FUNCTIONAL MEASUREMENT OF IMMUNIZATION DECISION MAKING

by

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B.S.N., University of Iowa, 1970
M.A., University of Iowa, 1979
M.S., Kansas State University, 2002

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Psychology
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2006

Abstract

Four variables from the HBM of healthcare behavior were used to examine immunization decision making by the lay public. Although there was evidence to support the HBM in general, results of these studies suggest that up to 70% of the variance in immunization decision-making could be explained by disease base rates alone. When there is a main effect of immunization side effects, this effect was entirely within the most severe category of side effect. In initial four experiments, there was a consistent interaction between the variable of disease type and the variables of disease severity and immunization side effects. The fifth experiment showed an interaction between disease type and immunization efficacy. Functional measurement was used to examine the nature of the interaction between the variables of disease base rates and immunization efficacy. This interaction is neither clearly additive nor multiplicative. Disease base rate dominates the other variables, although each modifies immunization likelihood somewhat in interaction with disease base rates. Furthermore, results suggest that participants did not appear to react to the difference between different disease base rates when the probabilities are small. Participants also did not conceptualize immunization efficacy as a conditional probability. Suggestions for how to address these issues via decision support were made. The principle contribution of this study, however, is development of a methodology. The method developed here investigates the variables of the HBM in an ecologically valid factorial design. This approach takes the HBM beyond description of variables to provision of prediction and generalizable results.

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Acknowledgements

The advice and encouragement of my committee members was invaluable. In addition to James Shanteau, PhD, chair, committee members were Jerome Frieman, PhD, Richard Harris, PhD, Robert Hamm, PhD and David Gustafson, PhD. Each provided different insights and valuable suggestions. Thanks to outside chair, Carol Shanklin, PhD, who ensured that university policies were followed. Thanks to colleagues Helen German, RN, BSN, Mary Beth Cassidy, RN, BSN, Roseanna West, RN, BSN, Kenneth Troupe, LPN and Linda Pickens, LPN for generously making suggestions with various forms of stimuli as they were developed. Thanks also to medical advisors P. Desaraju, MD and Joseph Schlageck, MD who suggested wording for stimuli and validated medical information necessary to the design of various studies. Thanks to Nancy Bolsen, PhD who facilitated contact with non-traditional students who might be interested in participating in this research. Thanks for the participation of not only undergraduate students who volunteered to participate for class credit, but also the participation of the many non-traditional students who were interested enough in this research to go out of their way and volunteer their time to provide insights into how people from various backgrounds might make immunization decisions. Finally, thanks to my three sons, Joseph Pingenot, James Pingenot, and Jesse Pingenot each of whom offered encouragement and understanding throughout this process and to my husband, David, who patiently checked data entries to ensure accuracy, proofed stimuli and handouts, and provided fast food when I was working late.

Dedication

To my parents

Albert Boyd Ferguson who taught me the wonders of science and art

and

Mary Bond Wetherbe Ferguson who taught me enjoyment of literature and music.

CHAPTER 1 - Introduction

"The (Salk polio) vaccine was instrumental in the near eradication of a once widely-feared disease." Wikipedia (2006)

"Our children face the possibility of death or serious long-term adverse effects from mandated vaccines that aren't necessary…." Jane M. Orient, MD, AAPS Executive Director. Vaccineinfo.net web site (22 August 2006)

The subject of the research to be discussed here is immunization decision making. The above quotes capture the range of views about immunization and suggest why decision making in this area is difficult. In an article in The New York Times on how Americans view disease, Fountain (Jan 15, 2006) notes that people seem to view rare and unfamiliar diseases as more harmful than common and familiar ones. This style of risk assessment may influence immunization decision-making. Healthcare personnel have long puzzled over the disparity between risk of infectious disease as assessed by healthcare providers and disease prevention behavior, such as immunizations, as practiced by the public.

At one time, people were termed non-compliant when their health practice behavior was counter to recommendations made by their physicians. However, more recently, the medical community has come to recognize that individuals may make healthcare decisions by weighting variables differently than do healthcare providers (Lerner, 2006). There are many approaches to studying the issue including surveys of variables affecting immunization decisions made by the lay public and by medical personnel, and experimental decision-making research. The present research is in the tradition of decision-making research and will focus on decisions about immunization acceptance.

What is known from the healthcare literature will be reviewed first. The HBM (HBM), identified in the early 1950s by social psychologists (Rosenstock, 1974) best describes this research. The HBM suggests that two disease factors, disease severity and disease likelihood, and two immunization factors, immunization effectiveness and immunization side effects, are likely to influence immunization acceptance by the general public. Surveys based on the HBM interpret the model in different ways and draw varied conclusions about the implications of the survey findings. This research will be discussed in Chapter 2.

Decision-making research models from cognitive psychology, including Expected Utility and Subjective Expected Utility (Edwards, 1961) and Heuristics and Biases (Tversky & Kahneman, 1974), the Lens Model (Hammond, 2000), and the cognitive tools school of thought (Gigerenzer & Selten, 2002) will be discussed in Chapter 3. Research on risky decision-making shows that the framing of information is important to decision-making. Mathematical equivalence of two alternatives while stating the decision in different frames of reference for each alternative is the hallmark of framing effects research. Although much of the heuristics and biases literature focuses on irrationality, Frisch (1993) suggested that the decisions evoked by different frames of reference can be quite rational. In addition, much of this research is highly artificial.

Hammond, Stewart and Behmer, *et al*. (1986) discuss a partial solution to these problems. They maintain that stimuli used in decision-making research should reflect those in the environment. Hammond (2000) maintains that the question asked is not what is the correct decision, but rather what the does the participant do in response to specific environmental cues. He refers to Brunswick's ideas of the matching of cues in the experiment to those in the environment "ecological validity" or a "representative design" (Hammond, Stewart & Behmer,

et al., 1986, p 61). However, Hammond's approach is limited because of a belief that achieving ecological validity precludes a factorial approach to investigation of these phenomena. The present research attempted to construct an ecologically valid design so that the variables in the HBM could be examined systematically.

Context issues were studied initially in an effort to identify how the HBM variables should be represented. There are numerous extraneous variables, such as how the information is presented, that may impact the problem. This makes the immunization decision complex. Using the four variables identified in the HBM, five studies were conducted to identify how some of these extraneous variables affect response to the variables of the HBM.

Initial experiments, discussed in Chapter 4, address the issues of framing the decision as risk/risk or as a risk/benefit trade off, the effect of presenting likelihood information as probability statements or as frequency statements, and the effect of naming a disease or just referring to the disease generically as "a disease". All of these variables could be thought of as context variables. Establishing their influence on immunization decisions was an important design issue. The general pattern of response across all experiments was the same. Response appeared to reflect the probabilities associated with each of the diseases used for the experimental stimuli.

Immunization for each disease has a given efficacy. Immunization efficacy had been held constant for each disease used in the initial experiment. Therefore, a fourth experiment specifically examined the effect of shot efficacy, on immunization decision-making by systematically manipulating this variable. Manipulation of this variable does not detract from the ecological validity of the experimental design because there is a range of efficacies for immunizations.

There were persistent effects of disease type across all initial experiments and significant interactions with the other variables. Therefore, another experiment examined the nature of the interaction of the disease variable with one of the other variables, shot efficacy. This study used the findings from the initial studies to examine how immunization information is integrated to form a decision. The methodology for this study was based on Information Integration Theory (Anderson, 1974).

Functional Measurement (Anderson, 1974) is an approach to cognitive psychology that models how information is cognitively integrated to form decisions on which behavior is based. Functional measurement analyzes data at both group and individual levels, since there may be important variation in how individuals integrate information that is missed when data is only examined at the group level. Functional measurement is discussed in Chapter 5.

Chapter 6 discusses the design for the final study. The problem is decomposed to the level of disease base rates and immunization effectiveness in order to carefully examine the interaction of these two variables. These two variables were shown in the earlier studies to be important to the immunization decision.

Simplifying the design to focus on two variables enables the investigator to examine how participants integrate information on these two variables to form a decision. Ecologically valid stimuli were selected based on the initial experiments, review of the medical literature, and consultation with medical personnel. This leads to a 3x4 factorial design which systematically varied probabilities for disease base rate and immunization effectiveness. The use of ecologically valid cues for the stimuli increases the likelihood that finding from this study would be replicable and would generalize to other situations.

Results of the information integration study are discussed in Chapter 7. The effects of various manipulations in the design are discussed along with learning effects. Across all studies, it was found that disease base rates explained more of the variance than any other HBM variable. However, the existence of a significant interaction and some residual effects suggests that there may be a more complex picture of integration that should be further studied. In addition, participants appear not to notice small differences in disease base rates and to be unable to recognize immunization efficacy as a variable that is contingent on disease base rates.

Limitations are discussed in Chapter 8. The most important limitation to this study is that participants are in a laboratory setting and are asked to place themselves into a hypothesized immunization situation. Therefore, decisions made in this setting are hypothetical. However, due to careful selection of stimuli and their presentation, findings are likely to be of value in understanding immunization decision-making.

Chapter 9 discusses the results and future directions suggested by these results. The ability to develop ecologically meaningful stimuli for use in a controlled laboratory experiment is an important methodological contribution of this study. With this approach, the key question of how much difference between stimulus values for each of the variables in the HBM is noticeable enough to change behavior can be systematically examined. Further, quantifying responses to different variables in the HBM can lead to a better understanding of immunization behavior and further refinement of the model.

One important contribution is demonstration that a disease base rate contributes a large amount to the variance in behavioral response. This suggests ways in which healthcare personnel might approach patient education. In addition, findings from this study can be used to design decision support programs for patients, putting variables in contexts that are meaningful

to the patient. Finally, the methodology developed in this series of studies can be used to examine other consequential healthcare decisions, such as use of medication or treatment follow through for such diseases as diabetes, hypertension and cancer.

CHAPTER 2 - The HBM of Immunization Decision Making: Literature Review

Acceptance of adult immunization against Influenza and acceptance of childhood immunization by parents are the two immunization behaviors most studied by healthcare providers. There have also been a few studies of cultural/family differences immunization acceptance. The field of health risk communication has conducted studies on how risk communication influences immunization behavior. Most of this research uses some form of the Health Beliefs Model (HBM) (Becker, 1974) as a theoretical frame of reference. This chapter will review what is known from healthcare research about factors influencing immunization behavior

The HBM (Becker, 1974) originated from a series of studies in the 1950s focused on answering the question: Why do healthy people sometimes decline to use preventive medicine behaviors aimed at maintaining health? The model posited four beliefs regarding preventive medical behavior: 1. A belief that one is susceptible to a given disease, 2. Belief that, if the disease were contracted, it would severely affect life, 3. Belief that specific action would be effective in preventing or reducing the effect of the disease and 4. Belief that preventive action would not entail severe barriers as in terms of cost, pain, embarrassment or difficulty. However, Rosenthal (1974) points out that there is no evidence that targeting any one component of the HBM will have a reliable and predictable effect on people.

Five studies addressing influenza immunization among the elderly represent the literature on influenza. Each study used a different design and method of analysis, but all were survey studies and all addressed beliefs about influenza and immunization.

Nexae, Kragstrup and Sogaard (1999) conducted a questionnaire study assessing general health, locus of control and beliefs about health in the fall, prior to the onset of influenza's seasonal onset. They then followed up with a second questionnaire in mid-winter, asking whether or not participants had obtained a flu shot. Participants who acknowledged poor health and/or reported that they had a chronic disease requiring medications were classed as "high risk" for complications from influenza. These are the people healthcare providers target for influenza campaigns. Health beliefs were assessed by questions based on but not exactly like the HBM.

The survey used by Nexae, Kragstrup and Sogaard (1999) included three of the dimensions based on the HBM: (1) perceived benefits, (2) perceived susceptibility, and (3) perceived severity. It also assessed perceived barriers, which they included in their interpretation of the HBM. Locus of control was also assessed. They found that vaccination rates, even among people in high-risk groups were low (just slightly over 50%). Although more people in the high-risk group were vaccinated than those in the lower risk groups, the belief that one was in a high-risk group did not predict vaccination. They concluded that their HBM did predict vaccination behavior, while the Locus of Control Scale did not predict vaccination.

Telford and Rogers (2003) interviewed elderly patients, ten of whom had accepted recommended influenza vaccination and ten of whom had refused the recommended vaccination. They found that subjective assessment of risk was a key factor in influencing immunization acceptance. Subjective reports of those who accepted immunization reflected trust in modern medicine, social networks, and personal experience. These beliefs were thought to reflect vaccination effectiveness and perception of personal risk of disease. Those who refused vaccination reported mistrust of modern medicine, social network, and personal experience with adverse effects or ineffectiveness of vaccine and perception of little vulnerability to disease.

These subjective beliefs appeared to influence vaccination decisions independently of risks and benefits assessed by the medical community. These finding are qualitatively compatible with the HBM described by Rosenstock, (1974) in that these elderly patients described a belief (or disbelief) in vulnerability to disease and belief (or disbelief) in effectiveness of immunization as motivating immunization decisions. However, this survey included several other factors, such as trust in modern medicine that are extensions of the HBM.

A study by Gene, et al. (1992) was similar to that done by Telford and Rogers (2003). This study focused on patients who were identified by healthcare providers as high risk for complications from the flu. As in the Nexae, Kragstrup and Sogaard (1999) study, this investigation surveyed patients prior to the flu season, then assessed immunization behavior toward the end of the flu season. This study found that belief that one is vulnerable to influenza, regardless of vulnerability assessed by medical personnel, was a key factor in predicting immunization behavior. However, many patients assessed as "high risk" by their healthcare provider did not assess themselves as high risk. In addition, patients who did not accept immunization reported a belief that the immunization was not effective. This study also identified the belief that the healthcare provider was providing adequate care as influential in immunization decision making. As in other studies, these findings were interpreted as compatible with the HBM.

A study by Bekker, Gough and Williams (2003) targeted people ages 65+, those who are more vulnerable to side effects from influenza. This survey found that people who refused immunization were not only likely to believe that immunization was not effective against the flu, but also were more likely to believe that immunization could actually cause the flu and that healthcare providers were not supportive of immunization. These results, while not inconsistent

with some variables of the HBM, go beyond that model to include other beliefs as well. However, results are interpreted as reflecting the HBM.

Thus, four surveys of patients at high risk for complications from influenza found that health beliefs were important factors in predicting immunization. Each study interprets the HBM differently. Each study suggested a different approach to influencing these beliefs. One study (Nexae, Kragstrup & Sogaard,1999) suggested that free vaccinations and advice from general practitioners would increase vaccination acceptance. One study (Gene, Espinola, Cabezas, et al., 1992) suggested that health education focused on influenza and directly targeting high-risk recipients would increase immunization acceptance. Two studies (Telford & Rogers, 2003; Bekker, Gough & Williams, 2003) each suggested addressing beliefs, but methods and focus were slightly different. Bekker, Gough and Williams (2003) argue that beliefs about immunization effectiveness and likelihood of side effect from immunization should be directly addressed in information campaigns. In addition, they believe communication showing that immunization acceptance is a positive social norm should be part of the immunization message. Telford and Rogers (2003) focused more on changing the perception of immunization messages as directive and using a generic approach (as opposed to taking personal views and experiences into consideration) would make people more likely to accept immunization.

