representative cross-section of those available at a large public university because students were recruited from a basic public speaking course that is required of all majors for graduation. Food allergies existed for 8.8% of the sample, with most food allergies identified as nuts, certain fruits, dairy products, and food dyes.

Survey Instrument

Comprehension

Eight comprehension questions based on message content were developed to measure participants’ understanding of the information and statistical evidence presented in the health messages. Three questions asked about comprehension of the overall text. (e.g., “According to the message, when are GM foods required to be labeled?”). Five questions asked about participants’ comprehension of the statistical evidence presented in each of the messages (e.g., “Based on the results of the study reported in the message, which person was the most sensitive to the GM soybeans?” or “Based on the results of
the study reported in the message, which type of potato has the smallest effect on the small intestine?”).

**Attitudes**

Attitudes were assessed by 17 items measured on a 5-point Likert scale, where one was *strongly disagree* and five is *strongly agree*. Examples of items that measured attitudes include “GM foods are safe to eat” and “offering unlabeled GM foods to consumers is bad.”

**Subjective norms**

Subjective norms were assessed by 6 items measured on a 5-point Likert scale, where one is *strongly disagree* and five is *strongly agree*. Examples of items that measured subjective norms include “I care about what my friends think about GM foods” and “my family thinks that GM foods are safe to eat.”

**Perceived behavioral control**

Perceived behavioral control was assessed by 11 items measured on a 5-point Likert scale, where one is *strongly disagree* and five is *strongly agree*. Examples of items that measured perceived behavioral control include “industry has more control over the food I eat than I do” and “I know how to read food labels correctly.”

**Behavioral intentions**

Behavioral intentions were assessed by 16 items measured on a 5-point Likert scale, where one is *strongly disagree* and five is *strongly agree*. These measures are constructed to deal specifically with the constructs within the content domain of genetically modified foods. Examples of the items include “I plan to purchase genetically modified foods” and “I plan to ask if restaurants are using GM foods.”
Demographics

Participants were asked to respond to nine questions about themselves including: sex, age, ethnicity, education level, student status and college major, length of residency in the United States, number of children, and types of allergies from which they might suffer.

Covariates

Numeracy

Numeracy was measured using six items taken from an instrument commonly used to measure math ability (Schwartz, Woloshin, Black, & Welch, 1997). The questions were included as a measure of basic math and problem-solving ability. Examples of questions include “On a $200 dinner, how much would a 15% tip be?” and “In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percentage of chance do you have of winning if you purchased 10 tickets?”

Math anxiety

Math Anxiety was measured using a revised version of the Mathematics Anxiety scale (Betz, 1978). The scale is part of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), and is designed to assess the feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics (Fennema & Sherman, 1976). Betz (1978) adapted the scale from high school students to college students to consist of ten Likert-type questions, ranging from one to five, where one is strongly disagree and five is strongly agree. Half of the questions are worded positively (e.g., “I usually don’t worry about my ability to solve math problems”) and half are word negatively (e.g., “Mathematics makes me feel uneasy and confused”). The
first item of the scale was adapted to reflect a recommendation to change the item to a positively worded item that reflects coping with a negative affective reaction (e.g., “I am not frightened of taking math tests”) (Pajares & Urdan, 1996). The scale is reported to have a high reliability, Cronbach’s alpha = .92 (Betz, 1978; Pajares & Urdan, 1996).

Math self-efficacy

Betz & Hackett’s (1983) Mathematics Self-Efficacy Scale was used to measure math self-efficacy. The original scale consists of 52 items measured on a 10-point scale ranging from no confidence at all to complete confidence. The instrument was abbreviated for this study to include only questions about math tasks. The instrument included 13 Likert-type questions measured on a 5-point scale, where 1 is strongly disagree and five is strongly agree. Examples of questions include, “I am confident in my ability to understand a graph accompanying an article on business profits,” and “I am confident in my ability to understand how much interest I will earn on my savings account in 6 months, and how that interest is computed.” The Mathematics Self-Efficacy Scale is reported to have a high reliability, Cronbach’s alpha = .90 (Betz & Hackett, 1983).

Data Collection Procedures

A consent form and a questionnaire packet were administered to participants in two settings, a communication laboratory (N=313) and a classroom setting (N=118). Approximately 11 participants completed the questionnaire packet in each data collection session in the communication laboratory, while 26 to 30 participants completed the questionnaire packet in each of the four classroom data collection sessions. The questionnaire packet included one of the 12 possible messages used in the study and the
survey instrument that included all the previously mentioned measures. The researcher asked each of the participants to read the consent form, sign it, and keep a copy for themselves. Messages were then randomly assigned to participants, using a pair of dice. Specifically, participants were asked to roll the dice and then given a message based upon the numbers shown on the upward face of the dice. Participants were then asked to complete the questionnaire, and the researcher remained available to answer any questions that participants might have in regard to the research. The same data collection procedures were used in both the laboratory and classroom settings except that directions were given to participants individually in the laboratory setting and to the entire group in the classroom setting. Additionally, random assignment of the messages occurred (still using dice) prior to the researcher’s arrival to the four classrooms. Similar to the pilot study, the questionnaire took approximately 25 minutes to complete. Upon finishing the questionnaire, the researcher answered any questions from participants and then thanked them for their involvement in the research.
CHAPTER 4

RESULTS

Chapter 2 provided a review of relevant literature and rationale for using the Theory of Planned Behavior to inform the construction of messages about genetically modified foods. Additionally, literature related to the use of statistical evidence and numeracy variables was discussed, leading to the six hypotheses and two research questions that guide the current inquiry. Chapter 3 detailed the methodology for the investigation of the hypotheses and research questions, providing information about the development of experimental materials, pilot data collection and related results, and procedures for data collection. Chapter 4 summarizes the results of the data analyses conducted to test the hypotheses and research questions.

Preliminary Data Analysis

Before data analyses were conducted to test hypotheses and research questions, missing data and order effects were addressed. A factor analysis was also conducted as a method for data reduction. Message equivalence checks conducted in the pilot study and reported in the previous chapter allow the three messages pertaining to GM foods to be collapsed for analyses of hypotheses and research questions. All analyses were conducted using the 9.0 version of the Statistical Package for the Social Sciences (SPSS).

Missing Data

The measures of central tendency were examined as a method for assessing an appropriate strategy to handle missing data. Mean replacement was used as it has been deemed to be an appropriate strategy when less than 2% of the data are missing.
The current data set had very few items that were not completed and in those cases where variables had no responses, the percentage met the above criteria.

**Data Distribution**

Descriptive statistics were examined to assess whether any variables fell outside the skewness and kurtosis range of -2 to +2 (Curran, West, Finch, 1996). Four such items were observed ("GM foods should be labeled," "My doctor’s attitude toward GM foods is positive," "My doctor thinks GM foods are safe to eat," and "My family’s attitude toward GM foods is positive.") and deleted from further analysis.

**Order Effects**

One-way ANOVAS were computed to assess whether the three versions of the survey, which differed in the order in which participants answered the items, had any items in which statistically significant differences occurred. The significance level was set at .004 for these tests, using the Bonferroni adjustment for multiple comparisons (.05 divided by 12 comparisons). Three items were found to be significant at the .004 alpha level ("I care about what my doctor thinks about GM foods," "I care about what my friends think about GM foods," and "Eating GM foods can change the genes of adults."). All three items were deleted from further analysis.

**Factor Analysis**

Exploratory factor analysis is an appropriate method for data reduction as it helps to define variables and the relationships between them more precisely (Comrey & Lee, 1992). Principal axis factoring yields similar results to principal components analysis, but

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2 Based on the findings and the more than adequate sample size of the pilot study (N=58), the researcher decided to remove message equivalence checks from the final study to reduce the length of the survey from
is a stronger method for detecting structure among variables because the analyses only use variability in an item that is in common with other items. Thus, principal axis factoring with varimax rotation was selected toward the aim of reducing items and creating reliable factors that account for a maximum amount of variance. Items for the factor analyses were initially retained based on the defined constructs of the theory of planned behavior (TPB). The following criteria were applied in decisions to retain an item: (a) the theoretical meaning of variables as they relate to the constructs of the TPB (Ajzen, 1985); (b) factor loading of .60 or greater; (c) no secondary factor loading exceeding .35; (d) loading on a factor with a minimum of two items; and (e) factor’s eigenvalue exceeds 1.0 (Comrey & Lee, 1992).

**Attitudes**

Application of the above criteria to the initial analysis of 28 attitude items ultimately contributed to the elimination of eight items. Based on the final analysis of the remaining 20 items, a three-factor solution emerged as the most parsimonious structure for attitudes, accounting for 62.56% of the variance.

**GM safety.** The first factor, labeled “GM Safety,” accounted for 28.38% of the variance and was comprised of ten items (e.g., “GM foods are unhealthy for humans to eat,” and “I think the risks associated with GM foods are high”). Reliability analysis resulted in a Cronbach coefficient alpha = .93. Table 4.1 provides a summary of the rotated factor loadings for the GM Safety factor.

**Developmental effects.** The second factor, labeled “Developmental Effects,” accounted for 20.20% of the variance and was comprised of five items (e.g., “Eating GM foods can change children’s genes,” and “Eating GM foods can harm adolescent’s
genes”). Reliability analysis generated a Cronbach coefficient alpha = .95. Please see Table 4.1 for the rotated factor loadings for the Developmental Effects factor.

**GM salience.** The third factor, labeled “GM Salience,” accounted for 13.97% of the variance and was comprised of five items (e.g., “The safety of GM foods is an important issue,” and “Labeling of GM foods is an important issue”). Reliability analysis obtained a Cronbach coefficient alpha = .84. Please see Table 4.1 for the rotated factor loadings for the GM Salience factor.

Table 4.1

**Retained Factor Loadings for Attitude Subscales**

<table>
<thead>
<tr>
<th>ATTHLTHY</th>
<th>ATTDVLP</th>
<th>ATTGMIMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM foods are safe to eat.</td>
<td>-.76</td>
<td>-.18</td>
</tr>
<tr>
<td>GM foods are unhealthy for humans to eat.</td>
<td>.75</td>
<td>.34</td>
</tr>
<tr>
<td>The effect of GM foods on people is bad.</td>
<td>.73</td>
<td>.32</td>
</tr>
<tr>
<td>GM foods are not safe to eat.</td>
<td>.84</td>
<td>.26</td>
</tr>
<tr>
<td>It is okay that some foods are GM.</td>
<td>-.71</td>
<td>-.20</td>
</tr>
<tr>
<td>GM foods are healthy for humans to eat.</td>
<td>-.71</td>
<td>-.20</td>
</tr>
<tr>
<td>Genetically modified foods are risky to eat.</td>
<td>.69</td>
<td>.24</td>
</tr>
<tr>
<td>I think the risks of GM foods are high.</td>
<td>.66</td>
<td>.24</td>
</tr>
</tbody>
</table>

**Note.** ATTHLTHY = Safety of genetically modified foods (Cronbach’s alpha = .93); ATTDVLP = Developmental effects associated with GM foods (Cronbach’s alpha = .95); and ATTGMIMP = Salience of genetically modified foods (Cronbach’s alpha = .84)
Table 4.1 Continued

Retained Factor Loadings for Attitude Subscales

<table>
<thead>
<tr>
<th></th>
<th>ATTHLTHY</th>
<th>ATTDVLP</th>
<th>ATTGMIMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think the benefits of GM foods are high.</td>
<td>-.61</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>I am afraid to eat GM foods.</td>
<td>.67</td>
<td>.23</td>
<td>.12</td>
</tr>
<tr>
<td>Eating GM foods can change children’s genes.</td>
<td>.35</td>
<td>.85</td>
<td>.00</td>
</tr>
<tr>
<td>Eating GM foods can harm adolescents’ genes.</td>
<td>.32</td>
<td>.88</td>
<td>.00</td>
</tr>
<tr>
<td>Eating GM foods can harm children’s genes.</td>
<td>.34</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Eating GM foods can change adolescents’ genes.</td>
<td>.19</td>
<td>.81</td>
<td>.00</td>
</tr>
<tr>
<td>Eating GM foods can harm the genes of adults.</td>
<td>.33</td>
<td>.79</td>
<td>.00</td>
</tr>
<tr>
<td>The safety of GM foods is an important issue.</td>
<td>.00</td>
<td>.00</td>
<td>.76</td>
</tr>
<tr>
<td>Labeling of GM foods is an important issue.</td>
<td>.22</td>
<td>.00</td>
<td>.72</td>
</tr>
<tr>
<td>The nutritional value of GM foods is an important issue.</td>
<td>.00</td>
<td>.00</td>
<td>.63</td>
</tr>
<tr>
<td>Allergens in GM foods are an important issue.</td>
<td>.11</td>
<td>.00</td>
<td>.70</td>
</tr>
<tr>
<td>Toxins in GM foods are an important issue.</td>
<td>.00</td>
<td>.00</td>
<td>.79</td>
</tr>
</tbody>
</table>

Note. GMSAFE = Safety of genetically modified foods (Cronbach’s alpha = .93); DE = Developmental effects associated with GM foods (Cronbach’s alpha = .95); and GMSAL = Salience of genetically modified foods (Cronbach’s alpha = .84)

Subjective Norms

Three subjective norm items were eliminated from further analysis due to kurtosis values greater than +2 or –2. Two more items were eliminated due to order effects,
leaving four items to be factor analyzed. Based on the factor analysis criteria for retaining items, one more subjective norm item was eliminated. The remaining 3 items (e.g., “My family thinks GM foods are safe to eat” and “Most of my friends’ attitudes towards GM foods are positive”) resulted in a single factor solution, which accounted for 46.58% of the variance. Reliability analysis obtained a Cronbach coefficient alpha = .71. Please see Table 4.2 for the factor loadings for the “Subjective Norm” factor.

Table 4.2

<table>
<thead>
<tr>
<th>Retained Factor Loadings for Subjective Norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>My family thinks that GM foods are safe to eat.</td>
</tr>
<tr>
<td>Most of my friends’ attitudes toward GM foods are positive.</td>
</tr>
<tr>
<td>Friends who are important to me think that GM foods are safe to eat.</td>
</tr>
</tbody>
</table>

Note. Cronbach’s alpha = .71

Perceived Behavioral Control

As a result of the application of the factor analysis criteria for item retention, six items were eliminated from the initial analysis of 11 perceived behavioral control items. Based on the final analysis of the remaining 5 items, a two-factor solution emerged as the most parsimonious structure for perceived behavioral control, accounting for 72.86% of the variance.

Label comprehension. The first factor, “Label Comprehension,” accounted for 44.39% of the variance and consisted of three items (e.g., “I understand food labels when
I read them,” and “I know how to read food labels correctly”). Reliability analysis achieved a Cronbach coefficient alpha = .90. Table 4.3 provides a summary of the rotated factor loadings for the Label Comprehension factor.

**GM food control.** The second factor, labeled “GM Food Control,” accounted for 28.48% of the variance and entailed two items (“The government has more control over the food I eat than I do,” and “Industry has more control over the food I eat than I do”). Reliability analysis resulted in a Cronbach coefficient alpha = .83. Please see Table 4.3 for the rotated factor loadings for the GM Food Control factor.

Table 4.3

<table>
<thead>
<tr>
<th></th>
<th>PBCCNTRL</th>
<th>PBCLABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry has more control over the food I eat than I do.</td>
<td>.84</td>
<td>.00</td>
</tr>
<tr>
<td>The government has more control over the food I eat than I do.</td>
<td>.84</td>
<td>.00</td>
</tr>
<tr>
<td>I understand food labels when I read them.</td>
<td>.00</td>
<td>.86</td>
</tr>
<tr>
<td>I know how to read food labels correctly.</td>
<td>.00</td>
<td>.86</td>
</tr>
<tr>
<td>I do not understand food labels.</td>
<td>.00</td>
<td>-.86</td>
</tr>
</tbody>
</table>

**Note.** PBCCNTRL = Control of GM foods (Cronbach’s alpha = .83); PBCLABEL = Comprehension of labels (Cronbach’s alpha = .90)

**Behavioral Intentions**

Application of the factor analysis criteria for item retention to the initial analysis of 24 behavioral intention items resulted in the elimination of 17 behavioral intention
items. Based on the final analysis of the remaining 7 items, a two-factor solution emerged as the most parsimonious structure for behavioral intentions, accounting for 64.73% of the variance.

**Information seeking.** The first factor, labeled “Information Seeking,” accounted for 36.96% of the variance and consisted of four items (e.g., “I plan to find out more information about GM foods,” and “I plan to ask my doctor about GM foods”). Reliability analysis obtained a Cronbach coefficient alpha = .86. Table 4.4 provides a summary of the rotated factor loadings for the Information Seeking factor.

**Anti-GM communication.** The second factor, labeled “Anti-GM Communication,” accounted for 27.76% of the variance and contained three items (e.g., “I plan to tell my friends that GM foods are not safe to eat,” and “I plan to protest against the manufacturing of GM foods”). Reliability analysis obtained a Cronbach coefficient alpha = .82. Please see Table 4.4 for the rotated factor loadings for the Anti-GM Communication factor.

**Hypothesis Tests and Research Questions**

**Hypothesis 1**

An important covariate in assessing behavioral intentions toward GM foods is existence of food allergies. Thus, to examine differences between participants with allergies and those without them, a MANOVA was conducted with each of the TPB variables as the dependent variables and existence of a food allergy as the independent variable. Levene’s test of homogeneity of variance indicated no significant differences between the groups on each of the dependent variables. Results indicated no significant differences in behavioral intention to seek information about GM foods ($F_{(1,321)} = .25; p$
behavioral intention to discourage consumption of GM foods ($F_{(1,321)} = .10; p = .75; \eta^2 < .001; power = .06$); attitude of safety about GM foods ($F_{(1,321)} = .13; p = .72; \eta^2 < .001; power = .07$); developmental effects about GM foods ($F_{(1,321)} = 2.62; p = .11; \eta^2 < .01; power = .37$); salience of GM foods ($F_{(1,321)} = 2.25; p = .13; \eta^2 < .01; power = .32$); perceived labeling comprehension ($F_{(1,321)} = .03; p = .87; \eta^2 < .001; power = .05$); perceived control over consumption of GM foods ($F_{(1,321)} = .53; p = .47; \eta^2 < .01; power = .11$); and the subjective norm factor ($F_{(1,321)} = 1.86; p = .17; \eta^2 < .01; power = .27$). Overall, there were no significant differences between individuals with allergies and those without them on attitudes, perceptions of control, and subjective norm toward GM foods. Thus, the two groups can be grouped together for further analyses.

Table 4.4
Retained Factor Loadings for Behavioral Intentions

<table>
<thead>
<tr>
<th>Behavior</th>
<th>BISEEK</th>
<th>BINEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to ask my doctor about GM foods.</td>
<td>.62</td>
<td>.35</td>
</tr>
<tr>
<td>I plan find out if GM foods are safe to eat.</td>
<td>.83</td>
<td>.30</td>
</tr>
<tr>
<td>I plan to use the internet to get more info.</td>
<td>.84</td>
<td>.25</td>
</tr>
<tr>
<td>I plan to find out more info about GM foods.</td>
<td>.76</td>
<td>.26</td>
</tr>
<tr>
<td>I plan to discourage my family from eating GM foods.</td>
<td>.30</td>
<td>.75</td>
</tr>
<tr>
<td>I plan to protest against the manufacturing of GM food.</td>
<td>.25</td>
<td>.69</td>
</tr>
<tr>
<td>I plan to tell my friends that GM foods are not safe to eat.</td>
<td>.25</td>
<td>.75</td>
</tr>
</tbody>
</table>

Note. BISEEK = Information Seeking (Cronbach’s alpha = .86); and BINEG = Anti-GM Communication (Cronbach’s alpha = .82)
Hypothesis one tested the Theory of Planned Behavior’s ability to predict the influence of attitudes, subjective norms and perceived control toward GM foods on behavioral intentions toward GM foods. Multiple regression analyses were conducted, with attitudes, subjective norms, and perceived control as the predictor variables and intention to seek more information about GM foods and intention to discourage the consumption of GM foods as the outcome variables. Pearson correlations were conducted to measure the relationship between attitudes, subjective norms, perceived control variables, and the outcome variables of behavioral intentions (intention to seek information and intention to discourage consumption of GM foods). See Table 4.5 for correlations between the predictor variables and behavioral intentions.

A stepwise regression analysis was conducted to test the predictive ability of the three attitude factors, a subjective norm factor, and two perceived behavioral control factors on behavioral intention to seek more information about GM foods. Attitudes about safety and GM salience, subjective norm factor, and perceived control over labeling comprehension contributed significantly to the regression equation \( (F_{(4,318)} = 64.01; \ p < .001; \ R^2 = .45) \). The attitude factor of GM salience accounted for 30% of the variance \( \beta = .40, (t = 9.02, \ p < .001) \); attitude about the safety of GM foods accounted for 13% of the variance, \( \beta = .44 (t = 9.19, \ p < .001) \), subjective norm factor 1% of the variance, \( \beta = .12 (t = 2.55, \ p = .01) \); and perceived control over labeling comprehension factor 1% of the variance, \( \beta = .11 (t = 2.53, \ p = .01) \).

A second stepwise regression analysis was conducted to test the predictive ability of the three attitude factors, a subjective norm factor, and two perceived behavioral control factors on behavioral intention to discourage consumption of GM foods.
Attitudes about safety and GM salience were the only two factors that contributed significantly to the regression equation \( (F_{(2,320)} = 342.21; p < .001; R^2 = .68) \). The attitude factor of GM salience accounted for 67% of the variance \( \beta = .79, (t = 23.74, p < .001) \) and attitude about the safety of GM foods accounted for just 1% of the variance, \( \beta = .11 (t = 3.42, p < .001) \). The results of the regression analyses partially support the constructs of the TPB as predictive of behavioral intentions.