Two studies specifically examined influences on parents making decisions for their children. New and Senior (1991) asked parents about immunization of their infants. They found that parental decisions were based on experience with immunization, advice from friends and relatives, as well as from healthcare providers and on accessibility to healthcare. They suggest that these factors interact to influence behavior.

Sporton and Francis (2001) studied the decision making of parents who had chosen not to have their children immunized. Parents who refuse to have their children immunized universally focus on risk of side effects. Health professionals were seen as not providing balanced information directly discussing the pros and cons of immunization. They recommended that information against immunization as well as for immunization be presented and the parents encouraged to discuss the decision with their healthcare provider.

As noted in some of the studies above, family and friends are influential in immunization decisions. These influences were examined specifically in two studies. In a case controlled survey study of patients older than 65, Takahasu, et al. (2003) identified family and close friends as influential in patient's decisions about accepting influenza vaccination. They suggested that, for some cultures, e.g. Asian and Hispanic, family opinion is a critical consideration in decision making for oneself. As in previous studies cited above, belief in vaccine efficacy was significantly associated with immunization acceptance and fear of side effects was significantly associated with immunization rejection. However, they did not consider other HBM variables, such as disease likelihood. They suggested that targeting the patients' social networks for information about these two issues would be much more important than targeting the individual.

Das and Das (2003) provide an important addition to the discussion of factors impacting immunization acceptance. Many studies discuss the effect of experience, both negative and positive with vaccination. Das and Das add a third kind of experience: no effect. That is, if there were no sign of imminent disease, vaccination would seem to be either ineffective or unnecessary. There might be a belief that the disease would not have affected the individual in the first place. This has long been the dilemma of preventive medicine: How do you show the effectiveness of prevention when the result is that nothing happens (maintenance of status quo).

Das and Das (2003) point out that most families do not weigh immunization decisions as a purely cost/benefit ratio with full knowledge of all the factors to be considered. Concrete observation of relationships between vaccination and disease prevention is very limited in most people's experience. They point out that the first step is establishing trust in healthcare providers though the demonstration of the effectiveness of other healthcare programs. This trust can then be transferred to vaccination programs because people would see that healthcare personnel, the people who suggest immunizations, are trustworthy in other situations.

Similar to Das and Das (2003), Sturm, Mays and Zimet (2005) conceptualize vaccination decisions as based on the interaction of government mandates, health beliefs and social/environmental information. They note that interaction with healthcare providers can specifically affect health beliefs. Sturm, Mays and Zimet (2005) found that American healthcare providers rarely initiate discussion of risk associated with childhood immunizations. They point out that parents often take temporal associations between an immunization and some change in a child's behavior as a causative association. They suggest that provision of explicit information on what they refer to as "attributable risk" (p. 450) (e.g. what side effects can be expected, if any occur) to the decision maker will help lay decision makers, such as parents, to base decisions on scientific evidence. This, then, is expected to impact health beliefs.

Sturm, Mays and Zimet (2005) suggest that the HBM has had poor predictive success by itself for at least two reasons. First, many studies using this model do not measure key concepts in the model carefully. Second, although the model may be predictive in theory, changes in the environment affect some of the components, such as the belief that a person is susceptible to the disease. They point out that in the 1950s, parents viewed their children as susceptible to polio, but today, many parents do not. In addition, the authors note that cognitive heuristics affect

decision making, such as omission bias in the vaccination of children. People in general prefer to avoid action that might harm someone, especially a child, even if that action has a good chance of preventing harm.

The above literature includes research on immunization decision-making by people 65 and older and decisions by parents for their children. A 2003 campaign to immunize healthcare providers against smallpox provided an opportunity to examine factors influencing vaccination decisions by physicians for themselves. Only 5% (3/60) of the physicians in a large university hospital who were contacted about immunization accepted it (Benin, Dmbry, Shapiro & Holmboe, 2004). Physicians who declined immunization cited a negative cost/benefit ratio. The costs of vaccination included risk of contagion from the vaccinated person to family or patients (unique to smallpox vaccination) as well as potential side effects. Most physicians reported that they did not believe it likely that there would be a bioterror attack (the only likely means of contracting smallpox) in the US in the next 5 years. Therefore, they assessed benefit from vaccination as low.

The consensus from the above medical literature appears to be that the HBM captures key variables describing immunization decisions. There is great divergence, however, in recommendations about how to influence these decisions. The most popular recommendation is some kind of educational approach, for the individual, family or group level.

One of the most sophisticated educational approaches was reported in "Practice Notes" (2004). This Health Maintenance Organization organized a flu immunization campaign involving every aspect of the HMO member's contacts with the agency from mass mailings of pamphlets, to inclusion or reminders in the phone message while waiting on "hold", and encouragement at every level of care provider to endorse immunization. In this example, nearly

all potential sources of belief influence were addressed in an effort to increase acceptance of flu immunization among the elderly. There was a reported increase from 45% immunization the previous year to 95% the year of this particular campaign. It would appear that this approach, especially if applied to all immunization decisions, might be effective, but quite costly.

How risk associated with disease and immunization is communicated was the subject of a workshop conducted by the Institute of Medicine (Stoto, M.A., Evans, G. & Bostrom, A., 1998). They found three concerns about how immunization information is communicated: (1) that the process often fails to take into account patient variables such as prior knowledge and beliefs, (2) that consent to immunize is not always fully informed but instead is frequently mandated, and (3) that uncertainty about risks are not always acknowledged. Ways in which participants thought uncertainty about immunization risk should be acknowledged include discussing risks more openly with the public.

In general, research discussed in this section has been largely based on surveys. Interpretations are generally consistent with at least some aspects of the HBM (Rosenstock, 1974). How health beliefs can be changed is addressed in numerous ways. The HBM, while intuitive and certainly a good description of key issues in decision-making, does not effectively identify specific interventions to produce predictable and reliable outcomes. The HBM does not help us understand how health beliefs are influenced or how information is used to affect health beliefs.

As a test of how the variables in the HBM are viewed by those doing research on healthcare decisions, the investigator in the studies reported in this dissertation informally surveyed members of the Society for Judgment and Decision Making who also were involved in healthcare decision research. Each member meeting the above criteria was asked how they

would weight the HBM variables. 3 out of 29 responded with estimates. All believed that there should be a non-zero weight for each of the four HBM variables, but each had a different weighting scheme. This demonstrates the ambiguity of the HBM in application.

CHAPTER 3 - Risky Decision Making Paradigms and Immunization Decision Making

Starting in the 1950s, the field of decision making as a science is fairly new (Connolly, Arkes & Hammond, 2003). Yates (1990) divides decision making research into three categories: choice, evaluation, and construction. Choice decision-making is the selection of one behavior from at least two alternatives. Evaluation is weighting of alternative values. Construction is assembling the best alternative from several potential combinations. Immunization decisions constitute choice decision-making because the decision is to accept or refuse an immunization. It is decision making under risk since if one refuses immunization, one risks disease; if one accepts immunization, one risks side effects of the immunization itself. As will be discussed later, the problem of immunization decision-making is more complex than this simple trade off. Behaviorally, the decision is a two alternative decision.

From the beginning, investigators in the field of decision-making have looked at decisions in terms of rationality. Gigerenzer and Selten (1999) date early thinking in decision making from the ideas of Locke, Pascal and Fermat. According to Gigerenzaer and Selten, Locke asserted that the only rational way to make a decision is to frame the problem in probabilistic terms. Pascal and Fermat applied this to decision-making by using gambling as a model. This approach is now called economic decision theory. Research in decision-making that followed this model used constructed alternatives that were mathematically equivalent, but structurally different in various ways. Thus, early research in decision-making used a mathematical model focused on making rational decisions. Rationality was defined as

maximizing the payoff in the long run through calculation of mathematical odds of payoffs and using these calculated payoffs as a basis for comparing alternatives in each choice situation.

Yates (1990) identifies two schools of research in risky decision-making: proscriptive and descriptive. Prescriptive decision-making answers the question: what is the best approach to making rational decisions? The assumption that underlies this approach is that if a rational approach is used to making decisions when the outcome is uncertain, the best decision will be the most rational. Descriptive decision-making research seeks to describe how people make decisions under different circumstances and how different variables affect decision-making. The assumption that underlies this approach is that if we understand the process and the pitfalls, we can help people make better decisions by designing training programs and decision aids that will help them overcome cognitive limitations interfering with good decision-making. Prescriptive decision making models will be discussed first.

Prospect theory is a popular example of a prescriptive model of decision-making that also provides a description of how people make decisions (Yates, 1990). People are faced with at least two or more different prospects between which they must decide. An examination of each of these prospects helps to identify specific outcomes that matter to the decision-maker. People usually first eliminate prospects that clearly don't result in outcomes of importance. When the prospects are narrowed down to two or three alternatives, each with different merits and probabilities associated with those merits, the problem can be reduced to mathematical solutions for comparison. Rational choice, as noted above, is choosing the alternative that maximizes the utility of the outcomes.

Expected value (EV) is a quantification of the essential features of alternatives so that the problem can be solved mathematically and the correct decision is made obvious. Each essential

or important feature for each alternative is identified. Multiplying each feature by its probability and then adding all these products together for each alternative provides a quantitative measure of the expected value of that alternative. If this calculation is done for each alternative, a choice can be made between prospects by simply comparing expected values for each alternative and choosing that with the highest expected value.

When applying EV to a single gamble, one would gamble only if the amount that one could win is positive. Thus, if one were gambling on the state lottery where the odds of winning are extremely small, one could calculate the expected value for the lottery by multiplying the payoff by the very small probability of winning. If this calculation were done, one would recognize that the logical decision is to refuse to play, since the expected value of playing is negative.

EV is based on objective values of essential aspects of the problem and is measured in objective terms: as money or time. When the expected value of a gamble can be quantified, there are two questions that can be asked: (1) which of two bets is the best gamble or (2) to play or not to play a single bet. However, in many situations, the value of a prospect is not so easily measured in objective terms. Utilities capture the subjective component of value. The term expected utility (EU) is used to describe a decision context in which a probability is multiplied by an subjective utility. Money is not does not have a linear value because someone who has a million dollars does not value addition of $1.00 in the same way that someone who has $100 would value an additional $1.00. EU allows for the subjectivity of those values.

In some situations, both value and probability are subjective estimates. In these situations, the probability of an event is uncertain, so the individual must estimate how likely an event is to occur as well as identify its value in that situation. An early decision scientist,

Edwards (1961), introduced the idea of subjectivly expected utilities (SEU) in which the participants estimate probabilities as well as give subjective values. Edwards recognized that probability is not necessarily linear. Cognitively, people do not necessarily treat probabilities in evenly spaced increments, as they would mathematically. Probabilities on the extremes of the scale may be treated differently than probabilities toward the center. For instance, a 1/1,000 chance of having something bad happen may not move a person to action, but at some point, the probability of having something bad happen will increase enough that action is taken. Where that point occurs is subjective.

An important point that Edwards (1961) made is that SEU is not an additive model. He cites several investigators whose work has supported a multiplicative model. This issue will be addressed later under Functional Measurement (Anderson, 1981). Further, Edwards pointed out that decision-making in real environments is dynamic, with information available at different times along a temporal continuum and sometimes contingent on previous decisions.

SEU is more useful than EV in situations where a person may not have more than one "chance" or replication of the situation and there is no objective estimate of probability available. The SEU model of decision-making is still normative in that the underlying assumption is that people seek to maximize utility and behave in ways that are consistent with the mathematical properties of the problem.

A large body of literature has been published describing ways in which people often violate these assumptions. Simon (1956) pointed out that learning theory provides a better model for decision making than do the economic models on which EV and its related rational, normative models are based.

Simon's (1956) model took into account elements of the environment that constrain decision-making. As described in Frieman (2002), payoff is only part of the story. In general, participants' performance has the effect of distributing effort in such a way that a manageable cost and payoff occur across various choices over time. Thus, the participant sacrifices maximization of value in any one choice situation for satisfactory value overall. Simon (1956) called this general behavioral approach to decision-making "satisficing" (p 129). Satisficing is adaptive behavior because it allows for change in the environment.

Tversky and Kahneman (1974) built on Simon's concept of human limitations in cognitive processing capacity and its effect on decision-making. Their approach is called "Heuristics and Biases". The term "heuristics" was coined by Simon to denote adaptive strategies used to make effective decisions (Simon & Simon, 1962).

Tversky and Kahneman (1974) used the same term to denote the rules used by novices to reduce cognitive complexity of probability judgments in everyday life. They focus their research on how these judgments result in what they see as "severe and systematic errors"(p. 35).

Tversky and Kahneman (1974, 1984) have identified a number of biases including "availability" and "anchoring/adjustment". Experiments in this paradigm are set up so that there is a mathematically correct answer using EV or Bayes' Theorem. A bias is reported when a large number of participants give a consistently wrong answer. The many studies following their paradigm have contributed to understanding errors in judgment. In some experiments half the participants are shown the problem stated as loss and half see it stated as gains (Kahneman, K. & Tversky, A., 1984). The problems are mathematically identical, but the frame of reference for one gives a reference point of gains (such as saving lives) and the other gives the reference point as losses (such as lives that can be lost). The resulting difference in the decisions made are

called “framing effects”. Numerous experiments have been published reporting various framing effects, many of them, like the Asian Disease problem above, involve medical decision-making.

Moxey, O’Connell, McGettigan and Henry (2003), note that how information is framed affects patient decision-making. They performed a meta-analysis of studies with decisions as either survival (a positive frame of reference) or death (a negative frame of reference) in several different medical decision contexts: a surgical decision, a medical decision and an immunization decision. They found that there was no consistent effect of framing for surgical decisions although the meta-analysis suggested that patients were generally about 1.5 times as likely to choose surgery if surgery was positively framed as saving lives. When the decision was about medical treatment, patients were generally more willing to tolerate more toxic treatment when a positive frame of reference was used. When immunizations were the focus of decision-making, there was no significant framing effect. However, they note that many of the studies used in their meta-analysis had design problems including lack of authenticity of the scenarios used.

Ritov and Baron (1990) demonstrated an important effect, which they named the “omission bias”, in which undergraduate college students were asked to make a decision to mandate vaccination for children. This effect is important because it showed that these students were averse to risking a child’s life, even when the risk of death for the child was small compared to the protective effect of the vaccination. Ritov and Baron’s (1990) study uses the classic framing effect approach, with a between-subjects design where the probabilities of both frames of reference are mathematically symmetrical. Their overall result suggests that participants generally prefer inaction when action may result in harm, even if action may also result in improved outcomes.