Table 4.5

<table>
<thead>
<tr>
<th></th>
<th>BISEK</th>
<th>BINEG</th>
<th>AHLTH</th>
<th>ADVLP</th>
<th>AIMP</th>
<th>PCLAB</th>
<th>PCTRL</th>
<th>SN</th>
</tr>
</thead>
<tbody>
<tr>
<td>BISEK</td>
<td>1.00</td>
<td>.58**</td>
<td>.50**</td>
<td>.27**</td>
<td>.54**</td>
<td>.09</td>
<td>.09</td>
<td>-.04</td>
</tr>
<tr>
<td>BINEG</td>
<td>1.00</td>
<td>.82**</td>
<td>.45**</td>
<td>.35**</td>
<td>-.01</td>
<td>.10*</td>
<td>-.24**</td>
<td></td>
</tr>
<tr>
<td>AHLTH</td>
<td>1.00</td>
<td>.55**</td>
<td>.30**</td>
<td>-.16**</td>
<td>.13*</td>
<td>-.36**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADVLP</td>
<td>1.00</td>
<td>.09</td>
<td>-.11*</td>
<td>.07</td>
<td>-.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIMP</td>
<td>1.00</td>
<td>.11</td>
<td>.04</td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBCLAB</td>
<td>1.00</td>
<td>-.12*</td>
<td>.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCTRL</td>
<td>1.00</td>
<td></td>
<td>-.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p<.05, ** p<.01; (N=431)
Hypothesis 2

Hypothesis 2a

Hypothesis 2a predicted that the presentation of statistical evidence about risks associated with GM foods would create negative attitudes of risk about GM foods. To test this hypothesis a MANOVA was conducted with statistical evidence about GM foods compared to statistical evidence in a control message on the dependent variables of attitudes toward safety, developmental effects, and salience of GM foods (see Table 4.6 and Table 4.7). Message topics about GM foods were collapsed into a single variable that represented statistical evidence about GM foods. Results indicated a multivariate main effect for statistical evidence about GM foods ($F_{(1,429)} = 2.71; p = .04; \eta^2 = .02$; power = .66). However, univariate results yielded no significant differences between statistical evidence about GM foods and the control message on safety of GM foods ($F_{(1,429)} = 2.96; p = .09; \eta^2 = .01$; power = .40), developmental effects of GM foods ($F_{(1,429)} = 2.11; p = .15; \eta^2 = .01$; power = .31), and salience of GM foods ($F_{(1,429)} = 3.04; p = .08; \eta^2 = .01$; power = .41). Hypothesis 2a was supported by the multivariate test.
Table 4.6
Means and Standard Deviations for Attitudes by Statistical Evidence Topic

<table>
<thead>
<tr>
<th>Attitude</th>
<th>GM Food Messages</th>
<th>Control Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 323)</td>
<td>(n = 108)</td>
</tr>
<tr>
<td>Safety of GM Foods</td>
<td>2.60 .64</td>
<td>2.72 .61</td>
</tr>
<tr>
<td>Developmental Effects of GM Foods</td>
<td>2.41 .82</td>
<td>2.54 .74</td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>3.87 .62</td>
<td>3.76 .52</td>
</tr>
</tbody>
</table>

Table 4.7
Multivariate Analysis of Variance: Attitudes by Statistical Evidence Topic

<table>
<thead>
<tr>
<th>Attitude</th>
<th>df</th>
<th>F-value</th>
<th>eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety of GM Foods</td>
<td>1</td>
<td>2.96</td>
<td>.01</td>
</tr>
<tr>
<td>Developmental Effects of GM Foods</td>
<td>1</td>
<td>2.11</td>
<td>.01</td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>1</td>
<td>3.04</td>
<td>.01</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01.
Hypothesis 2b

Hypothesis 2b predicted that graphic, more than textual, forms of statistical evidence about GM foods would result in more negative attitudes of risk toward GM foods. Independent samples t-tests were conducted with type of evidence (graphic or text) as the independent variable and attitudes toward safety, developmental effects, and salience of GM foods as the dependent variables (see Table 4.8 and 4.9). Results of the t-tests indicated no significant differences between the two types of evidence on attitude toward safety of GM foods ($t_{(218)} = .81; p = .42$), developmental effects of GM foods ($t_{(218)} = -.62; p = .53$), or on salience of GM foods ($t_{(218)} = 1.93; p = .06$). Hypothesis 2b was not supported.

Table 4.8

Means and Standard Deviations for Attitudes by Type of Statistical Evidence

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Text (n = 109)</th>
<th>Graph (n = 111)</th>
<th>Both (n = 103)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Safety of GM Foods</td>
<td>2.65</td>
<td>.63</td>
<td>2.58</td>
</tr>
<tr>
<td>Developmental Effects of GM Foods</td>
<td>2.37</td>
<td>.85</td>
<td>2.44</td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>3.98</td>
<td>.53</td>
<td>3.82</td>
</tr>
</tbody>
</table>

Note. Different subscripts denote significant differences between the means of two groups.
Table 4.9

Independent Samples t-tests: Attitudes by Type of Statistical Evidence

<table>
<thead>
<tr>
<th>Attitude</th>
<th>df</th>
<th>t-value</th>
<th>2-tail Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety of GM Foods</td>
<td>218</td>
<td>.80</td>
<td>.42</td>
</tr>
<tr>
<td>Developmental Effects of GM Foods</td>
<td>218</td>
<td>-.62</td>
<td>.53</td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>218</td>
<td>1.93</td>
<td>.06</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01.

Hypothesis 2c

Hypothesis 2c extended 2b by predicting that multiple forms (combined format) more than singular forms (text or bar graph only) of statistical evidence result in more attitudes of negative risk toward GM foods. To test this hypothesis a MANOVA was conducted with type of evidence as the independent variable and attitudes toward safety, developmental effects, and salience of GM foods as the dependent variables (see Table 4.8 and Table 4.10). Results indicated no multivariate main effect for statistical evidence ($F_{(3,318)} = 1.15; p = .33; \eta^2 = .01; \text{power} = .46$). Univariate results indicated no significant differences between the three types of statistical evidence on attitude toward safety of GM foods ($F_{(2,320)} = .59; p = .56; \eta^2 < .01; \text{power} = .15$), developmental effects of GM foods ($F_{(2,320)} = .23; p = .80; \eta^2 < .01; \text{power} = .09$), and salience of GM foods ($F_{(2,320)} = 2.46; p = .09; \eta^2 = .02; \text{power} = .49$). Hypothesis 2c was not supported.
Table 4.10

Multivariate Analysis of Variance: Attitudes by Type of Statistical Evidence

<table>
<thead>
<tr>
<th>Attitude</th>
<th>df</th>
<th>F-value</th>
<th>eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety of GM Foods</td>
<td>2</td>
<td>.59</td>
<td>.004</td>
</tr>
<tr>
<td>Developmental Effects of GM Foods</td>
<td>2</td>
<td>.23</td>
<td>.001</td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>2</td>
<td>2.46</td>
<td>.02</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01.

Hypotheses 2d & 2e

Hypothesis 2d predicted that graphic more than textual forms of statistical evidence would result in greater comprehension of statistical evidence. Relatedly, hypothesis 2e predicted that multiple forms (combined format) more than singular forms (text or bar graph only) of statistical evidence would result in greater comprehension of statistical evidence. Using all of the data (N=431) because comprehension of statistical evidence was not GM message specific, a one-way ANOVA was used to test the hypotheses with statistical evidence (text only, bar graph only, and combined format) as the independent variable and comprehension as the dependent variable (see Table 4.11). There were significant differences between the three types of evidence on message comprehension ($F_{(2,428)} = 5.30; p < .01; \eta^2=.02; \text{power} = .84$) such that participants who received the text only percentage evidence comprehended less than participants who
received either the bar graph only evidence (Mean difference = -.26; p<.01) or the combined format evidence (Mean difference = -.23; p=.03). No significant differences existed between the graph only and the combined format evidence at the .05 level. The results suggest that bar graphs used in messages assist in comprehension of statistical evidence, however, a combined format does not increase comprehension any more than the bar graph alone. Hypothesis 2d was supported, whereas no support existed for hypothesis for 2e.

Table 4.11

<table>
<thead>
<tr>
<th>Evidence</th>
<th>M</th>
<th>n</th>
<th>SD</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text Only</td>
<td>3.36</td>
<td>145</td>
<td>.81</td>
<td>5.30</td>
</tr>
<tr>
<td>Graph Only</td>
<td>3.62</td>
<td>146</td>
<td>.70</td>
<td></td>
</tr>
<tr>
<td>Combined Format</td>
<td>3.59</td>
<td>140</td>
<td>.73</td>
<td></td>
</tr>
</tbody>
</table>

Note: Different subscripts denote significant differences between the means of two groups. *p < .05. **p < .01.

Hypothesis 3

Hypothesis 3a

Hypothesis 3a predicted that numeracy ability would be positively related to comprehension of statistical evidence. To test this hypothesis a bivariate correlation was
conducted between the variables of numeracy ability and message comprehension. All data \( (N = 431) \) were used in this analysis as this hypothesis was not specific to GM foods. Results indicated that numeracy ability was positively correlated with message comprehension \( (r = .22, p < .001) \). Hypothesis 3a was supported (see Table 4.12).

Table 4.12

Correlations Between Numeracy Ability, Comprehension, Pre-math Anxiety, Post-math Anxiety, and Math Self-efficacy

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>NA</th>
<th>PRE</th>
<th>POST</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension (C)</td>
<td>1.0</td>
<td>.22**</td>
<td>-.20**</td>
<td>-.21**</td>
<td>.16**</td>
</tr>
<tr>
<td>Numeracy Ability (NA)</td>
<td>1.0</td>
<td>-.33**</td>
<td>-.32**</td>
<td>.32**</td>
<td></td>
</tr>
<tr>
<td>Pre-math Anxiety (PRE)</td>
<td>1.0</td>
<td>.97**</td>
<td></td>
<td>-.54**</td>
<td></td>
</tr>
<tr>
<td>Post-math Anxiety (POST)</td>
<td>1.0</td>
<td></td>
<td>-.53**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Self-efficacy (MSE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01.

Research Question 1

Research question one asked how numeracy ability relates to comprehension of different types of statistical evidence. To answer this research question a one-way ANCOVA was conducted with type of evidence as the independent variable, numeracy ability as the covariate, and comprehension as the dependent variable (see Table 4.13).
Results indicated that the covariate of numeracy ability was statistically significant in accounting for variance associated with comprehension ($F_{(1,427)}= 19.25, p<.001, R=.26; \text{power} = .99$). After partitioning out the effects of numeracy ability, type of statistical evidence had an effect on comprehension of statistical evidence in messages ($F_{(2,427)}= 3.93, p=.02, \eta^2 = .02; \text{power} = .71$) such that participants who received the text only percentage evidence comprehended less than participants who received either the bar graph only evidence (Mean difference = -.23; $p<.01$) or the combined format evidence (Mean difference = .19; $p=.03$). No significant differences existed between the graph only and the combined format evidence at the .05 level. Thus, results indicate numeracy ability is positively related to comprehension of statistical evidence. After partitioning out the effects of numeracy ability, the bar graph only and combined formats of evidence were also related to greater comprehension as compared to text only percentage formats.