Connolly and Jochen (2003) posed a challenge to the omission bias model. They show that design properties of these studies influence the outcome. Connolly and Reb (2003) conducted a series of experiments that showed that the seemingly irrational "omission bias" results from a combination of conceptual problems and the scales used for these studies. They propose "regret" as a better interpretation of motivation for immunization decisions. Specifically, they found that risk of disease vs. risk of side effects were the factors that influence immunization decisions. They suggest that participants wanted to make a decision that would get the best outcome (one they would not regret). Participants chose action (immunization) if they believed a change in the status quo was likely (disease was likely) and action seemed less risky than the potential change. Further, a study by Wroe, Turner and Salkovskis (2004) using expectant parents as participants found that anticipated responsibility and regret together explained more than 50% of the variance in decisions about immunization made by parents.

Exploration of omission bias (Ritov & Baron, 1994) suggested that it may explain most of what has been called the "status quo" bias. That is, people prefer the status quo in situations where action may result in harm, but also favored giving up the status quo if retaining it required action. Ritov and Baron (1994) also found that people believe that inaction resulting in harm was less culpable than action causing the same harm. They conclude that there is a bias toward inaction.

However, the study by Wroe, Turner and Salkoviskis (2004) above would suggest that giving up the status quo is likely when retaining the status quo would result in regret. Whether the omission bias is the same kind of cognitive bias as described by Tversky and Kahneman (1974) could be questioned, because this bias may be more a description of a cut point, or policy requiring a higher payoff for action, than for inaction. Action may even be preferred when the

status quo would increase risk. In research on immunization, these results are important, but may only describe part of the picture.

Gigerenzer *et al*. (1991) reviewed the role of probability theory in psychology. They point out that the normative model of psychology, discussed above, grew out of psychologists' use of statistical reasoning as a model for psychological processes, just as development of computers lead cognitive psychologists to use terms from computer technology to describe human mental processing. Neither the statistical model nor the computer model has been particularly helpful in understanding decision-making. Instead, Gigerenzer's group cites Simon (1956) to propose that context is an important consideration in decision making.

In this framework, the "correct" answer to a problem depends on variables other the mathematical calculation used in the heuristics and biases literature. Context and experience both impact what is a correct answer for any individual or group. As pointed out by Gigerenzer and Selten (1999), Simon emphasized the influence of environment, while Kahneman and Tversky emphasize the failure of the human. In contrast, Gigerenzer's group takes a more adaptive approach. Their research focuses on heuristics that serve to help humans overcome cognitive limitations to make adaptive decisions.

Instead of seeking to develop normative models for correct decision-making, Gigerenzer and Selten (1999) propose a framework of decision-making that they believe is significantly different from the normative framework. Their model is called "Fast and Frugal" heuristics. They showed people's decisions to be at least mathematically equivalent to regression models using the same variables, as long as the most important variables are used in the equations. It is perhaps important to note that, while introducing their model as non-normative, the proof offered is that the results are mathematically similar to those obtained with a normative model. Their

point of view is that successful human decision-making can be described using simple cognitive tools that help decision makers be wise decision-makers in difficult environmental situations.

Kee, *et al.* (2003) tested Gigerenzer's Fast and Frugal model of decision making against linear logistic regression in a medical decision making task. They found the two models to be similar in accuracy for the decisions made. It should be noted, however, that both models were descriptive. The use of environmental cues by the decision maker was the outcome of interest. The ability to describe cue use by participants in a study is of limited value in predicting behavior, since there are numerous cues that may be used by different participants to arrive at the same decision. A problem with Gigerenzer's (2003) Fast and Frugal approach is that, in order for it to be effective, the decision maker must reliably identify the key elements of the problem. This descriptive model does not help us to identify which elements are key to adaptive decisions.

Gigerenzer's and Selten's (1999) concept of bounded rationality echoes Simon's (1956) contention that humans are rational within the bounds of both environmental and cognitive limitations. Simon points out that the term "environment" is relevant to human decision making only in so far as specific elements of that environment are important to the decisions to be made, which he describes in terms of needs, drives and goals. Thus, if the need is to protect oneself from prevalent disease of devastating impact for which there is no cure and no other preventive intervention, as it was with polio in the 1950s, even experimental immunization may appear to be a good choice. On the other hand, if the need is to protect oneself from a rare disease, as with polio today, even common immunizations may not seem like a good choice because all immunizations have less than 100% efficacy and have some risk of side effects. This is consistent with the HBM discussed in the previous chapter and is adaptive.

As can be seen, each model of decision making promises to explain how decisions are made. Some models, such as EV and SEU, suggest methods of improving decision-making. As Huber (2004) points out, much of the research on risky decision-making has used artificial parameters not reflective of the common decisions to which they are usually generalized.

Applied to immunization decisions, a normative approach has three problems. First, although one may obtain some estimate of risk relative to disease and to immunization from multiple trials (this is done under supervision of the Federal Drug Administration), for an individual, there is only one decision. For the individual, it makes not sense to talk about multiple trails. Secondly, risk and payoffs for immunization are quite unlike those for gambles because there is risk of disease if one refuses immunization, and immunization reduces, but does not entirely obviate that risk. Thirdly, there is risk associated with immunization because immunization is an invasive procedure with attending side effects. Estimating risk of disease and risk from immunization involves multiple variables including host immunity, likelihood of exposure to the organism, virulence of the organism and type of immunization to name just a few potentially important variables.

Some approaches, such as Heuristics and Biases, suggest pitfalls to avoid (without specifying how to avoid them). Still others, such as the Fast and Frugal approach, suggest that decision makers should adopt specific strategies, such as looking for dominating cues, to make decision making more efficient without sacrificing accuracy. Like the HBM, specification of how one should decide is of limited value in predicting adaptive behavior in realistic situations, such as immunization decisions.

The economic models of decision making and the heuristics and biases model all seek to prescribe correct decision making. The Fast and Frugal approach is also prescriptive. The HBM

is descriptive and vague in its application. A fourth approach is the Lens Model approach (Hammond, 2000). This approach is generally applied to social policy decisions rather than to medical and healthcare decisions. One strength of this approach is its insistence on representative design. While many economic models and most if not all of the Heuristics and Biases studies use highly artificial stimuli, the Lens Model approach seeks to accurately represent the decision context with the goal of making findings generalizable to other similar situations. However, Hammond is less interested in how these representative cues are combined. The use of linear regression an essential component of the Lens Model approach, assumes additivity of components. Further, Hammond maintains that factorial design cannot be appropriately used with representative design because cues do not exist factorially in nature.

A fifth decision-making research approach uses the Functional Measurement developed by Anderson (1981). Like Simon (1956), this approach recognizes that human decision-makers exist in a complex environment and that humans have limited cognitive resources with which to make decisions in that environment. Like the Fast and Frugal group, these investigators do not focus on errors. Instead, they seek to describe how humans respond to specific aspects of this environment using what they call Cognitive Algebra. The research of this group will be discussed in the Chapter 5.

The challenge in designing immunization research that is both generalizable and that can predict behavior is to design a study that results in the ability to predict immunization behavior given a known set of variables. To do this, it is important to select ecologically valid cues for use in the stimuli while allowing for systematic manipulation of variables. The initial studies in this series were designed to address these cue selection issues. Careful review of medical literature on diseases and immunizations and consultation with practicing healthcare personnel

resulted in ecologically valid cue selection for three representative disease/immunization pairs. The four variables identified in the HBM were selected for inclusion in the information display for each disease. Stimulus display characteristics were then systematically examined to refine the presentation of information. These characteristics included the following: (1) whether information was presented as a risk vs. a benefit or as one risk vs. another risk, (2) whether information was presented as probabilities or as frequencies, and (3) whether the disease was named or a generic term used for the disease, Chapter 4 describes these initial studies and their results.

CHAPTER 4 - Initial Studies

Using the variables identified in the HBM (HBM) (Rosenstock, 1974), a series of experiments were conducted to answer four questions: (1) Does framing of the immunization decision as a risk/benefit tradeoff vs as a risk/risk tradeoff affect the pattern of response to the variables in immunization decision-making? (2) Do participants respond differently to risky immunization decisions when the statements use probability terminology than when the same information is provided as frequency statements? (3) Do participants respond differently to immunization scenarios when they are given the actual disease name compared to when the same information is provided but the disease is not identified? (4) Does immunization efficacy interact significantly with the other HBM variables?

The term "framing" used in asking the first question refers to using exactly the same information in two conditions, but stating one condition as a trade-off between risk of disease and benefit of immunization (reduced risk of disease) and the other as risk of disease vs risk of immunization. The two conditions are mathematically identical and contain the same information. Only the frame of reference is changed from one to the other. The issues around formulating risk/risk and risk/benefit scenarios for immunization decision-making will be discussed.

As discussed in the previous chapters, there has been research to suggest that the first three questions may influence responses in risky decision-making. However, there has been little direct study of them in immunization decision-making. It is important to understand how these framing effects might affect decision making prior to examining more directly how the immunization variables themselves are combined to make decisions.

Risk/Risk vs Risk/Benefit. Tversky and Kahneman (1974) demonstrated that framing decisions as gain leads to different decisions than does framing them as losses. The Asian Disease Problem, Tversky and Kahneman's (1984) prototype of the framing effect, used unrealistic medical scenarios and a between subjects design. Subsequent studies, as noted in the section on risky decision-making, showed various "biases" using the same general approach. Baron and Ritov (Ritov & Baron, 1990, Baron & Ritov, 1994, 2004) reported an "omission bias" in response to immunization decisions. Their design, much like the Asian Disease Problem, only gave general numbers of "those saved" and "those who would die from side effects of the treatment". These numbers were not based on realistic disease variables. Kuhbergere, Schulte-Mecklenbeck and Perner (2002) identified the artificiality of the tradeoffs in this paradigm as a serious problem with decision-making research. Not surprisingly, results reported using this approach are not universal.

In a study of physicians, Christensen, Heckerling and Mackesy-Amiti, (1995) showed that framing of medical decisions did not reliably influence medical decisions made by doctors. They found that experienced physicians were influenced by the framing of the problem as risk (mortality rates) vs benefit (survival rate) in only two out of twelve hypothetical medical cases.

It is not clear how lay people make immunization decisions in a realistic immunization decision framed as a trade off between risk of disease and risk of immunization side effects vs decisions framed as trade off between risk of disease and benefit of immunization. Although the two conditions can be constructed so that they are mathematically identical and provide the same information, examining how one would state the variables to construct the risk/risk frame vs. the risk/benefit frame suggests problems with studying framing effects using realistic immunization scenarios.

The first issue encountered in this study was how to describe immunization decisions as risk/benefit trade offs. This issue arises from the fact that three of the four variables identified in the HBM, likelihood of disease, severity of disease, and severity of treatment side effects, are logically discussed in terms of risk. Immunization efficacy is the only variable that can be easily stated as a benefit. For instance, likelihood of disease would be commonly thought of as risk of disease without immunization. This is actually the disease base rate.

Severity of disease is also a risk issue because it is thought of as risk of severe disease. Although the likelihood of some diseases is relatively high, the likelihood of severe disease in some of those cases is relatively low. Conversely, base rate for some diseases, such as Tetanus, is low relative to the severity of the disease if contracted. Further, likelihood of severe disease is contingent on contracting the disease. This is called a conditional probability. This issue will be discussed further in the discussion section.

In terms of immunization variables, it is possible to state immunization as a benefit by stating how likely the recipient of an immunization would be to avoid infection. In actuality, no immunization is 100% effective in all cases. There is a rather narrow range of immunization efficacies, due at least in part to Federal Drug Administration oversight. In general, the most effective immunization is 99% effective (e.g. Tetanus) and the least effective is not less than 80% effective (Influenza). Efficacy of most immunizations is in the range of 95% (Smallpox) and 90% (Pertussis) (Atkinson, Hamborsky, McIntyre & Wolfe, 2006).

In addition to prevention of disease, immunization sometimes will lessen the severity of disease. This is the case for influenza immunization (Humes, 2000). Therefore, immunization may be stated as a benefit. For experimental purposes, the statement of benefit must be stated more concretely than is the actual case. Instead of stating the likely reduction in severity of

disease, it is better to state that the disease likelihood is reduced. To include other variables is likely to unnecessarily complicate the picture by adding another variable. When complexity of the stimuli is increased, results can become difficult to interpret.

Immunization is a two edged sword. There is no way to describe immunization side effects as a benefit. While side effects of some medications, such as aspirin, might be beneficial (prevention of stroke and heart attack), the only circumstances under which immunization side effects might be beneficial is in evoking a general immune response. Even this possibility is not usually the point of immunization and is not a general practice. Therefore, immunization is usually thought of as risking loss or negative change from the status quo.

Side effects of immunizations vary from one kind of immunization to another. There are several types of immunization (Appendix A). The type of immunization affects not only immunization effectiveness ranges, but also what kind of side effects to expect. For instance, purified proteins evoke immunity with little side effect risk while attenuated viruses are much riskier. As in severity of the illness itself, side effect severity is variable from one immunization to another and from one individual to another depending on immunization type and host factors. However, to design an experiment that uses relatively realistic immunization variables, a concrete level of risk of side effect must be stated.

Experiment #1: Despite the difficulties of designing a study to test framing effects for immunization decisions, it was possible to develop scenarios to experimentally examine immunization decision making. The information used to devise these disease probability scenarios was obtained from the medical literature (Beers & Berkow, 1999; Chin, 2000; Department of Health and Human Services Centers for Disease control website, www.cdc.gov; Humes , 2000; Isada, Kasten, Goldman, Gray, & Aberg ,1999, Seattle and King County Public

Health Department website, www.metrokc.gov; Mandell, Bennet, & Dolin, 2000; and Springhouse Professional Guide to Disease, 1998). An occupational health physician, who was obtaining a MPH at the time, reviewed and approved the pilot scenarios for authenticity (Dr. J. Schlageck, personal communication, Spring, 2005). An infectious disease specialist reviewed and approved later versions (Dr. P. Dasaraju, personal communication, Nov 14, 2005).

The disease variable was stated as risk in all situations, e.g. "Your risk of a disease is less than 0.35". Immunization was stated risk of shot reaction along with a reduction in disease risk in the risk/benefit frame of reference, "e.g. If you get a shot, there is a 0.10 risk that you will have a moderate shot reaction, but the risk of getting a mild case of the disease would be reduced to 0.06". In the risk/risk frame of reference, immunization side effects were stated just as risk (e.g. If you get a shot, there is a 0.10 risk that you will have a moderate shot reaction. The risk of a mild case of the disease would be 0.06). This left participants to calculate the reduction in disease likelihood resulting from immunization for themselves. Immunization side effects were always stated as risk (see examples above).

Each stimulus stated one benefit and two risks. The three levels of disease severity included disease base rates, probability of severe disease, and probability of death from disease. The latter two levels of disease severity were actually probabilities conditionalized on getting the disease in the first place, but this was not made salient to the participant. Disease base rate and severity information obtained from the medical literature was not stated in conditional probabilities and information provided by medical personal is not usually stated in conditional probabilities. Therefore, it seemed realistic to provide information in a factual manner, but not to remind the participant that one must first be vulnerable to the disease before becoming part of a severity sub group.

The three levels of side effect severity were mild, moderate and severe, each with the probability of occurrence found in the literature. There was no description of what the terms "mild", "moderate" or "severe". Immunization efficacy was held constant across each level of immunization side effect for a given disease because shot efficacy for any immunization does not change.

In the interest of developing a representative design, three diseases were selected to represent a spectrum of diseases against which one might be immunized. The base rate of each disease is different as is the likelihood of severe disease, if the disease is contracted. Immunization effectiveness and side effect likelihood are different for the immunization against each of these diseases. Thus, the probability of disease and severe disease as well as the probability of side effects were different for each disease.

Three diseases for which there are immunizations were selected to provide a variation in disease base rate, disease severity, immunization efficacy and immunization side effect profiles. The three diseases represented (1) a rare, but severe disease for which immunization is common (Tetanus); 2) a common, but less severe disease for which immunization is also common (Influenza); and (3) a rare, severe disease for which immunization is not common (Smallpox). The immunizations for these diseases ranged in effectiveness from 80% effective (Influenza) to nearly 100% effective (Tetanus). Disease base rates, side effect rates and severe disease rates varied from one disease/immunization combination to another. Immunization efficacy was the same across all levels of side effects and was not a variable of interest for the first studies.

Stimuli: The above analysis of the problem of stating the variables as risk/risk vs stating them as risk/benefit resulted in a 3 (disease) by 3 (disease severity with likelihood) by 3 (immunization side effect severity with likelihood) design. These variables were printed on 4 x 7

card stock with the variables displayed as shown in Figure 4.1. The difference between the risk/risk and risk/benefit wording was insertion of the term "reduced to" probability of disease for the risk/benefit format. A simple statement of probability constituted the risk/risk format.

It was believed that stating the decision as a risk/benefit trade off would increase likelihood of immunization acceptance (Desaraju, personal communication, 14 November, 2005). The stimuli were shown with disease severity probability, then side effect probability followed by disease benefit (disease probability given shot: D|S) since it was thought that disease severity and side effect severity might be the key variables in decision-making.

Figure 4.1 Stimuli used for risk/benefit vs risk/risk trade off in immunization decisions.

Risk/Benefit

Your risk of a severe disease from which you could recover is 0.68.

If you get a shot, there is a 0.99 risk that you will have a mild shot reaction,
but the risk of the disease is reduced to 0.05.

Risk/Risk

Your risk of a severe disease from which you could recover is 0.68.

If you get a shot, there is a 0.99 risk that you will have a mild shot reaction.
The risk of the disease would be 0.05.

Participants: Eighteen undergraduate university students taking an introductory psychology class agreed to participate for class credit. Participants were first given a description

of the study and signed the informed consent. They were given 1 hour of class credit for participation. Each study was completed on one set of participants, who participated as a group. Stimulus cards, showing the risk of disease x risk of shot reaction x risk of disease with shot were shuffled prior to each experiment to randomize stimulus presentation. Each stimulus card included a code denoting which immunization scenario was on the card. Participants were provided with a response form with a separate Likert scale for each stimulus card. There was a blank for the participant to write the stimulus card code adjacent to each Likert scale. This allowed the stimulus to be paired with the response.

Response Scale: Each scale was anchored with 0 = "Never get a shot under these circumstances" to 10 = "Always get a shot under these circumstances". A space was provided with each response scale for the participant to write in the code for the stimulus card to which they were responding. Participants were instructed to read the one card at a time and answer the question: how likely would you be to accept an immunization under the circumstances described on the card? Each participant answered the question for each stimulus card by circling a number (0-10) on the response scale and passing the stimulus card to the next person. They were debriefed after participating in the experiment and asked to discuss their strategies for making decisions for the immunization scenarios.

Results: There was an effect of format ($F(1, 17) = 8.166$, $p < .01$, $\eta 2 = .324$) for this study. Stating the decision as risk/benefit did significantly increase likelihood of immunization acceptance.

Experiment #2: Because the goal was to test the effect of presenting the decision as a risk/benefit trade off vs. a risk/risk trade off, it was decided that a better method would be to present the benefit of disease reduction immediately after disease severity information.

Therefore, the experiment was repeated with new participants (N = 14) using the same wording as before, but with information on disease reduction with immunization (denoted here as D|S for "disease given shot") presented second (Figure 4.2). Format was not significant using this order of information presentation even though the statements of risk and benefits were the same as for the first experiment ($F(1, 13) = 1.202$, $p < .293$, $\eta^2 = .085$). As can be seen, the effect size was also smaller.

Figure 4.2 Reordering of Stimuli so that side effects are last and reduction in disease is second.

Risk/Benefit

If you don't get a shot, your risk of a disease from which you could recover is 0.68.

If you get a shot, your risk of the disease would be reduced to nearly 0.05,
But there would be a 0.99 risk of a mild shot reaction.

Risk/Risk

If you don't get a shot, your risk of a disease from which you could recover is 0.68.

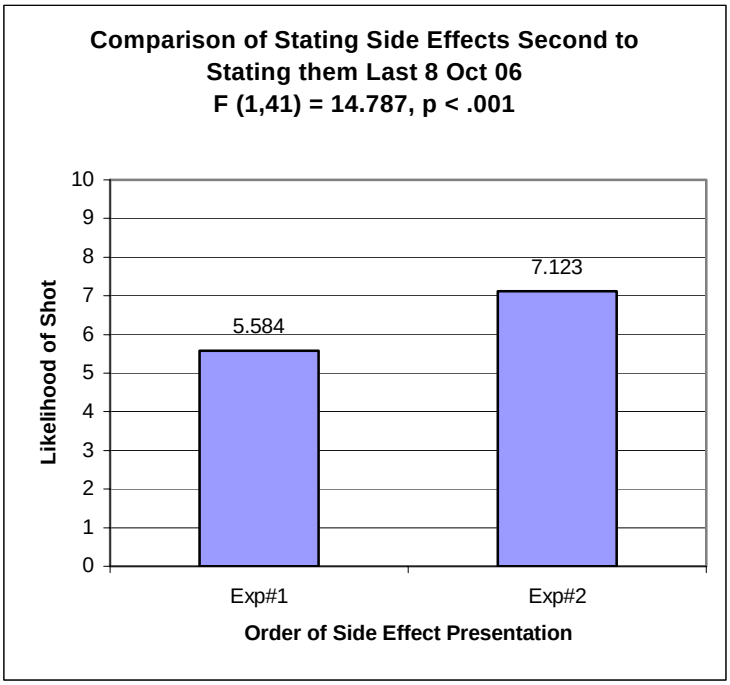
If you get a shot, your risk of the disease would be nearly 0.05.
The risk of a mild shot reaction is 0.99.

Experiment #2R: The difference in results in experiments #1 and #2 were surprising. Therefore, experiment #2 was exactly replicated with a new group of students (N=11). However, the results were similar for both experiment #2 and its replication, experiment #2R (F

(1, 10) = 4.041, $p < .072$, $\eta^2 = .288$), although the effect size was larger for the replication and there was near the .05 level of significance for format. Because there was no difference between the results for experiment #2 and its replication, the data from these two small experiments were combined to increase power.

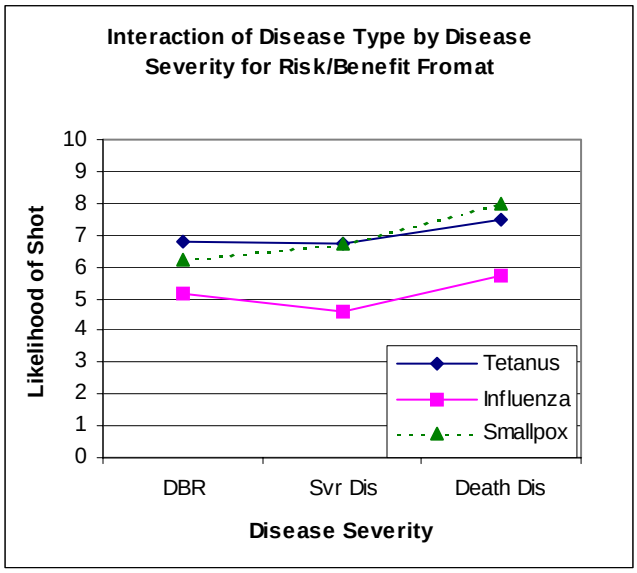
Since the results of experiment #2 and its replication were similar, the data from these two experiments were combined and compared with Experiment#1. The effect for the variable of format is illustrated in Figure 4.3. There is a significant difference between stating immunization side effects right after disease severity (Experiment #1) and stating immunization side effects last (Experiment #2). When immunization side effects are stated last, the reduction in disease likelihood is stated right after stating the probability of a given level of disease severity.

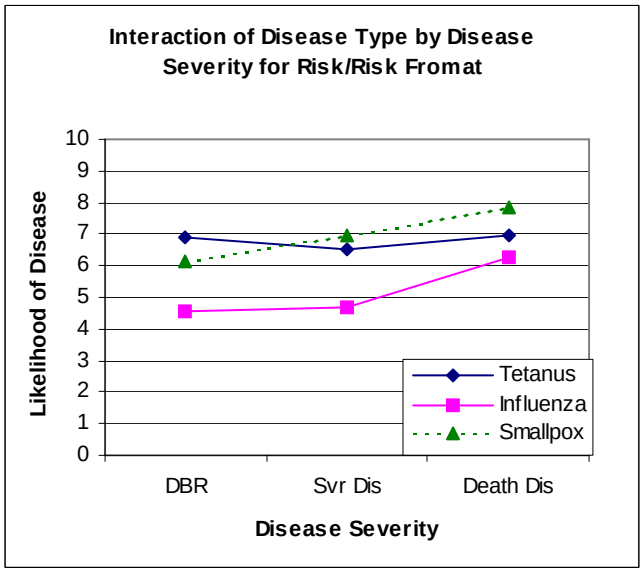
Figure 4.3 Comparison of Framing Effects for different orders of information presentation



There is no main effect of format (risk/benefit vs. risk/risk) when disease severity and reduction in disease likelihood are paired as in Experiment #2. However, there is a significant three way interaction between format, disease type and disease severity (Figure 4.4). Although the response to disease base rates for Smallpox and Tetanus is about the same in both formats, there is a small increase in the response to base rates for Influenza with the risk/benefit format.

Figure 4.4 Interaction of Format with Disease Type and Severity of Disease





At the most severe (death from disease) level of disease severity, there is an slight decrease in likelihood of immunization for Influenza in the risk/benefit condition and a slight increase for Tetanus, while the likelihood for Smallpox remains nearly the same as in the risk/risk condition. Overall, format seems not to affect Smallpox, but does affect immunization likelihood for both Tetanus and Influenza to a small degree, especially at the most severe level of disease severity. When the other variables in the experiment were examined, the pattern of response was virtually the same for each of the experiments. These results are consistent with studies by Christensen, *et al*. (1995) and by Moxey, *et al.* (2003).

The question addressed here was not whether there was a significant difference between the two formats, but rather, which format best presents information to the participant.

As noted in the discussion above, there are two risk factors (risk of disease and risk of side effects from immunization) in these scenarios and only one benefit (reduction in disease if immunized). Placing both risk statements one right after the other may have had the effect of enhancing their salience, requiring an explicit statement of "reduction in risk of disease" to offset the salience of juxtaposing the two risk statements. This possibility has relevance for risk communication and should be further explored. However, the goal of the current research is to examine the effect of the variables themselves on decision making, so these issues will not be pursued at this time. All further experiments used the format probability of disease (severity) followed by probability of reduction in disease given immunization, then probability of immunization side effects, the format used in experiment #2 (Figure 4.2).

Experiment #3: Probability vs Frequency. Gigerenzer, Hoffrage and Kleinboting (1991) point out that people can make accurate judgments when the stimuli are expressed in understandable terms. For people without sophisticated mathematical and statistical training, it

may be that likelihood estimates presented in terms of frequency of events will be better understood than the same information presented as point probabilities of events. This was tested in an experiment using stimuli identical to that discussed above except that frequency was given instead of probability of events, as had been done in the previous studies. Figure 4.5 shows the stimuli for Experiment #3, which uses frequency statements to describe likelihood of events rather than probability statements.

Figure 4.5 Stimuli for Experiment #3 using frequency statements instead of probability statements

Risk/Benefit

If you don't get a shot, your risk of a disease from which you could recover is 680/1,000.

If you get a shot, your risk of the disease would be reduced to nearly 50/1,000,
But there would be a 990/1,000 risk of a mild shot reaction.

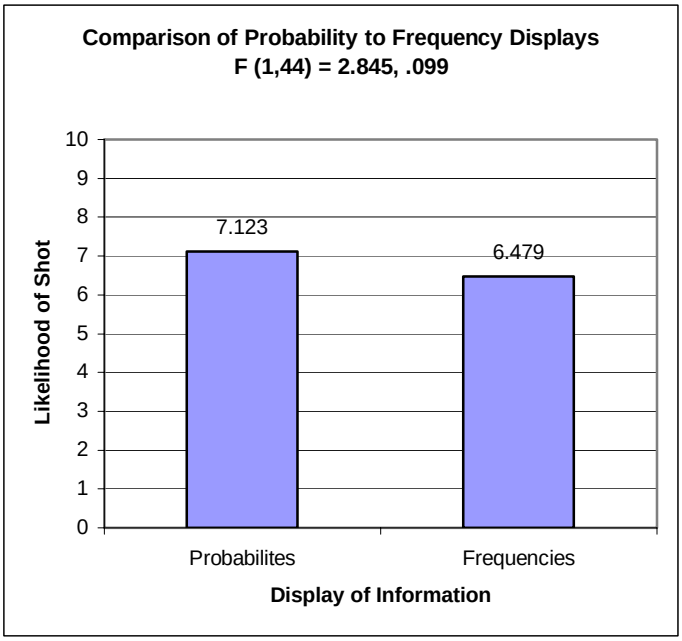
Risk/Risk

If you don't get a shot, your risk of a disease from which you could recover is 680/1,000.

If you get a shot, your risk of the disease would be nearly 50/1,000.
The risk of a mild shot reaction is 990/1,000.

Results of this study were combined with those of Experiment #2 to test the effect of stating likelihood information as probabilities (Exp#2) or as frequencies (Exp#3). Figure 4.6

Figure 4.6 Information provided as probability statements or as frequency statements
Standard Error for probabilities = .258 and for frequencies = .281.



shows this comparison. There is no main effect of stating information as likelihood or probabilities and no interaction with other variables.

Response to the key variables of the HBM was significant, both when information was provided as probability statements and as frequency statements (Table 4.1). The only exception was a null main effect for disease severity when information was presented as frequency.

Interestingly, frame (risk/risk vs. risk/benefit) was non significant when frequencies were used instead of probabilities. Effect sizes were a little larger when information was presented as frequency statements. While there was a significant three way interaction of Disease type x Side effect x Frame (format) for the stimuli when information was presented as probability statements there was no significant interaction between these variables when information was presented as frequencies. When information was presented as frequencies, there was a significant three way

interaction between disease type x severity of disease x Frame (format) and none for information presented as probabilities.