Table 4.13

One-way Analysis of Covariance: Comprehension by Type of Statistical Evidence with Numeracy Ability as Covariate

<table>
<thead>
<tr>
<th>Evidence</th>
<th>M</th>
<th>n</th>
<th>SD</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text Only</td>
<td>3.38a</td>
<td>145</td>
<td>.81</td>
<td>3.93</td>
</tr>
<tr>
<td>Graph Only</td>
<td>3.61b**</td>
<td>146</td>
<td>.70</td>
<td></td>
</tr>
<tr>
<td>Combined Format</td>
<td>3.58b*</td>
<td>140</td>
<td>.73</td>
<td></td>
</tr>
</tbody>
</table>

Note. Different subscripts denote significant differences between the means of two groups. *$p < .05$. **$p < .01$. 
Hypothesis 3b

Hypothesis 3b predicted that numeracy ability would covary with comprehension of statistical evidence such that greater numeracy ability would be related to less negative attitudes of risk toward GM foods, as the scientific evidence suggests that the actual risk is not as high as many individuals perceive the risk to be. Bivariate correlations between the predictor variables and outcome variables were conducted (see Table 4.14). A linear regression was then conducted for each of the three attitude variables, using a hierarchical method to input predictor variables in two blocks, with numeracy ability and comprehension as the first and second predictor variables, respectively. The same predictor variables and method were used for regression analyses on each of the outcome variables including, attitude about safety, developmental effects, and salience of GM foods as the dependent variables.

The first regression analysis indicated that numeracy ability contributed significantly to attitude about safety of GM foods \(F_{(1,321)} = 7.71, p < .01, R^2 = .02; \beta = -.15, t(321) = -2.78, p < .01\). The additional variable of comprehension of statistical evidence was also entered in a second regression equation, but the variable did not contribute any unique variance to the regression model \(R^2\) change = .003; \(\beta = -.06, t(320) = -2.78, p = .29\). The regression analyses for the dependent variables of attitude about developmental effects of GM foods and salience of GM foods did not produce significant regression models, \(F_{(1,321)} = 2.57, p = .11, R^2 = .01\) and \(F_{(1,321)} = 1.51, p = .22, R^2 = .01\), respectively. The results reveal that even though numeracy ability and comprehension of statistical evidence are correlated, comprehension does not add any unique variance in predicting attitudes about GM foods, whereas numeracy ability accounted for a small percentage of
variance, 2%, in attitude about the safety of GM foods. Hypothesis 3b was partially supported.

Table 4.14
Correlations Between Numeracy Ability, Comprehension, and Attitudes

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>NA</th>
<th>SAF</th>
<th>DE</th>
<th>SAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension (C)</td>
<td>1.0</td>
<td>.22**</td>
<td>-.08</td>
<td>-.09</td>
<td>.02</td>
</tr>
<tr>
<td>Numeracy Ability (NA)</td>
<td>1.0</td>
<td>-.18**</td>
<td>-.14**</td>
<td>-.05**</td>
<td></td>
</tr>
<tr>
<td>Safety of GM Foods (SAF)</td>
<td>1.0</td>
<td>.58**</td>
<td>.25**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Effects (DE)</td>
<td>1.0</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salience of GM Foods (SAL)</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01.

Hypothesis 4

Hypothesis 4a

Hypothesis 4a predicted that math anxiety would be negatively correlated with numeracy ability. To test this hypothesis a bivariate correlation was conducted between the variables of math anxiety and numeracy ability. All data (N = 431) were used in this analysis as this hypothesis was not specific to GM foods. Results indicated that both pre-math anxiety and post-math anxiety were negatively correlated with numeracy ability (r = -.33, p < .001; r = -.32, p < .001). Hypothesis 4a was supported (see Table 4.12).
Hypothesis 4b

Hypothesis 4b predicted that math anxiety would be negatively correlated with comprehension of statistical evidence. Bivariate correlations were conducted with the variables of pre-math anxiety, post-math anxiety, and comprehension (see Table 4.12). Results indicated that math anxiety was significantly negatively correlated with comprehension of statistical evidence ($r = -.20, p < .01; r = -.21, p < .01$). Hypothesis 4b was supported.

Hypothesis 4c

Hypothesis 4c predicted that math anxiety would be positively correlated with attitudes of risk toward GM foods. Bivariate correlations were performed with the variables of post-math anxiety and attitudes associated with the safety of GM foods, developmental effects of GM foods, and salience of GM foods (see Table 4.15). As expected, pre- and post-math anxiety were significantly correlated with both concern about the safety of GM foods ($r = .26, p < .01; r = .24, p < .01$) and the developmental effects of GM foods ($r = .15, p < .01; r = .24, p < .01$). There was not a significant correlation between pre- and post-math anxiety and salience of GM foods ($r = .05, p = .35; r = .02, p = .68$). Hypothesis 4c was partially supported.
Table 4.15

Correlations Between Math Anxiety, Math Self-Efficacy, Comprehension, and Attitudes

<table>
<thead>
<tr>
<th></th>
<th>POST</th>
<th>MSE</th>
<th>SAF</th>
<th>DE</th>
<th>SAL</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Math Anxiety (Pre)</td>
<td>.97</td>
<td>-.51**</td>
<td>.26**</td>
<td>.15**</td>
<td>.05</td>
<td>-.20**</td>
</tr>
<tr>
<td>Post-Math Anxiety (Post)</td>
<td>1.0</td>
<td>-.49**</td>
<td>.24**</td>
<td>.14**</td>
<td>.02</td>
<td>-.21**</td>
</tr>
<tr>
<td>Math Self-Efficacy (MSE)</td>
<td>1.0</td>
<td>-.25**</td>
<td>-.09</td>
<td>.03</td>
<td>.16**</td>
<td></td>
</tr>
<tr>
<td>Safety of GM Foods (SAF)</td>
<td>1.0</td>
<td>.55**</td>
<td>.30**</td>
<td>-.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Effects (DE)</td>
<td>1.0</td>
<td>.09</td>
<td>-.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salience of GM Foods (SAL)</td>
<td>1.0</td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01; (N = 323)

Research Question 2

Research question two asked how different types of statistical evidence affect levels of math anxiety. The variable of math anxiety was measured before and after the presentation of statistical evidence. A within-subjects repeated-measures ANOVA was conducted to determine whether type of evidence impacted math anxiety from pre-test to post-test (see Table 4.16). Math anxiety was used as the within-subjects variable and evidence was the between-subjects variable. Results indicated a main effect for anxiety ($F_{(1,428)} = 13.09; \ p < .001; \ \eta^2 = .03; \ \text{power} = .95$), such that there was a decrease in math anxiety from pre-test ($M=2.21$) to post-test ($M=2.17$; Mean difference = .04). However, there was not an interaction between anxiety and evidence ($F_{(2,428)} = .34; \ p = .71; \ \eta^2 =$...
.002; power = .10), indicating that different forms of evidence did not have an effect on decreasing levels of math anxiety from pre-test to post-test.

Table 4.16

Means and Standard Deviations for Pre- and Post- Math Anxiety by Type of Evidence

<table>
<thead>
<tr>
<th>Evidence Type</th>
<th>Pre Math Anxiety</th>
<th>Post Math Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text/Percentage Only (N=145)</td>
<td>2.27 .94</td>
<td>2.24 .94</td>
</tr>
<tr>
<td>Graph Only (N=146)</td>
<td>2.20 .97</td>
<td>2.15 .96</td>
</tr>
<tr>
<td>Combine Format (N=140)</td>
<td>2.17 .86</td>
<td>2.13 .90</td>
</tr>
</tbody>
</table>

Hypothesis 5

Hypothesis 5a

Hypothesis 5a predicted that math self-efficacy would be negatively correlated with math anxiety and positively correlated with numeracy ability. To test this hypothesis bivariate correlations were conducted between the variables of math self-efficacy, pre- and post-math anxiety, and numeracy ability. All data (N = 431) were used in this analysis as this hypothesis was not specific to GM foods. Results indicated that math self-efficacy was negatively correlated with both pre-math anxiety and post-math anxiety ($r = -.54, p < .001; r = -.53, p < .001$), respectively. Results also found that math self-
efficacy was positively correlated with numeracy ability ($r = .32$, $p < .001$). Hypothesis 5a was supported (see Table 4.12).

**Hypothesis 5b**

Hypothesis 5b predicted that math self-efficacy would be positively correlated with comprehension of presentations of statistical evidence. Bivariate correlations were conducted using the variables of math self-efficacy and comprehension of statistical evidence (see Table 4.15). Results indicated a significant positive correlation between math self-efficacy and comprehension of statistical evidence ($r = .16$, $p < .01$). Hypothesis 5b was supported.

**Hypothesis 5c**

Hypothesis 5c predicted that math self-efficacy would be negatively correlated with attitudes of risk toward GM foods. Bivariate correlations were performed with the variables of math self-efficacy and attitudes associated with the safety of GM foods, developmental effects of GM foods, and salience of GM foods (see Table 4.15). Results indicated a significant negative correlation between math self-efficacy and concern about the safety of GM foods ($r = -.25**$, $p < .01$). There were no significant relationships between math self-efficacy and developmental effects of GM foods ($r = -.09$, $p = .11$) or math self-efficacy and salience of GM foods ($r = .03$, $p = .01$). Hypothesis 5c was partially supported.

**Hypothesis 6**

**Hypothesis 6a**

Hypothesis 6a predicted that math self-efficacy, numeracy ability, and math anxiety would predict comprehension of statistical evidence. Hierarchical regression
analyses were conducted with math self-efficacy, numeracy ability, and pre-math anxiety as the predictor variables and comprehension of statistical evidence as the outcome variable. Results revealed a significant regression model ($F_{(2,428)} = 15.41; p < .001$), with numeracy ability as a significant predictor $\beta = .18 (t = 3.55, p < .001; R^2 = .05)$ and pre-math anxiety as a significant predictor $\beta = -.14 (t = -2.88, p < .01; R^2 = .02)$ of comprehension of statistical evidence. To further investigate whether type of evidence is also a significant predictor of comprehension, another regression analysis was conducted with math self-efficacy, numeracy ability, pre-math anxiety, and type of evidence (text, bar graph, both) as the predictor variables, and comprehension as the outcome variable (see Table 4.17). Results again revealed a significant regression model ($F_{(3,427)} = 10.33; p < .001$), with numeracy ability $\beta = .18 (t = 3.54, p < .001; R^2 = .05)$ and pre-math anxiety $\beta = -.14 (t = -2.88, p < .01; R^2 = .02)$ as significant predictors of comprehension of statistical evidence. Type of evidence did not add any unique variance to the prediction of comprehension $\beta = .02 (t = .46, p = .65)$. Overall, results demonstrated that numeracy ability and pre-math anxiety are significant in comprehension of statistical evidence, whereas math self-efficacy and type of statistical evidence are not.

**Hypothesis 6b**

Hypothesis 6b stated that the variables of math self-efficacy, numeracy ability, math anxiety, and comprehension of different types of statistical evidence would predict attitudes about GM foods. Hierarchical regression analyses were conducted with math self-efficacy, numeracy ability, and post-math anxiety as the first block of predictor variables, type of statistical evidence as the next block, comprehension of statistical
evidence as the third block, and different attitudes toward GM foods as the outcome variables.

Table 4.17

Hierarchical Regression of Math Anxiety, Math Self-Efficacy, Numeracy Ability, and Type of Evidence on Comprehension of Statistical Evidence

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Math Anxiety</td>
<td>-.14**</td>
<td>.02</td>
<td>10.32***</td>
</tr>
<tr>
<td>Math Self-Efficacy</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numeracy Ability</td>
<td>.18***</td>
<td>.05</td>
<td></td>
</tr>
<tr>
<td>Type of Evidence</td>
<td>ns</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

Safety of GM foods. Attitude of safety about GM foods was regressed on the five predictor variables (see Table 4.18). Results revealed a significant regression model ($F_{(5,317)} = 6.08; \ p < .001$), with pre-math anxiety $\beta = .16 \ (t = 2.48, \ p < .05)$ and math self-efficacy $\beta = -.15 \ (t = -2.33, \ p < .05)$ accounting for 9% of the variance. Type of evidence and comprehension of statistical evidence were not significant predictors of attitude toward safety of GM foods.
Table 4.18

Hierarchical Regression of Math Anxiety, Math Self-Efficacy, Numeracy Ability, Type of Evidence, and Comprehension of Statistical Evidence on Attitude of Safety about GM Foods

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Math Anxiety</td>
<td>.16*</td>
<td>2.48*</td>
<td>.09***</td>
<td>6.08***</td>
</tr>
<tr>
<td>Math Self-Efficacy</td>
<td>-.15*</td>
<td>-2.33*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numeracy Ability</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Evidence</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. ***p < .001.

Developmental effects of GM foods. Attitude of developmental effects of GM foods was regressed on the five predictor variables of post-math anxiety, math self-efficacy, numeracy ability, type of statistical evidence, and comprehension of evidence (see Table 4.19). Results revealed a significant regression model (F (3,319) = 2.65; p < .05), with pre-math anxiety as the only significant predictor of attitude of developmental effects of GM foods β = .13 (t = 1.94, p < .05; R² = .03). The next two blocks of predictors did not add any unique variance to the regression equation. The results simply indicate that math anxiety is the only predictor variable that is related to attitude about the developmental effects of GM foods.
Table 4.19

Hierarchical Regression of Math Anxiety, Math Self-Efficacy, Numeracy Ability, Type of Evidence, and Comprehension of Statistical Evidence on Attitude of Developmental Effects of GM Foods

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>t</th>
<th>R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Math Anxiety</td>
<td>.14*</td>
<td>2.04*</td>
<td>.02*</td>
<td>2.65*</td>
</tr>
<tr>
<td>Math Self-Efficacy</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numeracy Ability</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Evidence</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05. **p < .01. *** p < .001.

Salience of GM foods. Salience of GM foods was regressed on the five predictor variables (math anxiety, math self-efficacy, numeracy ability, type of evidence and comprehension of statistical evidence). Results did not indicate a significant regression model (F(5,317) = .74; p = .60).

Hypothesis 6c

Hypothesis 6c takes into account all of the variables in this investigation, including the three math competency variables (math anxiety, math ability, numeracy ability), type of evidence, comprehension of statistical evidence, and the constructs of the TPB (three attitudes measures, two perceived behavioral control measures, and subjective norm) to predict behavioral intentions toward GM foods. The hierarchical regression
analysis entered the math variables in the first block, type of evidence in the second block using effect coding, comprehension of statistical evidence in the third block, and attitudes, perceived behavioral control, and subjective norm in the fourth block.

Behavioral Intention to Seek More Information. The first outcome variable was behavioral intention to seek more information about GM foods. Results revealed a significant regression model only when the final block of variables was entered into the regression equation ($F_{(11,311)} = 23.03; p < .001; R^2=.45$). Specifically, the attitude factor of GM salience $\beta = .40, (t = 8.80, p < .001)$, attitude about the safety of GM foods $\beta = .43 (t = 7.10, p < .001)$, subjective norm factor, $\beta = .12 (t = 2.43, p = .02)$; and perceived control over labeling comprehension $\beta = .11 (t = 2.34, p =.02)$ accounted for 45% of the variance associated with behavioral intention to seek more information about GM foods (see Table 4.20).

Behavioral intention to discourage GM foods. In the second analysis, behavioral intention to discourage consumption of GM foods was regressed onto the same predictor variables as the previous regression equation. Results indicated a significant regression model ($F_{(11,311)} = 62.46; p < .001; R^2=.69$). Specifically, the attitude factor of GM salience $\beta = .10, (t = 2.92, p < .01)$, attitude about the safety of GM foods, $\beta = .81 (t = 17.65, p < .001)$, and numeracy ability $\beta = -.07 (t = -1.93, p =.05)$ accounted for 69% of the variance associated with behavioral intention to discourage consumption of GM foods (see Table 4.21). In sum, the additional variable of numeracy ability accounted for an additional 1% of the variance than the variance accounted for by the constructs of the TPB, demonstrating that the numeracy ability can be linked to behavioral intentions to discourage consumption of GM foods.
Table 4.20

Hierarchical Regression of Math Anxiety, Math Self-Efficacy, Numeracy Ability, Type of Evidence, Comprehension of Statistical Evidence, and TPB Variables on Behavioral Intention to Seek More Information About GM Foods

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$R^2$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Math Anxiety</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Self-Efficacy</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numeracy Ability</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of Evidence</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety of GM Foods</td>
<td>.43***</td>
<td>7.10***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Effects</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>.40***</td>
<td>8.80***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Control of Labeling</td>
<td>.11*</td>
<td>2.34*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived External Control</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>.11*</td>
<td>2.43*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. *$p < .05$. **$p < .01$. ***$p < .001$.**
Table 4.21
Hierarchical Regression of Math Anxiety, Math Self-Efficacy, Numeracy Ability, Type of Evidence, Comprehension of Statistical Evidence, and TPB Variables on Behavioral Intention to Discourage Consumption of GM Foods

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$R^2$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety of GM Foods</td>
<td>.81***</td>
<td>17.65***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Effects</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salience of GM Foods</td>
<td>.10**</td>
<td>2.92**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Control of Labeling</td>
<td>ns</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Perceived External Control</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>ns</td>
<td></td>
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</tr>
</tbody>
</table>

Note. *$p < .05$. **$p < .01$. ***$p < .001$. 
CHAPTER 5
DISCUSSION

Health message consumers are exposed daily to technical information via the internet, television, and print media with the latter available from doctors, health fairs, libraries, and other sources that supply health information. The information provided by these sources is sometimes unclear, and at times completely confusing. Health communication researchers often serve as translators, making sense of technical health information like genetically modified (GM) foods, for example, for the lay public. The effectiveness of the translation process often depends on the theoretical strategies and message design tools used by health communicators. Theoretically derived messages that translate technical information for the lay public have the greatest opportunity for comprehension and therefore, would likely increase the lay public’s ability to make informed health decisions. Additionally, theoretically derived messages may increase the likelihood of securing the intended message effects identified by the message source.

This dissertation attempts to add to the health communication literature by providing significant theoretical and practical contributions to the message design process.

The overriding goals of this research were to inform message design in three ways. First, the theory of planned behavior (TPB) was systematically incorporated into experimental messages about GM foods as a strategy to shape attitudes, subjective norms, and perceptions of control, which would then increase the influence of the message on behavioral intentions toward GM foods. The second way the dissertation addressed message design was to manipulate presentations of statistical evidence within the message content to examine its effects on comprehension, attitudes, subjective norms,
perceived behavioral control, and behavioral intentions. Third, the dissertation informed message design by expanding the conceptualization of numeracy ability to math competency, including the dimensions of math ability, math anxiety, and math self-efficacy. The three themes will be discussed in this final chapter as they relate to the results reported in the previous chapter. Implications related to the issue of GM foods will also be discussed as will limitations and suggestions for future research.

The Theory of Planned Behavior in Message Design

The first goal of the dissertation was to use the theoretical framework of the TPB to guide message content for the purpose of influencing behavioral intentions toward GM foods. Three messages pertaining to risks associated with GM foods incorporated each of the constructs of the TPB, including attitudes, subjective norms, and perceived behavioral control, to influence behavioral intentions (Ajzen, 1985). The three message conditions pertaining to GM foods were collapsed due to pilot results that indicated message equivalence on clarity, affect, and involvement. The ability to collapse messages increases the validity of the study because significant findings due to the message topic are less likely to be a possible explanation for the results. Support was found for the predictive ability of the TPB such that attitudes about safety and salience of GM foods, the subjective norm factor, and perceived labeling comprehension contributed to behavioral intention to seek more information about GM foods. The two attitude variables also contributed to behavioral intention to discourage consumption of GM foods. These findings were consistent with previous research, with the attitude construct emerging as the strongest predictor of behavioral intention, explaining 30% and 67% of the variance, respectively. While the attitude construct was the most important predictor
for behavioral intention toward GM foods, the predictive ability of the individual constructs of the TPB varies, depending on the behavior and population under consideration (Reinecke, Schmidt, & Ajzen, 1996).

One explanation for why the subjective norm factor was only slightly predictive for the behavioral intention to seek information about GM foods items relates to the fact that subjective norms have yet to emerge regarding the consumption of GM foods (Silk et al., in press). People are unfamiliar with what others perceive about GM foods and therefore it is limited in its use as a predictor of behavioral intention. Similar to the subjective norm construct, perceived behavioral control also contributed very little unique variance to seek information about GM foods. The issue of volitional control may help to explain why perceived behavioral control did not emerge as a significant predictor.

Volitional vs. Non-volitional Control

The primary difference between the TPB and TRA is the construct of perceived behavioral control, which the TRA does not include. The TRA asserts that most behaviors are under volitional control, while the TPB recognizes that some behaviors are not entirely under volitional control. According to the TPB, perceived behavioral control only becomes an important predictor of behavioral intention and behavior when individuals feel they do not have control over the behavior under consideration. This distinction becomes important in this study. Specifically, the reading of food label perceived behavioral control factor is of a more volitional nature compared to the government and industry perceived behavioral control factor, which is beyond the realm of volitional control. The level of volitional control associated with these two variables
might help to explain why only the first model associated with perceived behavioral control variable was predictive and the second one was not. Since government and industry control over food is out of the realm of volitional control for the lay public, it was not a significant predictor for behavioral intentions. Reading food labels, however, is not completely volitional (e.g., it requires that manufacturers label foods, literacy, and more specifically, familiarity with nutrition labels), explaining why its inclusion added a slight amount of unique variance in behavioral intention to seek more information about GM foods. It is also likely that individuals who already engage in information seeking behavior (read nutrition labels) would be more likely to continue to seek information about related topics like GM foods.

One other explanation for why perceived behavioral control was not a sufficient predictor might be related to an inaccurate relationship between perceived behavioral control and actual control over the consumption of GM foods. Most participants reported that they had control over whether or not they ate GM foods. In reality, participants do not have control over their consumption of GM foods because government does not require industry to label GM foods as such. Thus, although the perceived behavioral control is high, the actual control is low, making perceptions about government and industry control a factor that adds little to the accuracy of behavioral predictions. This argument can be extended to perceived behavioral control over reading labels. While it is true that individuals have greater control over this behavior, in reality it will not help them discern whether or not a product contains GM material.