Table 4.1 Results of studies to examine effect of probability statements vs frequency statements

Variable	**Probabilities** (Experiment #2) (N = 25)	**Frequencies** (Experiment #3) (N = 21)
ME Disease Type	F (2,48) = 38.537, p <.001, η^2 = .616	F (2,40) = 57.655, p < .001, η^2 = .742
ME Severity SE	F (2,48) = 18.752, p <.001, η^2 = .439	F (2,40) = 21.838, p < .001, η^2 = .522
ME Severity Disease	F (2,48) = 9.706, p < .05, η^2 = .288	ns
ME Frame of Ref.	F (1,24) = 4.899, p < .05, η^2 = .17	ns
Disease Type x SE	F (4,96) = 6.706, p <.05, η^2 = .218	F (4,80) = 6.120, p < .001, η^2 = .234
Disease Type x Severity of Disease	F (4,96) = 33.337, p <.001, η^2 = .581	F (4,80) = 32.976, p < .001, η^2 = .662
Severity of Disease x Severity SE	ns	ns
Disease Type x Frame	ns	ns
SE x Frame	ns	ns
Disease Severity x Frame	ns	ns
Disease Type x SE x Severity of Disease	ns	ns
Disease Type x SE x Frame	F (4,96) = 6.649, p <.05, η^2 = .098	ns
Disease Type x Severity of Disease x Frame	ns	F (4,80) = 3.835, p < .01, η^2 = .161
SE x Severity of Disease x Frame	ns	ns
Four way interaction	ns	ns

Experiment #4: Naming Disease vs. No Name for Disease. The third issue of concern is the effect of knowing the name of the disease for which the likelihood information is provided. That is: Does knowing the name of the disease affect how one responds to the likelihood information about the disease/immunization variables? To answer this question, stimuli identical

to that shown participants for examining the effect of frequencies on decision patterns were shown to a new group of participants (N = 18), but actual names of the diseases for each example were included in the stimuli. Figure 4.7 shows an example of the stimuli used for Experiment#4.

Results of comparing using correct disease names with using a more generic term "a disease" are shown in Figure 4. 8. There is no significant effect of using the real disease name on likelihood of immunization. There is, however, a significant interaction with Disease Type as can be seen in Figure 4.9. When the correct disease name is used, there is a slight increase in likelihood of immunization for both Smallpox and Influenza and a slight decrease for Tetanus.

Figure 4.7 Stimuli for Experiment #4 using correct disease names

Risk/Benefit

If you don't get a shot, your risk of smallpox
from which you could recover is 680/1,000.

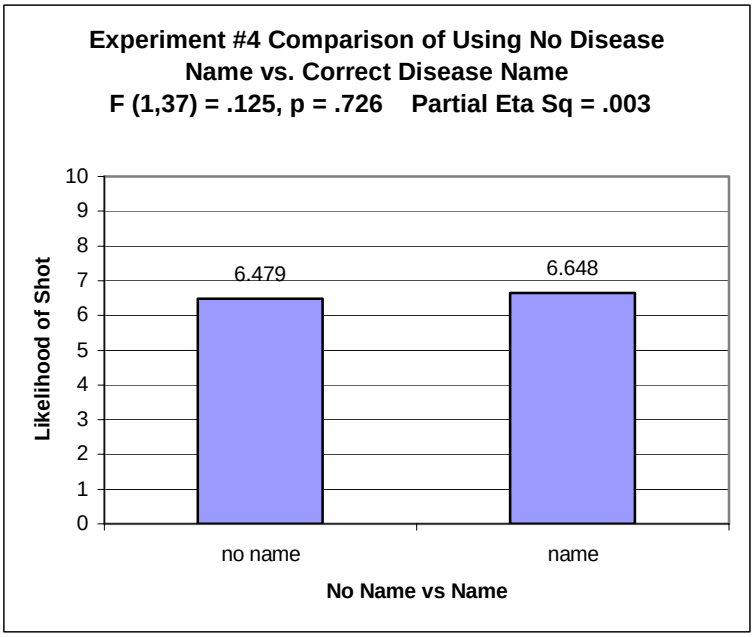
If you get a shot, your risk of smallpox would be
reduced to nearly 50/1,000,
But there would be a 990/1,000 risk of a mild shot reaction.

Risk/Risk

If you don't get a shot, your risk of smallpox
from which you could recover is 680/1,000.

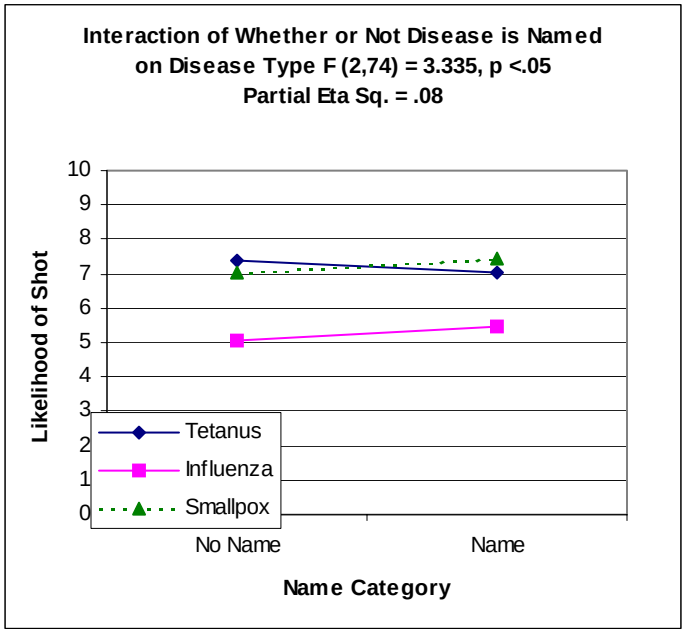
If you get a shot, your risk of smallpox would be nearly
50/1,000.
The risk of a mild shot reaction is 990/1,000.

Figure 4.8 Comparison of Naming the disease or not.
Standard Error for "no name" conditions is .325 and for "name" condition is .351.



The pattern of results was similar to that seen with all the other experiments (Table 4.3). Although there are consistent main effects for disease type and side effects, there is also a consistently significant interaction between disease type and side effect severity as well as between disease type and disease severity. There is a three way interaction between Disease type x Side Effects x Frame for Experiment #4, although this was not the case for Experiment #3. The significant interaction between Disease type x disease Severity x Frame seen in Experiment #3 was not found in Experiment #4. Therefore, these interactions seem uninteresting. However, the persistent two-way interactions involving Disease Type raised the issue of the possibility that there was something about the disease profile that might be affecting this interaction. One obvious source of difference between was that, for each disease, immunization efficacy was constant across all levels of side effect.

Figure 4.9 Interaction of naming disease with disease type



Standard errors for disease type in each name condition are presented in Table 4.2 below.

Table 4.2 Standard Errors for disease type in each name condition.

		Standard Error
No Name		
	Tetanus	.343
	Influenza	.377
	Smallpox	.321
Name Used		
	Tetanus	.370
	Influenza	.407
	Smallpox	.347

Table 4.3 Results of studies to examine effect of no name vs. correct name of disease

Variable	**No Name** (Experiment #3) (N = 21)	**Correct Disease Name** (Experiment #4) (N = 18)
ME Disease Type	F (2,40) = 57.655, $p < .001$, $\eta^2 = .742$	F (2,34) = 38.097, $p < .001$, $\eta^2 = .691$
ME Severity SE	F (2,40) = 21.838, $p < .001$, $\eta^2 = .522$	F (2,34) = 11.864, $p < .001$, $\eta^2 = .411$
ME Severity Disease	ns	F (2,34) = 5.227, $p < .05$, $\eta^2 = .235$
ME Frame of Ref.	ns	ns
Disease Type x SE	F (4,80) = 6.120, $p < .001$, $\eta^2 = .234$	F (4,68) = 7.631, $p < .001$, $\eta^2 = .310$
Disease Type x Severity of Disease	F (4,80) = 32.976, $p < .001$, $\eta^2 = .662$	F (4,68) = 32.901, $p < .001$, $\eta^2 = .659$
Severity of Disease x Severity SE	ns	ns
Disease Type x Frame	ns	F (2,34) = 3.387, $p < .05$, $\eta^2 = .166$
SE x Frame	ns	ns
Disease Severity x Frame	ns	ns
Disease Type x SE x Severity of Disease	ns	ns
Disease Type x SE x Frame	ns	F (4,68) = 2.529, $p < .05$, $\eta^2 = .130$
Disease Type x Severity of Disease x Frame	F (4,80) = 3.835, $p < .01$, $\eta^2 = .161$	ns
SE x Severity of Disease x Frame	ns	ns
Four way interaction	ns	ns

Experiment #5: A fifth experiment (N = 14) was conducted in which shot effectiveness was systematically varied across the other two variables. The format for this experiment was the same as for the previous experiment, except shot effectiveness was varied with each disease profile (severity of disease by severity of shot side effect) and instead of a generic disease name or a real disease name, a hypothetical disease name was used for each disease. In this way,

immunization efficacy could be varied without calling attention to the fact that the disease was the same with different shot efficacies. Also, the immunization effectiveness for influenza was

Figure 4.10 Stimuli for Experiment #5 using artificial disease names and systematically varying immunization efficacy

The card code shown in the upper left corner of each stimulus denotes the disease type (Neches River Disease (smallpox), level 1 of disease severity by level 1 of immunization side effects using immunization efficacy for Tetanus (NR 11 PT), Influenza (NR 11 PIf) or Smallpox (NR 11 PS).

NR11 PT

If you don't get a shot, your risk of Neches River Disease
from which you could recover is 680/1,000.

If you get a shot, your risk of Neches River Disease would be reduced to nearly 0/1,000,
But there would be a 990/1,000 risk of a mild shot reaction.

NR11 PIf

If you don't get a shot, your risk of Neches River Disease from which you could recover is 680/1,000.

If you get a shot, your risk of Neches River Disease would be reduced to nearly 100/1,000,
But there would be a 990/1,000 risk of a mild shot reaction.

NR11 PS

If you don't get a shot, your risk of Neches River Disease is 990/1,000.

If you get a shot, your risk of Neches River Disease would be reduced to nearly 50/1,000,
But there would be a 990/1,000 risk of a mild shot reaction.

increased to 90% from the previously used 80%. In the medical literature, effectiveness for this immunization is rated as ranging from 70%-90%. By increasing the efficacy shown participants, shot efficacy could be rank ordered in terms of effectiveness. Figure 4.10 shows and example of stimuli used for experiment #5.

Results of this experiment were consistent with that of the previous experiments with two notable exceptions. First, there was a significant main effect of shot efficacy ($F(2, 26) = 20.897$, $p < .001$, $\eta^2 = .616$). Second, there was no main effect of immunization side effects in this experiment. When shot efficacy was held constant within stimuli for each disease in all previous experiments, there was a significant main effect of immunization side effects with an effect size between .325 and .660. The significant two-way interactions seen in all previous experiments, Disease type with Side Effect Severity ($F(4, 52) = 7.789$, $p < .001$, $\eta 2 = .375$) and Disease Type with Disease Severity ($F(4,52) = 40.416$, $p < .001$, $\eta 2 = .757$) were also seen in this experiment (Figures 4.11 and 4.12). However, when immunization efficacy was systematically manipulated,

Figure 4.11 Two-way interaction of Disease type and Side Effect Severity

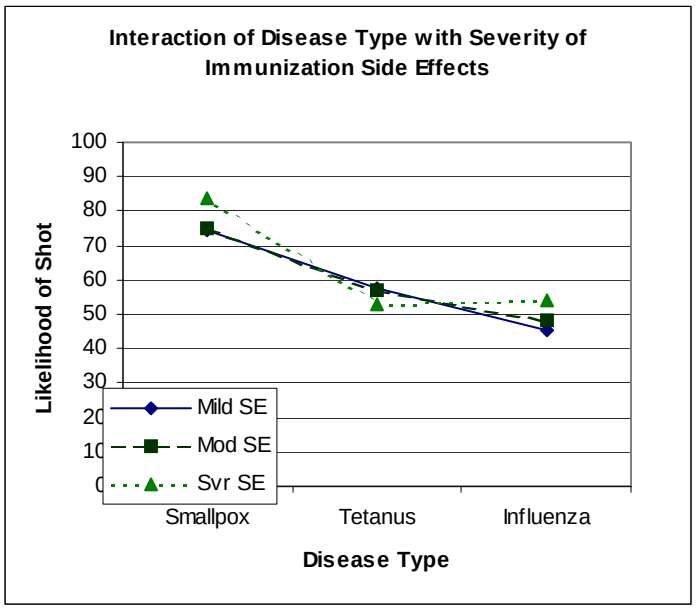
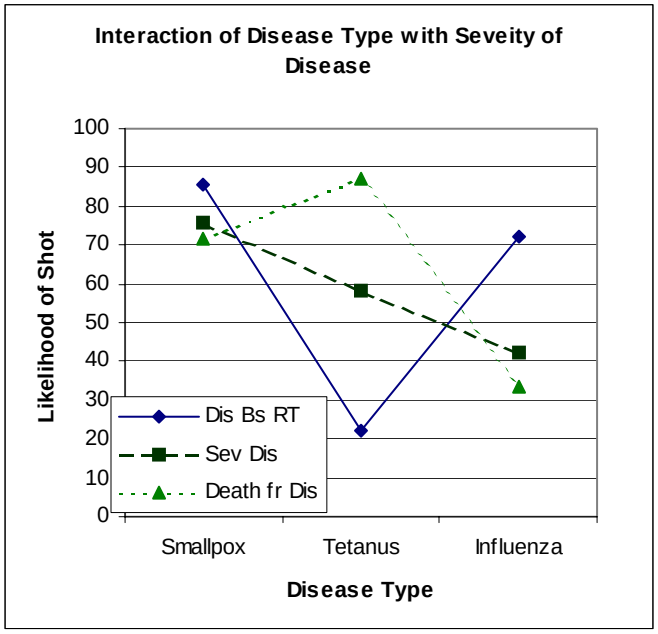
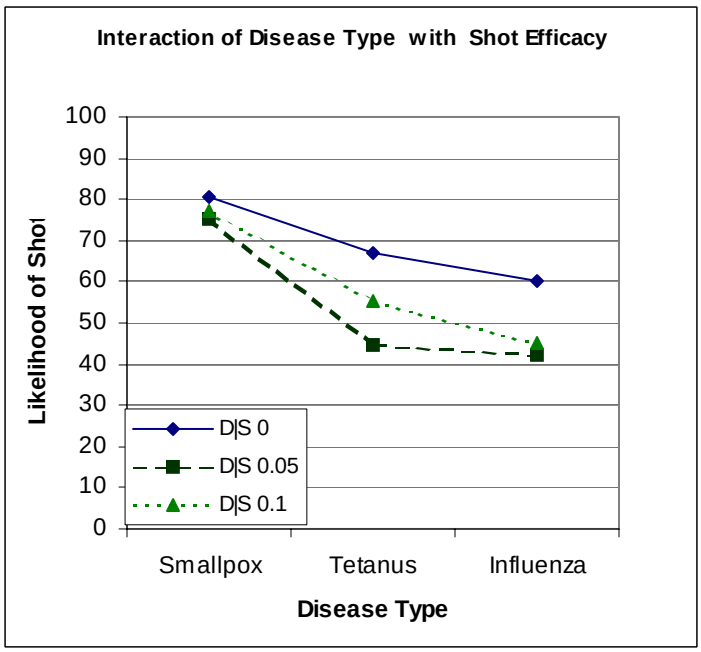


Figure 4.12 Two-way interaction of Disease Type and Disease Severity



Note that likelihood displayed in these graphs are transformed by a factor of 10. Transforming the scale from 0-10 to 0-100 makes the graphs easier to interpret.