Participants’ perceptions of control were probably higher prior to reading the message because the message indicated that GM foods are not currently labeled,
decreasing their level of perceived behavioral control over reading labels. Additionally, industry and government control over food is a more global question that might not be cognitively linked to people’s perceptions of personal control. In other words, I might think that government and industry have quite a bit of control over the food I eat, but I might still believe that I have a significant level of control too. The links between perceived behavioral control of external forces (industry and government) and behavioral intentions might be a bit tenuous, while the link between perceived control over labeling comprehension and behavioral intention to seek information about GM foods is much more immediate.

**Theoretical Application for the TPB**

The ability of a theory to help us explain a phenomenon at hand is the ultimate bridge between theory and praxis. The TPB is one theory that provides a lens for making sense of what is important to predict behavioral intentions and subsequent behavior. Previous research has demonstrated the utility of the TPB by testing its predictive ability in a variety of health-related realms (Norman, et al., 1999; Orbell et al., 2001, Armitage & Conner, 1999). However, to increase the predictive as well as the explanatory power of messages, designers of health messages need to go beyond the use of psychological constructs to explain outcomes and use them to guide message content and instrument development.

The TPB provides a straightforward framework to design messages around attitudes, subjective norms, and perceptions of control to impact intentions. Formative research that identifies salient issues related to the TPB can supply message designers with data that informs how to address each of the theory’s constructs (Silk et al., in
press). Health message designers should operationalize theory within message content because incorporating each of the constructs maximizes the opportunity to influence behavioral intentions and subsequent behavior. The methods chapter of this dissertation supplies guidance for the development of health messages. The rationale provided for each of the constructs and control variables in the methods chapter shows how theory can be integrated into the body of health messages. The “how-to” of message construction is not a formula that works each time a given strategy is implemented. Researchers need to extend beyond the use of the TPB and other theories for testing and predicting outcomes. Rather, researchers should appreciate the flexibility and use theory as a means to strengthen message design.

Statistical Evidence in Messages

A second goal of this research was to examine the effects of statistical evidence on comprehension, attitudes, and behavioral intentions. It was predicted that statistical evidence about risks associated with GM foods would shape negative attitudes toward GM foods. The three GM food messages were compared against a control message about book preservation. The results of the multivariate analysis of variance indicated a main effect for evidence about GM foods, suggesting that providing statistical evidence about GM foods may affect negative attitudes toward GM foods. This finding does not take into consideration the important variable of comprehension of the evidence, but it does mirror the notion in the literature that people form a general understanding of risk and work from that general understanding as a means to make sense of information (Adelsward & Sachs, 1996; Steen, 1991). However, the critical consumption and consequent comprehension of statistical evidence might have a different effect on attitudes toward
GM foods because individuals’ general sense of risk would be replaced by a more precise understanding of the statistical evidence provided in a message about GM foods. Although the statistical evidence provided in the messages is specific and scientific, it is also inconclusive in regard to the measurable long-term consequences of consuming GM foods.

Determining which type of statistical evidence yields the greatest effect on attitudes toward GM foods is another way this research informs message design. Similar to earlier findings regarding evidence, it was expected that repeated exposure to evidence, as in the combined format, would influence attitudes more than a single exposure to either a bar graph only or percentage only message (Reinard, 1988). Additionally, because visual presentations are often more helpful than numeric information presented in a text format (Steen, 1991; Schwartz et al., 1997), it was expected that the bar graph only message would have a greater influence on attitudes than the percentage only message. Results indicated no significant differences between types of evidence on attitudes toward GM foods. Perhaps when messages present technical information, the more pertinent issue is source credibility rather than multiple representations of different evidence formats. In other words, individuals may not understand the statistical evidence provided in a message so they rely more heavily on the information source as a means to assess the credibility of the message. The sources provided in each of the messages were the same across the different types of statistical evidence, thus there would be no expected differences based on source credibility.

Evidence and Comprehension
Health message designers strive to create messages that include information that is easily comprehended by target audience members. This research predicted that greater comprehension would result from a combined format of statistical evidence followed by bar graph evidence and then percentage evidence. Results indicated that participants comprehended information presented in the combined and bar graph only formats more than they did in the percentage only evidence format. No significant differences existed between the combined format and the bar graph evidence, indicating that the bar graph was the key element to the increase in comprehension over the percentage only evidence. This finding supports previous work that indicates statistical evidence has been found to be clearer and understood better in visual presentations (Schwartz et al., 1997). Therefore, it may be fruitful for message designers to consider the use of visual presentations like bar graphs, histograms, pie charts, etc., in the construction of health messages as a strategy to increase comprehension of statistical evidence.

This research also found that numeracy ability was positively related to comprehension of statistical evidence. Intuitively, it makes sense that individuals confident in their ability to solve math problems, or high in math self-efficacy, would be able to comprehend statistical evidence, and previous research has shown a relationship between the two variables (Richardson & Suinn, 1972; Dew, Galassi, & Galassi, 1984). Numeracy ability was also found to be a statistically significant covariate, but only marginally. In other words, when effects of numeracy ability were partitioned out, bar graphs were still related to greater comprehension than other presentations of statistical evidence. While numeracy ability does play a role in comprehension of statistical evidence, it was not a large role in this study. One explanation for the small role of
numeracy as it relates to comprehension of statistical evidence could be that the measure used in this study was more general, whereas the comprehension questions in the study were very specific to the statistical evidence provided in the message. Numeracy ability was measured by a standardized scale of questions, the comprehension questions were constructed based on information provided in the translated research studies. The significant results suggest that a more comprehensive measure of numeracy ability might yield stronger support for the relationship between numeracy ability and different forms of statistical evidence. Or, a more general measure of comprehension might also yield a stronger relationship. For example, a question that measures comprehension might be worded more generally like “GM foods contribute to changes in people’s genes.”

This research also predicted that numeracy ability would covary with comprehension of statistical evidence such that greater numeracy ability would be related to less negative attitudes of risk toward GM foods. (As the expert evidence suggests that the actual scientific risk is small – though the perceived risk is captured in negative attitudes.) The findings revealed that numeracy ability accounted for 2% of the variance associated with attitude about the safety of GM foods. Specifically, individuals who were high in numeracy skills were more likely to have less negative attitudes toward GM foods. Individuals with high numeracy skills may have been able to recognize that the statistical evidence provided in the messages was inconclusive as to the severity and long-term effects of GM foods on humans and that the probability of harm or serious risk is very small (Ewen & Pusztai, 1999; Nordless et al., 1996). Although the messages suggest possible consequences, the studies presented in the messages do not provide causal evidence to support excessive risks associated with GM foods. Individuals who
were able to extract the quantitative meaning of the statistical evidence may be less convinced that high personal risks exist or are imminent, decreasing their perceptions of risks toward GM foods. Furthermore, numeracy ability may not have been a significant predictor for attitudes related to the developmental effects of GM foods and GM salience because the statistical evidence provided in the messages did not directly link GM foods to developmental effects or provide enough information for GM foods to be an issue of great concern. Attitudes are complex constructs that are based on a variety of behavioral beliefs that have different outcome evaluations and strength of beliefs associated with them (Ajzen & Fishbein, 1980). Therefore, the statistical evidence provided about GM foods accounts for only a piece of a much larger construct that defines attitudes toward GM foods.

Comprehension of statistical evidence was not a significant predictor for any of the attitude variables. It is quite likely that a sleeper effect may account for the current lack of significance. The sleeper effect refers to “an effect that is not immediately apparent but becomes evidenced over the course of time” (Frey, Botan, & Kreps, 2000, p.120). A novel topic like GM foods may require much more time for the effects of comprehension to manifest themselves to affect attitudes toward GM foods. Relatedly, the topic and the evidence provided about GM foods is of such a scientific nature that participants may also need more time to process the information than the duration provided within the study. This explanation is supported by the fact that the majority of participants typically acknowledged the general importance of GM foods (M=3.87; SD=.62), but indicated more neutral agreement in regard to specific attitudes of risk about GM foods (M=2.60; SD=.64) and their developmental effects (M=2.41; SD=.82).
It is also possible that the more important component of the message was the narrative that introduced the statistical evidence and then suggested that individuals might want to contact the FDA for further information. Perhaps the embedded nature of the statistical evidence in the message content had less of an impact on individuals than the information that flanked the presentation of statistical evidence. There is much research that suggests that recency and primacy effects exist, indicating that individuals would be less likely to remember the specifics of the statistical evidence and more likely to remember the information that appeared first or last in the message. Finally, participants may not have connected the specific nature of the comprehension questions to attitudes, which again points to a sleeper effect.

A Multi-dimensional Construct of Math Competence

Message designers understand that literacy issues remain a barrier for many members of the lay public. In response, message designers strive to create readable and understandable messages to maximize comprehension of the content. Numeracy is also a barrier for the lay public and message designers need to strive in this arena of message construction. Math competency, a construct that has not been previously addressed by communication scholars, might be helpful in addressing numeracy issues. There has been somewhat of a focus on numeracy skills as demonstrated by the literature (Steen, 1991), but the constructs of math anxiety and math self-efficacy provide an opportunity to expand the definition of numeracy ability to encompass a more comprehensive one. The three variables of math anxiety, math self-efficacy, and numeracy ability are highly correlated with each other, suggesting that as a collective they provide a rich definition of math competency. The construct of math competency includes an affective, cognitive,
and behavioral component. The affective component pertains to math anxiety, the cognitive component pertains to math self-efficacy, and the behavioral component pertains to numeracy ability. When all three of these dimensions are considered together, we begin to understand the complexities that may need to be considered in regard to the lay public’s ability to interpret statistical evidence in messages.

This research found that comprehension of statistical evidence was correlated with all three dimensions of math competency, suggesting that all three constructs can contribute to comprehension of statistical evidence. However, when type of evidence was added as a predictor variable, results indicated that type of evidence did not significantly contribute to comprehension of statistical evidence. These results suggest that math competency dimensions are more critical to comprehension than the format in which statistical information is presented within a message. While some research suggests that visual presentations are related to improved comprehension (Steen, 1991; Schwartz et al., 1997), it may not be the case with more complex statistical evidence like GM foods, for example. This finding points to the challenge of communicating complicated health information to the lay public and again highlights the role of addressing the construct of math competency as a strategy for increasing comprehension of health messages.

Math competency variables were also useful in predicting attitudes toward GM foods. Specifically, math self-efficacy and math anxiety were significant predictors of attitude about GM food safety, and math anxiety was a significant predictor of attitude about developmental effects of GM foods. The fact that different math competency dimensions were relevant for different attitudes points to the importance of a multi-
dimensional construct of math competency. Math competency can be considered as one explanatory variable that can be used to understand outcomes associated with different types of statistical evidence because the variable accounts for the affective, cognitive, and behavioral components related to overall math competency.

For example, consider a person who is high in math competence. This person typically performs well on math challenges, feels good about their math skills, and does not feel anxious about math tasks. However, a person low in math competence would be less likely to perform well on math tasks, does not feel confident in their math ability, and may have anxiety related to completing math tasks. In addition to those people who score high or low in math competency are individuals that report high levels of math anxiety and low math self-efficacy, but still successfully complete math tasks. These individuals might manage their math self-efficacy and math anxiety in ways that empower them to be proficient at math, but they still perceive themselves as having math deficits and feel anxious about math. As multiple audiences are targeted by health messages, strategies beyond those that directly address numeracy ability may need to be implemented in the creation of rational appeals. Rational appeals that specifically tell message consumers to: “Do the math. You know how,” may help to increase levels of math competency. In other words, rational appeals that use strategies that bolster feelings of math self-efficacy and minimize math anxiety could be put into practice.

The results of this study also indicate that math anxiety might be best conceptualized as math state anxiety. Math anxiety was measured before and after exposure to the statistical evidence presented in the messages. A repeated measures analysis of variance indicated a decrease in math anxiety from time one to time two, but
no significant differences in math anxiety based on statistical evidence. The decrease in math anxiety could simply be a result of the math task being complete, possibly a “practice effect,” therefore math anxiety is relieved somewhat. Also, a perceived sense of success in the completion of the math problems may also contribute to a decrease in math anxiety. Even with the small effect size, the change in scores from pre-test to post-test provides evidence for math anxiety as a state. If math anxiety was a trait, a significant difference from pre- to post-test should not have been revealed because the level of anxiety would have stayed consistent from time one to time two.

The type of statistical evidence presented in the messages was not significantly related to post-math anxiety scores, suggesting that the type of statistical evidence used in the messages may not be a strategy for decreasing math anxiety. However, if math anxiety decreases as individuals work their way through math challenges, health communicators may do well to incorporate that finding in their design of health messages. For example, one strategy might be to place multiple repetitions of statistical evidence throughout a health message as a strategy that capitalizes on the decrease of math anxiety over time. It is possible, however, that multiple repetitions might heighten math anxiety, especially if message consumers perceive themselves to be inundated with interpretations of statistical evidence. It is also possible that individuals might just skim over subsequent repetitions of the same information, which may not actually contribute to more understanding of the statistical evidence. In the best case scenario, multiple exposures to the statistical evidence would decrease math anxiety, and also facilitate greater message elaboration (Petty & Cacioppo, 1979), increasing opportunities for message comprehension.
If individuals are to successfully consume health information, math challenges need to be addressed in proactive ways that allow individuals to feel capable of understanding statistical evidence.

The Issue of GM Foods

The primary contributions of this research center on the theoretical use of the Theory of Planned Behavior and the use of statistical evidence in message design as well as the expansion of numeracy to a multi-dimensional construct of math competency. By virtue of the nature of the topic considered in the messages, GM foods, this research also contributes to an understanding of the lay public’s attitudes, subjective norms, and perceptions of control about GM foods. Information about lay public perceptions may help to determine what kinds of strategies may be useful to communicate about GM foods in a climate that has members of the lay public questioning the safety of agricultural biotechnology.

Current scientific research provides a strong case for the benefits of biotechnology, including more nutritious foods and cost-effectiveness in production techniques (Datta & Bouis, 2000; Philips, 2000). However, contrary to the conventional position taken by the majority of scientists that GM foods are a wonderful advancement of modern biotechnology, there is some evidence to suggest that risks do exist even though the probability is small. The messages translated for this research provide a slice of that evidence, pointing to changes in the size of organs belonging to rats (Even & Pustzai, 1999), allergic reactions (Nordless et al., 1996) and food recalls associated with GM foods (Falci, 2001). This dissertation touches broadly the idea of risk analysis in that individuals considered messages that presented possible risks associated with GM foods.
Then participants answered questions regarding their attitudes, intentions, perceptions of control, and subjective norms based on the evidence provided in the message. The context in which the information about statistical evidence was presented in the messages asked individuals to consider contacting the FDA about the labeling of GM foods.

Analyses revealed that the lay public is concerned about GM foods, but not concerned enough to stop consuming them. This research suggests that most Americans would be in favor of the labeling of GM foods as demonstrated by their mostly neutral to strongly agree responses to questions about labeling them. The fact that the lay public considers labeling of GM foods a reasonable option has implications for the FDA, industry, advertisers, and even farmers such that acceptance of GM foods might increase. These stakeholders may consider the findings of this study and interpret that the lay public supports them (e.g., they plan to keep eating them); therefore, there is no need to worry about labeling GM foods. However, some stakeholders may consider these findings and recognize that labeling of GM foods may help to increase public acceptance and overall consumption of GM foods. Regardless of the interpretation by these groups, the fact remains that while individuals do not intend to change habits any time soon, they do communicate uncertainty around the topic of GM foods.

In particular, the lay public expresses uncertainty about the effect of GM foods on humans and the environment. The messages in the study stress the possibility that GM foods may have some negative consequences, information that stakeholders are not expressly communicating about GM foods. The scientific uncertainty with GM foods has been spotlighted more so than other new technologies. The recent focus on GM foods might relate to the fact the public has a greater, more direct relationship with their food.
Food is a personal issue; each day we make decisions about what to eat. Historically, the majority of Americans have been confident in the United States ability to maintain a safe and healthy food supply, but reports of food contamination and threats to the food supply may be undermining previous faith in the public food supply. European nations’ skepticism, opposition, and outright outrage toward GM foods has also made its way into the minds of Americans, but probably with less of an impact than what might have been expected. In other words, while there are certainly groups of individuals in the United States that oppose the use of advanced biotechnology in growing food, most Americans feel relatively confident in our food supply even though they would prefer to have GM foods labeled as such. Perhaps labeling of GM foods would translate into perceptions of greater control over food choices for consumers despite the fact that little choice would really exist as most foods would be labeled as containing genetic material.

One of the most interesting questions raised by this research is why so many individuals have responded negatively or hesitantly to the introduction of GM foods. In purely scientific terms, the risks associated with GM foods are not significantly greater than those risks associated with non-GM foods, but many consumers have taken a rigid stance on what they believe to be a risky form of food production. Around the world, particularly in the European nations, consumers have argued convincingly for stronger regulation of GM foods, which has resulted in a much slower growth rate of GM crops in those countries. In Africa, donations of food from the United States are currently not distributed based on concerns that the food threatens the health of Africans and could contaminate their own food supply. Perhaps affective responses to risks associated with GM foods have predominated over more cognitive responses, resulting in negative
attitudes toward GM foods. Proponents of agricultural biotechnology may do well to develop campaigns that directly address the negative attitudes and perceived risks that the lay public connects to GM foods. Although scientific uncertainty exists about GM foods, the lay public still needs to be kept abreast with current scientific evidence that points to the risks and benefits associated with GM foods. Increased communication about agricultural biotechnology may lead to greater understanding within and beyond the boundaries of the United States.

Limitations and Future Research

There are inherent limitations with external validity when college students comprise a sample. It is possible that the findings of this research would translate into different results if a representative community sample were used instead of college students because college students may have math ability above that of members of the lay community. The very fact that participants attend college may be an indicator of higher math ability beyond the lay public. Additionally, because college students are in more of a “test-taking” mode due to the academic requirements of that status, they may also perform better when asked to answer questions based on statistical evidence. However, college students do qualify as members of the lay public in this study because they are not experts about GM foods and like all members of the population whom are exposed to new information in the media, they are often asked to draw conclusions based on statistical evidence. They also comprise an audience whose votes may make a difference for GM policy and whose offspring may be affected by GM consumption. Future research should incorporate a representative random sample of the lay public.
It was not within the scope of this research to examine all possible modes of presentation for statistical evidence. The findings regarding evidence in this study are limited to statistical evidence that presents bar graphs and textual/percentage formats in the message content. In other words, there are multiple types of visual evidence (e.g., pie charts, dendograms) that could also be tested beyond the bar graph and percentage formats used in this study. Future research could be conducted that incorporates a greater variety of statistical evidence.

A stronger test of the TPB could have included another GM message that did not incorporate constructs of the TPB. A separate message would have enabled the direct comparison of a message that incorporates theory to one that does not. Difficulty in locating another risk message associated with GM foods contributed to its lack of inclusion in the study. Few risk messages pertaining to human consumption of GM foods were available at the time this research was conducted. Regulations regarding testing on human subjects serve as a barrier to determining the short and long-term effects of GM foods on humans. Future research should strive to include more messages about GM foods. Additionally, future research should extend beyond the realm of GM foods to test the use of the TPB with multiple message conditions, specifically testing theoretically constructed messages against messages that were not constructed in a systematic fashion.

Another limitation of this research is the ability to be sure that messages were equivalent. While the pilot study included measures that indicated that each of the message types were similar in terms of clarity, affect, and involvement, the final study did not include those same measures. Future research could increase the validity of its
findings by including manipulation check items in the final survey instrument to ensure perceived message equivalence across sample populations.

A final limitation pertains to the low statistical power related to some of the statistical tests reported in Chapter IV. Power statistics in this study ranged from very poor (.06) to excellent (.99). While the results of this study should be considered within the limitation of low statistical power, they should also be considered of value for future research in this domain.

Conclusion

Health communicators are often charged with the task of creating health messages that are accessible to the lay public because effective messages are imperative for and facilitate informed decision-making. However, constructing messages that are involving, informative, and understandable is a complicated task. Sparse research is available that demonstrates how to incorporate theory into messages and also considers math-related issues in message construction. This research expands both our theoretical and practical knowledge of message design in three primary ways. First, it shows how theory can be incorporated into messages. Specifically, this research used the topic of GM foods to extend the theoretical utility of the TPB by using it as a framework for constructing health messages. Second, this research reveals that the use of bar graphs as a strategy to present statistical evidence results in greater comprehension than percentage formats. The third way this research expands both our theoretical and practical knowledge is by defining the multi-dimensional construct of math competency. Math competency, formed through the expansion of numeracy ability to include the dimensions of math anxiety and math self-efficacy, should be considered when using statistical evidence to
form rational appeals. Overall, the incorporation of theoretical constructs into messages and the promotion of strategies that increase comprehension as well as influence attitudes and behavioral intentions are pivotal to a more informed decision-making process for health message consumers.
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APPENDIX A

A RECENT HISTORY OF FDA FOOD ALLERGEN RECALLS, V#1

We hear a lot about genetically modified (GM) foods being a major part of our food supply. In fact, about 2/3 of the food found in grocery stores has some form of GM material in it. Research has found that most people in the United States do not know a lot about GM foods. People do not often discuss them with their friends and family. The Food and Drug Administration (FDA) says GM foods are as safe as non-GM foods. You may, however, want to decide for yourself. This information is intended to help you begin talking about GM foods with your friends and family because eating them might affect your health.

GM foods are a product of genetic engineering (GE). GE allows the crossbreeding, or joining and transfer, of genes between both related and unrelated plants and animals. In nature, crossbreeding only takes place between very closely related species. Any genetic changes occur slowly, over time. GM foods change this process because scientists combine the genes of both related and unrelated organisms in a short amount of time. As a result of GE, food allergens or plant toxins may transfer as well.