Figure 4.13 Two-way interaction of Disease Type with Immunization Efficacy.



Legend: D|S = Disease given Shot. This is immunization effectiveness (see p. 35)

Note that likelihoods displayed in this graph are transformed by a factor of 10.

there was also a significant interaction between disease type and immunization efficacy ($F(4, 52) = 4.606$, $p < .01$, $\eta^2 = .262$). This interaction is shown in Figure 4.13.

The interaction of disease type and immunization side effect severity, although significant, does not appear to be impressive. The interaction of disease type and disease severity is compatible with probabilities associated with each level of each disease regardless of whether participants are presented the disease base rate or the disease severity level.

However, in the interaction between disease type and side effect severity, only the most severe level of immunization side effect was involved in the interaction. In the case of the interaction between disease type and disease severity, participants were clearly responding to the probability information provided in the stimuli. Tetanus has a very low disease base rate, but very high mortality. The response to this information is clear from the graph, which shows low likelihood of immunization given low base rates and high rate of immunization given high mortality. Likewise, Smallpox has a very high disease base rate (given exposure), but a moderate (30% mortality). This information is reflected in participants' preference for immunization against this disease both in the base rate and the mortality conditions. Influenza has a lower disease base rate than does smallpox, but a higher base rate than does Tetanus. However, Influenza has a low mortality rate compared to either of the other two diseases. These facts are reflected in participants' estimates of immunization likelihood. It appears that shot efficacy interacts primarily with disease factors, since there is no significant interaction between shot efficacy and either severity of immunization side effect or shot efficacy and disease severity.

The above series of experiments help to clarify the variables from the HBM that impact decisions about immunization. More importantly, they show that those variables interact. The

fact that there is a consistent main effect of disease type with a large effect size and a consistent interaction of this variable with the other variables across all experiments suggests that disease base rate may be key to immunization decision-making. Initial studies examined formatting issues for stimuli and show that interaction of specific variables is important to predicting immunization decision-making. The fifth study showed the importance of the interaction between disease and immunization efficacy.

Examination of format (risk/risk vs. risk/benefit, probability vs. frequency, and name versus no name) suggests that these issues are not as important as they might appear on the surface. Therefore, one could safely present information to participants in any of these formats and expect to get results described above. However, the nature of the interaction between disease base rates and immunization efficacy appear to be key to understanding how decisions about immunization acceptance are made. When there is an interaction between variables, it is important to ask the question: How are the two variables combined? Functional Measurement (Anderson, 1981) offers a method of answering this question. Understanding the nature of the interaction between disease and immunization effectiveness should help us to understand immunization behavior when changes occur in the variables and thus enable us to generalize across diseases and immunization contexts.

CHAPTER 5 - Functional Measurement Applied to Immunization Decision Making

Information Integration Theory (ITT) (Anderson, 1981) examines how people combine information from their environment to arrive at a judgment. One advantage of IIT is its ability to predict future behavior based on how cues are combined (generally additively or multiplicatively). Although IIT is based on mathematical models of how cues are combined, it is not a normative model because there is no "correct" answer, but rather a description of how different cues are incorporated to provide an overall behavioral outcome. It is important to understand that the mathematical description of cognitively driven behavior provided by ITT does not imply that people actually perform the mental calculations, but rather that these are "as if" models.

An example of the difference between description of the process and concrete translation of that process is provided from perception research. For the purposes of studying proprioception, one can calculate the amount of pressure placed on a glass by fingers, where the fingers are placed and how many it takes to provide enough support to pick up a given glass. However, no one would assume that the person who picks up the glass is actually performing those calculations nor is his/her ability to pick up a glass dependent on their ability to perform those calculations. In the same way, when making decisions, people select and cognitively combine cues to arrive at a decision. ITT is a method of describing mathematically how those cues are used. Using that knowledge, clinicians can predict how people are likely to respond to changes in cue values, such as increase in disease likelihood, etc.

As Weiss (2006) succinctly states, although people often believe they are using a complex process to make a decision, analysis of that process may reveal much simpler rules of

cue combination. This is one reason that surveys asking for insight into decision processes, such as how one decides to get an immunization or not, is of limited utility and must be followed up by careful experimental testing of how the individual actually uses those cues to arrive at a decision.

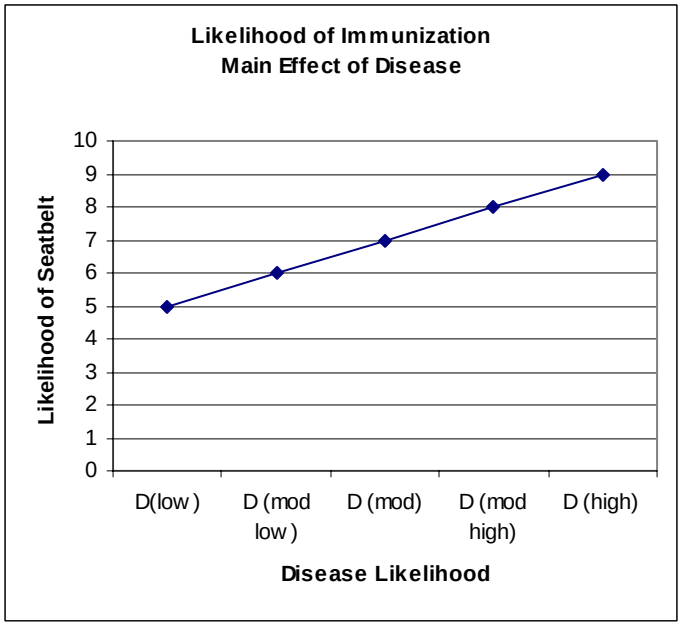
Although stating that complex processes often can be boiled down to simple decision rules echoes the Gigerenzer and Selton (1999) approach of Fast and Frugal Heuristics, IIT goes beyond identification of the cues and describes how they are integrated cognitively. The F&F approach would identify which cues are most diagnostic. ITT would both identify them and describe how they are combined and weighted to arrive at a decision. Functional measurement provides a statistical picture of how objective information is subjectively combined to inform behavior (Anderson, 1981). Anderson called this integration function "cognitive algebra". A significant linear by linear effect suggests that participants are using an additive model of information integration. The presences of other effects suggest other models, including multiplicatively. This ability to describe algebraic combination rules provides predictive power.

The predictive power of ITT can be seen in an example of immunization decision making, using simulated data. As was seen in the discussion of the HBM of healthcare decision making in Chapter 2, two variables reported in survey research to be associated with healthcare decisions are whether or not a disease is likely to affect the individual and the effectiveness of the offered treatment. Using this logic, you would expect that a person who thought there was some chance that they could be contract a communicable disease and who thought that an immunization was likely to improve their odds of surviving the accident, would be more likely to get immunized than one who held neither of these beliefs.

Example of application of ITT to healthcare decision problem: The ITT approach to prediction can be used in a hypothetical immunization example. To study such an decision, the degree of belief that one might get a disease and the degree of belief that an immunization is likely to improve odds of surviving that disease would need to be varied to present multiple combinations of these two variables. Responses would be an estimate of the participant's likelihood of accepting and immunization under each combination of the two variables. Further, IIT focuses on the interaction (integration) of the two variables rather than on either variable in isolation. If there is no interaction, the variables are operating independently and there is no integration. The tool used in ITT is Functional Measurement. Functional Measurement measures the function of stimuli in evoking a response.

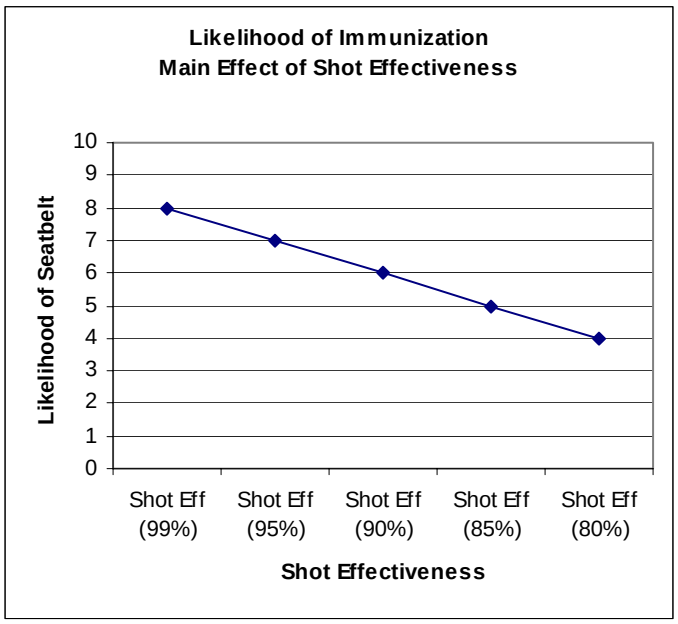
Figure 5.1 illustrates a hypothetical main effect of likelihood of disease on likelihood of immunization. Here, there is a systematic step increase in likelihood estimates of immunization

Figure 5.1 Main effect of belief that a disease is likely



as the independent variable of likelihood of disease. There would likely be a main effect as well of belief that immunizations prevent disease. Figure 5.2 illustrates a main effect of belief that immunizations are effective in preventing disease, using simulated data.

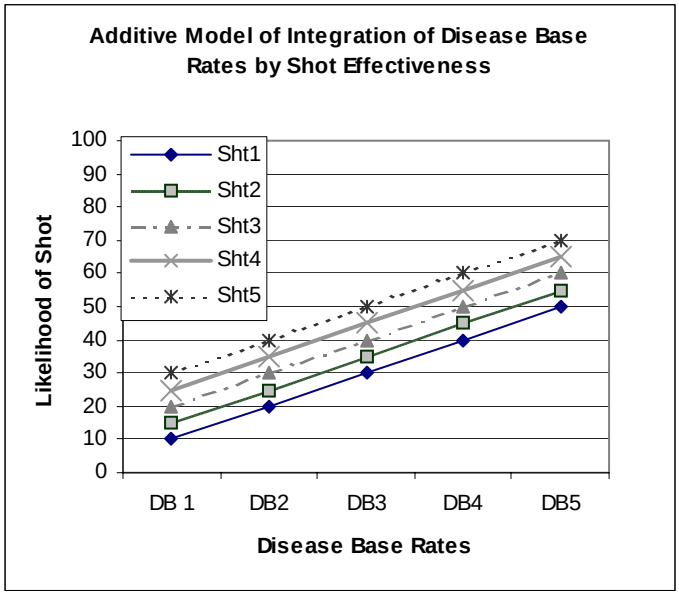
Figure 5.2 Main effect of belief that immunization prevents disease



Neither of these beliefs is likely to exist in isolation however, so one would want to know how they interact. Figure 5.3 illustrates the interaction of simulated data from the two HBM variables for immunization effectiveness if people combine the two isolated variables additively. The diagnostic evidence for additivity is the absence of a significant interaction. This is seen on the graph in parallel lines as levels of each variable change. As can be seen, although likelihood of immunization falls off with declining belief that immunizations are effective, it falls off at the same rate for every level of belief in likelihood one could get a disease. With this information, one could increase likelihood of immunization by focusing on lives saved with immunization vs

lives lost when people are not immunized and expect that there would be the same amount of increase in immunization for everyone, regardless of how likely they would be to get a disease.

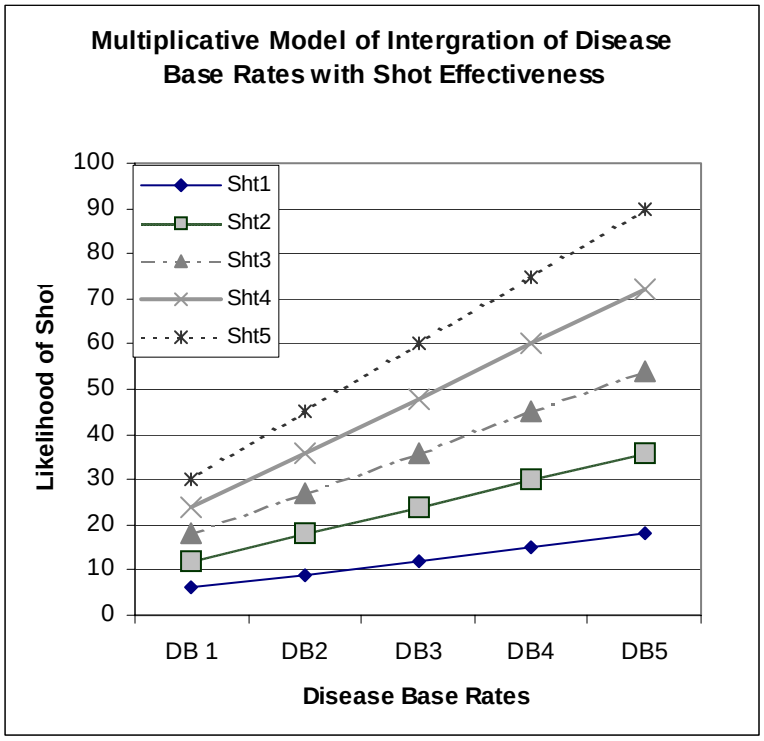
Figure 5.3 Additive model of integration of disease base rates with immunization effectiveness.



However, if participants' combination of the likelihood of getting a disease with the effectiveness of immunization is multiplicative, a different prediction would be made. Figure 5.4 illustrates simulated data, but with a multiplicative interaction. When people multiplicatively combine belief that they might get a disease with belief that immunizations work, the degree of belief in both variables matters very much. When a multiplicative rule is used to combine information, the impact of a change in the level of one variable will vary with change in the level of the other variable so that a fan shape is seen as the two variables diverge from one another. The fan shape is diagnostic of multiplicative information integration.

When the belief that immunizations work is low, there is little difference in likelihood of immunization for all levels of belief that one might get a disease. However, as belief in effectiveness of immunization increases, the effect at different levels of disease likelihood is magnified. Therefore, a dual approach is warranted because increasing the belief that

Figure 5.4 Multiplicative model of integration of disease base rates with immunization effectiveness.



Legend: DB1= disease base rate low, DB2 = disease base rate moderately low, DB3 = disease base rate moderate, DB4 = disease base rate moderately high, DB5 = disease base rate high

Sht1 = shot efficacy low (diamond), Sht2 = shot efficacy moderately low (square), Sht3 = shot efficacy moderate (tiragle), Sht4 = shot efficacy moderately high (x), Sht5 = shot efficacy high (*).

immunizations work at the same time one increases the belief in the likelihood that one might get a disease has enormous payoff in terms of increasing immunization rates.