Labeling of GM foods may be the only way to detect allergens or toxins. Statistics from the FDA about food recalls show that food companies do not always follow the rules for labeling. The FDA has two types of recalls for food allergens. Class I recalls occur when serious health threats exists and Class II recalls occur when health threats are present, but less serious. In 1997, 20% of the 300 recalls were Class I. In 1998, about 50% of the 165 recalls were Class I. In 1999, 62% of the 195 recalls were Class I. The bar graph also reports the FDA findings on food allergen recalls.
The FDA does not call for labels on all GM foods because they are not thought to differ in content from other foods. If the GM food differs significantly in nutrients or it causes allergies, the FDA requires it to be labeled. People with known food allergies need to be able to detect allergens in their food because no cure exists for food allergies. People may also want to know that foods are GM because some effects on humans are not yet known. If you have questions about GM foods, you may want to contact the FDA about how the public can detect GM foods and why labeling is not required.

MORE INFORMATION? This research was published by Kenneth J. Falci (2001). The FDA, food allergens and you. FDA Center for Food Safety and Applied Nutrition. Available at: www.cfsan.fda.gov For additional information, you can do an on-line search using the key words “food allergens.”
APPENDIX B

A RECENT HISTORY OF FDA FOOD ALLERGEN RECALLS, V#2

We hear a lot about genetically modified (GM) foods being a major part of our food supply. In fact, about 2/3 of the food found in grocery stores has some form of GM material in it. Research has found that most people in the United States do not know a lot about GM foods. People do not often discuss them with their friends and family. The Food and Drug Administration (FDA) says GM foods are as safe as non-GM foods. You may, however, want to decide for yourself. This information is intended to help you begin talking about GM foods with your friends and family because eating them might affect your health.

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For example, scientists used GE to put a lectin gene (natural poison) into potatoes to kill harmful insects. However, the lectin gene in the GM potatoes also transferred to the organs of rats. In one study, 36 rats were fed three types of potatoes for 10 days: GM lectin, non-GM with lectin added to it, and non-GM. The rat organs were then compared to each other. Results showed that one part of the rats’ small intestine was 37% longer in GM potatoes than in non-GM potatoes; and 29% longer in GM potatoes than in non-GM ones with the lectin added to it. The stomach was about 20% thicker in rats that ate GM potatoes than in non-GM ones. The stomach was 4% thicker in GM potatoes as compared to non-GM ones with the lectin added to it.

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APPENDIX E

THE EFFECTS OF LECTIN GENE ON RAT ORGANS, V#2

We hear a lot about genetically modified (GM) foods being a major part of our food supply. In fact, about 2/3 of the food found in grocery stores has some form of GM material in it. Research has found that most people in the United States do not know a lot about GM foods. People do not often discuss them with their friends and family. The Food and Drug Administration (FDA) says GM foods are as safe as non-GM foods. You may, however, want to decide for yourself. This information is intended to help you begin talking about GM foods with your friends and family because eating them might affect your health.

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For example, scientists brought a protein from the Brazil nut into soybeans. The addition of the protein improved the nutritional value of the soybean. In the research study, scientists exposed three people with a known allergy to Brazil nuts to different levels of GM soybeans (with Brazil nuts in them). The three people were also exposed to similar levels of pure Brazil nuts. Allergic reactions to the GM soybeans occurred in each person. Person one had 8mm hives at a .001% level. Person two had 9mm at a .0001% level. Person three had 14mm hives at a .000001% level. The bar graph also reports the results of the research.

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APPENDIX H

ALLERGIC REACTIONS TO GM SOYBEANS, V#2

We hear a lot about genetically modified (GM) foods being a major part of our food supply. In fact, about 2/3 of the food found in grocery stores has some form of GM material in it. Research has found that most people in the United States do not know a lot about GM foods. People do not often discuss them with their friends and family. The Food and Drug Administration (FDA) says GM foods are as safe as non-GM foods. You may, however, want to decide for yourself. This information is intended to help begin talking about GM foods with your friends and family because eating them might affect your health.

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APPENDIX I

ALLERGIC REACTIONS TO GM SOYBEANS, V#3

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APPENDIX J

SHOULD BOOK PRESERVATION BE A PRIORITY, V#1

We hear a lot about how important it is to preserve the history of our country. In fact, it is believed that nearly 3/4 of books published just 30 years ago cannot be used now. Research has found that most people do not know a lot about how to preserve books. People do not often discuss the topic with friends and family. The Library of Congress has approved millions of dollars because it believes that saving books is as important as other efforts to preserve our history. You may, however, want to decide for yourself. This information is intended to help you begin talking about how to preserve books because so many of them are falling apart in libraries.

Two centuries ago, books were printed on a high quality, cotton-fiber paper. However, in the 19th century printers changed to acid-based paper because it was cheaper than the cotton-fiber paper. Over time, the acid has broken down the paper in books, causing them to completely fall apart. As a result, books, records, songs, and other types of documents that record our heritage are at risk.

Libraries say that there are three ways to save books. Mass de-acidification is a liquid-based process that lowers the amount of acid in the paper. It is a cost-effective, long-term solution. Microfilm is another solution that lasts a long time, but it is costly. It also makes it hard to find and read information. Lastly, books can be digitized to computers. However, computer transfer methods cost the most money. One report compared the costs of the three methods for two libraries. Results for the Yale library showed that the microfilm method was 85% more costly than the acid method; the digital method was 73% more costly than the acid method; and the microfilm method was 33% more costly than the digital method. Results for the Library of Congress showed that the microfilm method was almost 90% more costly than the acid method; the digital method was 96% more costly than the acid method; and the digital method was 65% more costly than the microfilm method.

The Library of Congress uses these three methods to preserve our national treasures and heritage. The Library also uses a full range of more common methods to preserve its collections. They keep materials in the proper environment; prepare for problems such as water leaks; ensure proper care and handling of materials; and stabilize fragile and rare materials in acid-free containers to protect them from further harm. You may want to contact the Library of Congress if you have questions about saving books.

MORE INFORMATION? This research was published by the Library of Congress and can be retrieved at www.loc.gov; and Rhys-Lewis, J. (2001). The enemy within! Acid deterioration of our written heritage. A report to the British library co-operation and partnership programme on the behalf of the project steering committee. Available at http://www.bl.uk./concord/pdf_files/massdreport.pdf. For additional information, you can do an on-line search using the key words “book preservation.”
APPENDIX K

SHOULD BOOK PRESERVATION BE A PRIORITY, V#2

We hear a lot about how important it is to preserve the history of our country. In fact, it is believed that nearly 3/4 of books published just 30 years ago cannot be used now. Research has found that most people do not know a lot about how to preserve books. People do not often discuss the topic with friends and family. The Library of Congress has approved millions of dollars because it believes that saving books is as important as other efforts to preserve our history. You may, however, want to decide for yourself. This information is intended to help you begin talking about how to preserve books because so many of them are falling apart in libraries.

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Libraries say that there are three ways to save books. Mass de-acidification is a liquid-based process that lowers the amount of acid in the paper. It is a cost-effective, long-term solution. Microfilm is another solution that lasts a long time, but it is costly. It also makes it hard to find and read information. Lastly, books can be digitized to computers. However, computer transfer methods cost the most money. One report compared the costs of the three methods for two libraries. Results for the Yale library showed that the microfilm method was 85% more costly than the acid method; the digital method was 73% more costly than the acid method; and the microfilm method was 33% more costly than the digital method. Results for the Library of Congress showed that the microfilm method was almost 90% more costly than the acid method; the digital method was 96% more costly than the acid method; and the digital method was 65% more costly than the microfilm method. Results of the report also appear in the bar graph.
The Library of Congress uses these three methods to preserve our national treasures and heritage. The Library also uses a full range of more common methods to preserve its collections. They keep materials in the proper environment; prepare for problems such as water leaks; ensure proper care and handling of materials; and stabilize fragile and rare materials in acid-free containers to protect them from further harm. You may want to contact the Library of Congress if you have questions about saving books.

MORE INFORMATION? This research was published by the Library of Congress & can be retrieved at www.loc.gov. Also, some information was published by Rhys-Lewis, J. (2001). The enemy within! Acid deterioration of our written heritage. A report to the British library co-operation and partnership programme on the behalf of the project steering committee. [Online.] Available: http://www.bl.uk/concord/pdf_files/massdreport.pdf. For additional information, you can do an on-line search using the key words “book preservation.”
APPENDIX L

SHOULD BOOK PRESERVATION BE A PRIORITY, V#3

We hear a lot about how important it is to preserve the history of our country. In fact, it is believed that nearly 3/4 of books published just 30 years ago cannot be used now. Research has found that most people do not know a lot about how to preserve books. People do not often discuss the topic with friends and family. The Library of Congress has approved millions of dollars because it believes that saving books is as important as other efforts to preserve our history. You may, however, want to decide for yourself. This information is intended to help you begin talking about how to preserve books because so many of them are falling apart in libraries.

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![Bar Graph](image)

The Library of Congress uses these three methods to preserve our national treasures and heritage. The Library also uses a full range of more common methods to preserve its collections. They keep materials in the proper environment; prepare for problems such as
water leaks; ensure proper care and handling of materials; and stabilize fragile and rare materials in acid-free containers to protect them from further harm. You may want to contact the Library of Congress if you have questions about saving books.

MORE INFORMATION? This research was published by the Library of Congress and can be retrieved at www.loc.gov. Also, some information was published by Rhys-Lewis, J. (2001). The enemy within! Acid deterioration of our written heritage. A report to the British library co-operation and partnership programme on the behalf of the project steering committee. [Online.] Available: http://www.bl.uk/concord/pdf_files/massdreport.pdf. For additional information, you can do an on-line search using the key words “book preservation.”
Dear Study Participant,

In November of 2001, you participated in a study that asked your opinions about genetically modified (GM) foods. You first completed math-related survey questions and then you read one of the following message topics: 1) possible allergic reactions to GM foods; 2) the effects of GM foods on rat organs; 3) food recalls associated with GM foods; and 4) different methods of book preservation. Each message included statistical information presented in a bar graph, percentage, or combination of both format. Finally, you completed attitude measures, more math-related questions, and then provided some demographic information.

The purpose of the study was to understand attitudes about GM foods and also to figure out what kinds of ways we can best construct messages about GM foods that are understandable to the lay public. Specifically, we were interested in how to communicate statistical information about risks to the lay public. The following paragraph provides some of the results from the study in which you participated.

A total of 431 people participated in the study. Results of the study indicated that individuals really don’t know much about GM foods and they are uncertain about the safety of GM foods. Overall, a neutral attitude toward GM foods was reported by the majority of participants. Participants were also uncertain about their families’ attitudes toward GM foods. Almost half (45%) of participants reported that they would seek more information about GM foods. Results also indicated that individuals who received statistical information in the form of a bar graph comprehended information in the message better than those individuals who did not receive a bar graph. This lets us know that using graphs may be a very useful way to translate technical information that includes numbers. Other results indicated that messages that deal with technical topics like GM foods should be carefully structured based on known theories and health message design techniques.

The above reported results are simply a general summary of the project. If you have any further questions about the study, please feel free to contact Kami Silk at kjs21@psu.edu or by phone at (814) 863-0100. Your participation in our project is greatly appreciated.

Thank you.