Functional Measurement applied to healthcare problems. Rundall and Weiss (1994, 1998) reported how functional measurement predicts behavior in two separate experiments, one with healthcare personnel (nurses) and the other with patients. Rundall and Weiss (1994) used Functional Measurement (FM) to examine how nurses' fear (the dependent variable) resulted

from the integration of two independent variables of contagiousness and severity of disease. A factorial arrangement of disease variables based on actual, but un-named, diseases was used for the experiment. By systematically examining how fear was affected by the two disease variables, this experiment showed that fear could be predicted to increase multiplicatively with increases in transmissibility and severity of disease. Knowing this, training of nurses to prevent contamination should address both variables.

Rundall and Weiss (1998) used F M again to explore how disease symptom severity (the disease severity experienced by the patient) and disease prognosis (how severe the disease could become) interacted to influence patients' compliance with recommended medical treatments. A multiplicative relationship between the two variables predicted medication compliance in this study. When the variables were changed to examine the relationship of medication side effects and disease prognosis on medication compliance, this relationship was shown to also be multiplicative.

Knowing both multiplicative interactions, patient education regarding medication should teach each of these variables carefully so that patients understood not only medication how affects their current experience the disease, but also how it prevents the disease from worsening. In terms of the interaction between side effects and disease prognosis, a multiplicative effect would suggest that patients be taught to report side effect early so that medications could be adjusted. They then would be more likely to continue with treatment, preventing more severe disease.

Immunization behavior is a preventive medicine issue for which functional measurement might be useful. Initial studies conducted with the four variables identified by the HBM, (disease likelihood, disease severity, immunization side effect severity and effectiveness of

immunization) explored these variables for three different diseases with different stimulus display characteristics. The largest effect size (consistently around $\eta^2 = .60$) was for the variable of disease base rate, which consistently interacted with the other variables.

Through all of these studies, a persistent interaction between variables was observed. As noted in chapter 4, significant interactions were found in study five for Disease type by disease severity, disease type by side effect severity and for disease type by shot efficacy. Since the only important interaction between immunization side effects and other variables was at the most severe level of immunization side effects, further exploration of this interaction is less interesting than are other interactions. The interaction between Disease Type and Disease severity, while relevant, seems relatively easy to explain. Immunization effectiveness appears to interact only with disease type, and not with disease severity or with immunization side effects.

It appears that disease base rate might be key to understanding the interaction between disease type and immunization efficacy. Exploration of how information on both of these two variables may be important to designing immunization programs, establishing public policy on immunization and providing informed consent to individuals for immunization. Functional Measurement was therefore used to explore the nature of the interaction between disease base rates and immunization efficacy.

CHAPTER 6 - Method for Functional Measurement of Interaction between Disease Base Rates and Immunization Efficacy

Two research questions are addressed in this study: First, how does probability of disease (disease base rate, referred to as "D") and effectiveness of immunization against the disease (referred to as probability of disease given shot, or simply "D|S") combine to influence participant's willingness to accept the immunization? Secondly, if there is an interaction between these two variables, what is the nature of that interaction?

Stimuli developed here through a series of pilot studies (see chapter 4) use accurate probabilities for two variables found to be important to decision making: probability of disease and effectiveness of immunization. The latter is a conditional probability predicating reduction in disease on the disease base rate. Although one might expect that both base rates for disease and reduction in the base rate due to immunization might be absolutely known, this is not always the case. Disease base rates are related to a number of variables, as is immunization effectiveness. Therefore, the best estimates available for these variables were obtained from the medical literature (Atkinson, *et al.* 2006).

As noted in Chapter 3, Hammond (2000) pointed out that providing ecologically valid cues to the participant is important to generalizability of the results. This series of studies has attempted to provide ecologically valid cues by using diseases, immunizations and probabilities from the medical literature. However, to provide the participant with all possible cue information at one time is to complicate the decision to the point that results may be uninterruptible. Simplifying accurate disease probability information for experimental study

appears to provide valuable information about how participants respond to key disease variables in an immunization decision-making situation. In the present study, the nature of the interaction between disease base rates and immunization efficacy was the focus of investigation. It has already been established that there is a significant interaction between these two variables.

Based on findings from earlier studies, the final study used the following elements: The probability of disease without immunization was stated first. This was followed by the estimated effectiveness of immunization for that disease. That statement was followed by the probability of severe side effect for a given immunization; probabilities were stated in frequency of occurance/1,000 people.

In the interest of ecological validity, real diseases and accurate probabilities were used as much as possible. However, some cells in the design required disease base rates and immunization effectiveness that were not readily found in diseases against which participants might be asked to be immunized. In these cases, hypothetical diseases were used that fit those categories. These issues are discussed further in the stimulus section.

However, pilot studies demonstrate that more complex disease scenarios are not necessary to study the key factors influencing these decisions.

A 3 (disease probability without immunization) x 4 (reduction in disease probability with immunization) design was used to examine the effect of the immunization variables of disease base rates and immunization effectiveness on acceptance of immunization. The variable of immunization side effect was included in the scenarios for authenticity, but was held constant and is therefore, not part of the study. Review of the medical literature reveals that most immunizations are reported to have a very low incidence of "severe" side effects. Since this rate is nearly uniformly about 1/1,000 or lower, this figure was used for all scenarios. The only two

variables that were systematically manipulated therefore were the variables of disease base rate and immunization effectiveness.

Participants included 31 traditional undergraduate students (ages 18-21, mean 19) taking an introductory psychology class who participated for class credit. Connolly and Jeb (2003) found that the behavior of adults was comparable to that of undergraduates. However, it may be possible that experiences accumulated by non-traditional students would influence their likelihood of accepting immunizations. A solicitation was sent through the Adult Student Services department at the university inviting non-traditional students to participate. 29 nontraditional students accepted this solicitation. No class credit could be given these volunteers; therefore, a discount pizza coupon was offered these students for participation.

Non-traditional students were both graduate and undergraduate students. Two non-traditional participants reported during debriefing that they had not followed the instructions for the experiment. In spite of explicit instructions to look only at one stimulus card at a time and not to review previous cards, one non-traditional student reported reviewing previous stimuli in order to "make sure responses were consistent". The other reported being unable to make decisions based on the information provided. Review of this participant's data revealed that all responses were between 45 and 55 on a 100mm scale. Data from these two participants was not used for analysis.

One other student provided an estimate of 100 (always accept immunization) for all stimuli. However, this student stated that it was her policy to accept immunization whenever it was offered. Since this stated policy is one extreme of how participants may view decision-making and was accurately reflected in their responses, this student's data was included in the

data for analysis. Therefore, data from 27 non-traditional students was used (ages 24-62, mean 36.44).

None of the traditional undergraduate students were parents. Fourteen of the non-traditional students were parents. There were a total of 18 males and 40 females who participated in the experiment. Four of the 18 male participants were non-traditional students and the remaining 14 male participants were traditional students.

There was little ethnic diversity. All but 4 of the non-traditional students were Caucasian with the four non-Caucasian students each representing a distinct ethnic group. Some of the Caucasian non-traditional students were non-American, but were Caucasians from Europe. Diversity among the traditional students was even less with only three students reporting non-Caucasian heritage (two Hispanic and one African-American). Therefore, all non-Caucasian students were grouped together. This still represented a very small group of 7 out of 58 participants.

A pilot study had suggested that healthcare training might impact likelihood of immunization acceptance. Participants were divided into three groups based on healthcare training: no training (14 participants), lay training (12 participants), and professional training (5 participants.

Stimuli were presented in the format already discussed with only the changes noted below. Stimuli were printed on 5 x 7 card stock and re-randomized using a list of random numbers prior to each administration. A set of 3 stimuli was presented first each time and the same stimuli presented again at the end to examine any effect of learning during the experiment.

Table 6.1 shows the diseases and immunizations that were used as stimuli in this study. Several immunizations that a college student might be asked to accept were selected for

construction of the stimuli. In addition to immunizations now commonly recommended or required by most colleges (e.g. against bacterial meningitis and hepatitis B), other immunizations that might be recommended were included (e.g. pneumonia). One immunization, from the initial studies, which could be recommended in the event of a bioterror incident, Smallpox, was also included. It seems important to include at least one such disease in any study of immunization behavior to enable healthcare personnel can anticipate variables of importance if there were need to immunize against such a disease. Since the name of the disease had no effect in pilot studies, correct disease names were used in this study.

The real immunizations displayed in Table 6.1 are: Bacterial Meningitis, Pneumonia, Hepatitis B, Smallpox, Pertussis, and Chickenpox. Frequencies for Meningitis and Smallpox are adjusted a slightly to fit them into the matrix (smallpox may be more contagious than 90% and Meningitis may be less contagious than 1%). At the debriefing, participants were provided with the actual incidence of these diseases along with the actual immunization efficacy according to *Epidemiology and Prevention of Vaccine-Preventable Diseases 9th Ed. (2006).*

As noted earlier, two problems were encountered in designing the experiment: First, no actual diseases were found to fit into the remaining cells of the 3X4 design. Therefore, Hypothetical diseases were inserted into the empty cells and given names that might be interpreted as disease names. Since the use of hypothetical names in the pilots yielded the same pattern of results as did real disease names, this seemed to be a reasonable solution. Potential names to be used for these hypothetical diseases were selected after collaboration with healthcare personnel with whom the primary investigator works.

Second, absolute probability information was required to fit diseases into cells in the

Table 6.1 Probability of Disease (Given Exposure) Without Immunization (Base Rate for Disease)

Probability of Disease (Given Exposure) With Immunization (below)	Disease p = 1/1,000	Disease p = 50/1,000	Disease p = 900/1,000
Shot effectiveness = more than 999/1,000 are protected.	**Bacterial Meningitis** p disease= 1/1,000 With shot, 999/1,000 are protected	***Verde's Disease*** p disease = 50/1,000 With shot, 999/1,000 are protected	***Fibularosis*** p disease = 900/1,000 With shot, 999/1,000 are protected
Shot effectiveness = 950/1,000 are protected	***Casalosis*** p disease =1/1,000 With shot, 950/1,000 are protected	***Black Spot Fever*** p disease = 50/1,000 With shot, 950/1,000 are protected	**Smallpox** p Disease = 900/1,000 With shot, 950/1,000 are protected
Shot effectiveness = 900/1,000 are protected	***Neches River Fever*** p Disease = 1/1,000 With shot, 900/1,000 are protected	**Hepatitis B** p disease = 50/1,000 With shot, 900/1,000 are protected	**Pertussis** p Disease = 900/1,000 With shot, 900/1,000 are protected
Shot effectiveness= 800/1,000 are protected.	**Pneumonia** p disease = 1/1,000 With shot, 800/1,000 are protected	***Appalachian Pharyngitis*** p disease =50/1,000 With shot, 800/1,000 protected	**Chickenpox** p Disease =900/1,000 With shot, 800/1,000 are protected

Note that hypothetical disease names are italicized.

matrix. Since disease probability is situational, some diseases were given a probability that only fits some situations, although there is a range of probabilities that might be associated with that

disease, depending on other factors, such as personal behavior or environment. The actual diseases and their actual range of probabilities and shot efficacy were provided to participants as part of the debriefing to clarify any misunderstanding.

As noted earlier, in nearly every case the incidence of severe immunization reaction is nearly 1/1,000 and sometimes less, so the uniform number of 1/1,000 was used to make the scenarios seem authentic. This factor was not varied because previous studies suggested that it is not the primary focus of immunization decision making for participants

In addition to the experimental scenarios, the following diseases/shot combinations were be used as fillers:

Influenza (also known as "Flu"): Base Rate = 350/1,000 (Chin, 2000) and immunization effectiveness = 800/1,000 are protected (Isada, 2000)

Hepatitis A: Base Rate (estimate based on Atkinson, Hamborsky, McIntyre & Wolfe, 2006) = 330/1,000 and immunization effectiveness = 950/1,000 are protected (Atkinson, *et al.* 2006)

Tarsallis (a hypothetical disease): Base Rate = 150/1,000 and immunization effectiveness = 900/1,000

These three disease/immunization combinations do not fit into the design of the experiment and were not be a part of the analysis. However, it was anticipated that response to them would be consistent with probability information displayed. Table 6.2 shows how controls on design fit within the overall matrix of disease base rates by immunization efficacy. Controls are in bold and can be seen to represent three levels of shot efficacy and are intermediate between the second and third levels of disease base rates.

Table 6.2 Design control stimuli fit into the stimulus matrix

Stimuli used as controls on design are seen in **bold** and hypothetical stimuli are *italicized*.

Shot Efficacy	Disease Base Rate 50/1,000	Disease Base Rate 150/1,000	Disease Base Rate 330/1,000	Disease Base Rate 350/1,000	Disease Base Rate 900/1,00
950/1,000	*Black Spot Fever*		**Hepatitis A**		Smallpox
900/1,000	Hepatitis B	***Tarsallis***			Pertussis
800/1,000	*Appalachian Pharyngitis*			**Influenza**	Chickenpox

Presentation format of stimuli were the same as for previous studies (Figure 6.1). Disease base rate was shown first. Immunization Effectiveness was shown second. and immunization side effect was shown third. All probability estimates were shown as frequency of event per 1,000 people.

Figure 6.1 Format for stimuli

There is a 900/1,000 chance of people without immunization getting Smallpox if exposed to it.

The immunization against Smallpox is effective in 950/1,000 cases.

However, there is a 1/1,000 chance of a serious side effect of the shot.

Replicates: Two replications of each experiment were conducted with each experiment. Two sets of experimental stimuli were printed onto two different packs of cards. Each set of cards were randomized separately so that the entire experiment was conducted once, and then again. Each set of cards was separately randomized. One replicate was administered, then demographics collected and a distracter task[1] completed before the second replicate was administered.

Random numbers were obtained for each experiment and arranged in sets for each pack of cards for each experiment. Random.com uses numbers generated from photons from space and purports to be a truly random number generator. Design filler cards were included in the randomized card pack.

Control for Learning Effect: Since the participants saw each scenario twice, a control to test for learning effects was included in the design. Three cards were always presented first in the first pack of cards and last in the last pack of cards. The learning control stimuli were counterbalanced via Latin Square.

Response: Connolly and Jeb (2003) note that many of the omission bias studies used truncated and/or asymmetrical scales. The study proposed here used a 10 mm unmarked line anchored at each end (Appendix B). The left end indicated that the participant did not believe they would accept an immunization at all under these circumstances. The right end indicated that the participant would always expect to accept an immunization under these circumstances. This response format was selected to approximate how a participant might think about immunization acceptance. Use of a line scale allowed for intermediate responses rather than forcing responses into a fixed-point scale. Weiss (2006) also notes that a line scale such as this

1. The distracter task is described on p. 70.

Reduces participants' ability to recall previous responses. There was a separate line with anchors for each stimulus card along with a place to write in the code for the card to which the participant was responding. Scoring of responses was accomplished by measuring where the participant placed a mark crossing the response line.

Demographics: Participants were asked to complete a demographics questionnaire (Appendix C). Demographic information included age, ethnicity, whether or not the participant had children, any healthcare experience or chronic diseases and experience with immunizations. As described under participant description above, healthcare training was divided into three categories: No healthcare training, lay training, and professional training.

Lay training in healthcare included people who were trained as lifeguards, veterinary assistants, or were in pre-healthcare professional classes or otherwise were minimally trained and minimally experienced with healthcare issues, such as disease and treatment. This category was thought to represent people who had some exposure to the variables of disease and possibly immunization, largely through classes or just being around providers, but did not have a professional level of experience. The "no healthcare training and lay healthcare training groups included participants from both the traditional and non-traditional student groups.

Professional training included licensure as a Certified Nursing Assistant, having been in medical, nursing, or veterinary school, or currently working in healthcare. Participants in this group were all in the non-traditional student group. In addition to being around the sick and witnessing death from disease, healthcare providers are required to accept immunization against various diseases to protect them from diseases in the patients for whom they provide care and to protect these vulnerable patients from diseases that the healthcare provider might bring to work.

Distracter task: In order to reduce participants' memory for initial responses to the primary task, a distracter task was administered (Appendix F). This task is a simple decision task asking for an estimation of a nurse's competence with and without use of a decision aid. The response scale was the similar to that used for the primary task, but with appropriate anchors.

The distracter task is similar to the experimental task in that participants were given a scenario and responded with an estimate made on a line scale as in the experimental task. Also, the task was somewhat related in that it asked for judgment about a healthcare professional. However, it is different in that the scenario description was longer and focused on an entirely unrelated judgment. At least one participant reported during debriefing that they thought the distracter task was part of the experiment.

Post Experiment Interview: After all data was collected, each participant completed a post experiment interview form (Appendix D) asking about the strategy they used for their decisions and for their suggestions about the experiment. This form also asked for an estimate of the participant's own assessment of the probability of getting each of the diseases used in the experiment. Both the actual diseases and hypothetical diseases were included. The inclusion of hypothetical diseases allowed for inference of the degree to which participants were aware that these were hypothetical diseases, i.e. if a participant states they are likely to get a hypothetical disease, it can be inferred that they believe the disease could be real. After this form was completed, it was reviewed with the participant. They were asked to clarify any comments and add other comments they wished so that each participant was given a chance to clarify with the investigator how they approached the experiment and thought about the tasks.

Debrief: A debriefing statement (Appendix E) concluded the experiment with an explanation of the experiment and how it contributes to our knowledge of decisions made about

coping with disease and immunizations. Any information that might be unclear to participants about actual disease and immunization probabilities were clarified to ensure that participants were not inadvertently misled by any component of the experiment. The latest information on actual diseases and their probability as well as vaccine efficacy was provided as part of this debrief. Participants were allowed to keep this debriefing statement.

Protocol: Participants were administered the experiment individually. Nearly all participants finished the experiment in 45 minutes or less. All materials used by each participant were presented together in a folder. Participants were first given an overview of the experiment (App. G). They then signed an informed consent form (Appendix H). The consent was immediately separated from all other data and is stored in a locked file to be maintained for three years after the experiment.

Participants were instructed on experimental procedure. They were provided one set of the experimental stimuli as described above (see stimuli). They responded to each stimulus card, one at a time, by marking their estimates on the answer sheet provided (Appendix B), indicating likelihood of accepting an immunization under the circumstances shown on the card.

When participants completed one set of stimuli for the experiment, they were asked to fill out the demographic form (Appendix C), and then completed a distracter task (Appendix F) as described above. Participants then completed the second replication of the experiment.

After the second replication of the experiment was completed, participants went through the post experiment interview (Appendix D) as described above. They were then given debriefing information (Appendix E). They were informed at that time which diseases are hypothetical. They were allowed to keep the information from this debrief. All participant questions were answered prior to their exit of the experiment.

Analysis: Initial analyses were conducted using CalStat (Weiss, 2005), a statistical software package for performing functional measurement. Functional measurement was used to identify significant variables, describe the nature of the interaction of those variables, and to examine how individuals contributed to the overall result. Since group analysis provides only a summary of how people behave and does not reflect individual differences, analysis was conducted at both the individual and the group level. After data were examined using functional measurement, a repeated measure ANOVA was used to examine how demographic variables might relate to the results.

CHAPTER 7 - Results

Hypothetical vs. Real Disease Names: Since hypothetical diseases were not uniformly distributed through out the design, direct comparison of response to hypothetical vs real diseases could not be statistically tested. Participants did indicate, however, that there was some likelihood of contracting each of the diseases presented, regardless of whether or not it was a real or hypothetical disease. The question asked in the post experiment interview was how likely the participant would be to get that disease. Participants indicated that, although they might get the disease, if they had not heard of it, they were less likely to be exposed. They did not indicate having seriously considered whether or not the disease was real. Many expressed surprise at the question of which diseases they thought were real, suggesting they thought all were real. They indicated that they interpreted the question of which diseases were "real" to indicate which ones they had heard of.

Many of the participants indicated that they were considering whether they would be likely to be exposed to each of the diseases as part of their decision strategy. In this light, it is interesting that participants responded to Smallpox as if they might be exposed to it. Participants in this series of experiments have been uniformly willing to accept Smallpox immunization in line with its disease base rate. The data shows that participants are nearly as likely to accept immunization against the hypothetical disease of Fibrilosis as they are against the real disease of Smallpox and as likely to accept immunization against the hypothetical disease of Verde's Disease as they are the real disease of Bacterial Meningitis. Indeed, participants are more likely

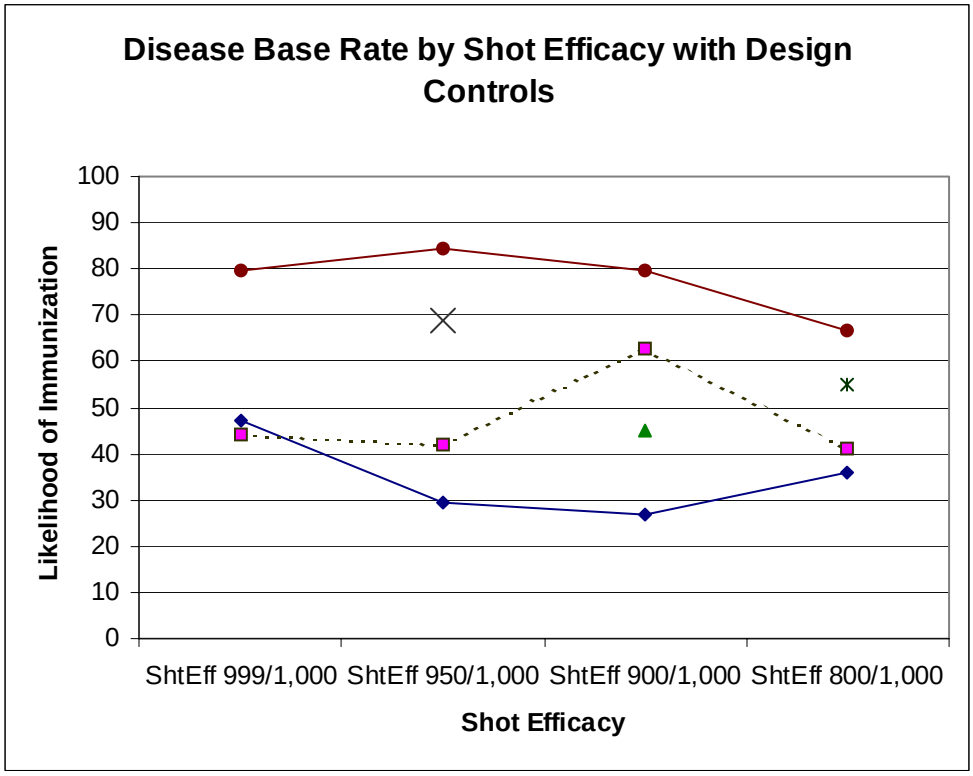
to accept an immunization against the hypothetical disease of Appalachian Pharyngitis than they are the real disease of Pneumonia.

Some participants reported that they were unfamiliar with the disease of Pertussis until, during debriefing, it was identified by its more common name of Whooping Cough. Thus, the response to Pertussis for many was the same as it would have been with a hypothetical disease. Nonetheless, participants were more willing to accept an immunization against Pertussis (which had a higher base rate and the same shot efficacy) than against a disease they all recognized, Hepatitis B, which had a lower base rate and the same shot efficacy. The fact that participants responded as expected to Pertussis, in spite of failure to recognize the disease by that name suggests that use of hypothetical disease names did not influence results.

However, personal beliefs about the familiar diseases may have influenced decisions. The data do suggest that likelihoods for both disease and immunization did significantly influence decisions in spite of whether or not the disease name was familiar. Some participants reported considering how likely they thought they might be to get a particular disease in addition to considering the variables presented in the stimuli, although this influence seems not to be systematic. Methods of limiting this framing of the variables in future experiments will be discussed below.

Results of Control on Design: The pattern of response to the design controls was consistent with that for the rest of the design (Figure 7.1). Design controls are shown in Figure 7.1 as individual points on the graph. Lines connect variables used in the study design. Results for the experimental variables will be discussed later. Overall, with the exception of Hepatitis B, to be discussed later, participants appear to have responded to probability statements in both the target and control stimuli rather than to the specific disease names.

Figure 7.1 Design Controls with Disease Base Rates by Shot Efficacy for rest of design



ShtEff 999/1,000= shot efficacy of 99%; ShtEff 950/l,000= shot efficacy of 95%; ShtEff 900/1,000= shot efficacy of 90% and ShtEff 800/1,000= shot efficacy of 80%

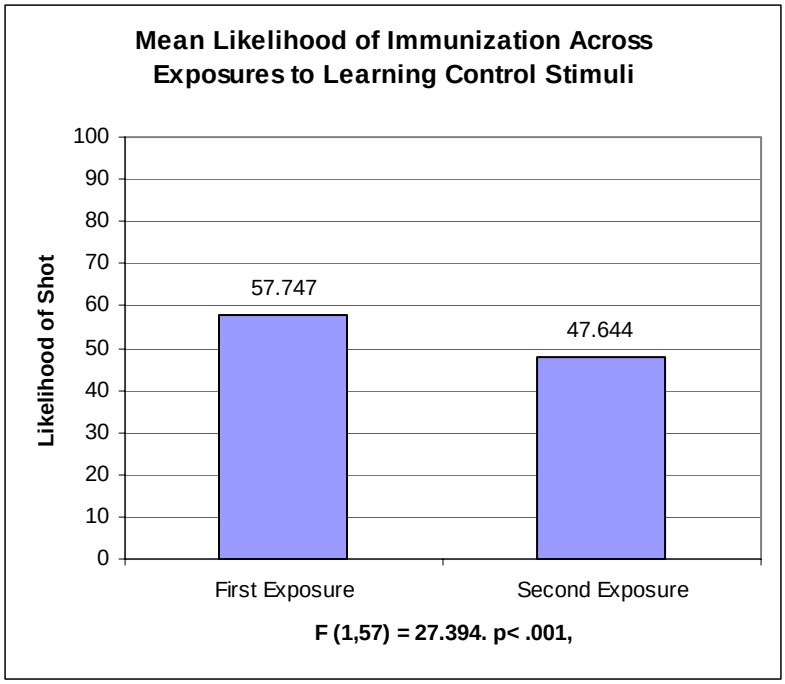
Disease base rate 1/1,000 (blue diamond), disease base rate 50/1,000 (dotted line with square), disease base rate 150/1,000 (green triangle), disease base rate 330/1,000 (large black X), disease base rate 350/1,000 (small dark asterisk), and disease base rate 900/1,000 (dark circle: top line). Disease base rates 150, 330 and 350 are results for each of the design control stimuli. Each of these results are single point entries with no line on the graph. These results are consistent with what would be expected if participants attend to probability statements in each scenario. Results for the design control stimuli fit well with overall results of the experiment.

Results of Learning Control: The question of adaptation or fatigue resulting from multiple presentations of the stimuli was addressed by placing three test stimuli at the beginning of the first pack of cards and the same three stimuli at the end of the second pack of cards. There was a significant ($F(1, 57) = 27.394$, $p < .001$, $\eta^2 = .325$) overall reduction in likelihood of

immunization with replication of the stimuli. Effect of replicates can be seen in Figure 7.2. The question to be asked is: What was learned?

It may be that, with replication of the stimuli, participants began mentally comparing stimuli to one another and adjusting their likelihood estimates downward with experience. If

Figure 7.2 Learning Effect



A significant effect of experience with the stimuli was found. In general, participants were less likely to accept immunization with a second replication of the stimuli.

that is the case, participants may not be looking at each immunization decision in isolation, but rather they may be comparing variables from one situation to another, at least in a general way. Perhaps the participants are asking themselves: "How bad is this disease compared to the others I've seen?" This would seem to be a normal adaptation process. Perhaps this is similar to the

well-known effect of habituation where the contrast is more salient with repeated exposure to immunization. Further exploration of this possibility is warranted.

Individual Analysis: Functional measurement is based on initial individual analysis of decision rules. It must be recognized that power is very low when looking at only two replications (the number for each individual in this study). There is considerable variation between individuals. Figure 7.3 shows the percent of individual participants who demonstrated significant main effects and interactions, grouped by patterns of results. As can be seen, the two largest categories by far were for participants with only a main effect for disease base rates.

Figure 7.3 Percent of individuals with significant effects by category of effect pattern

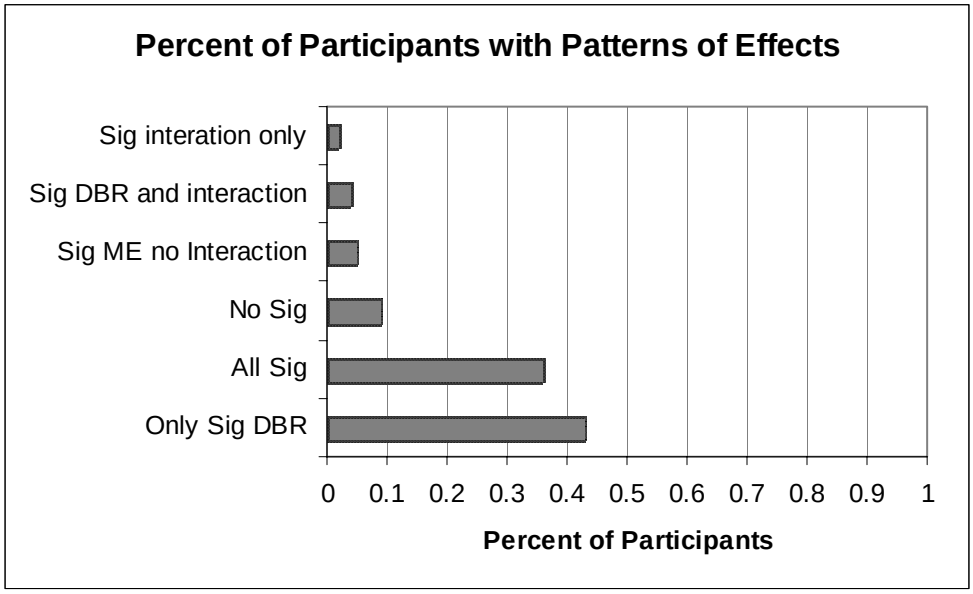
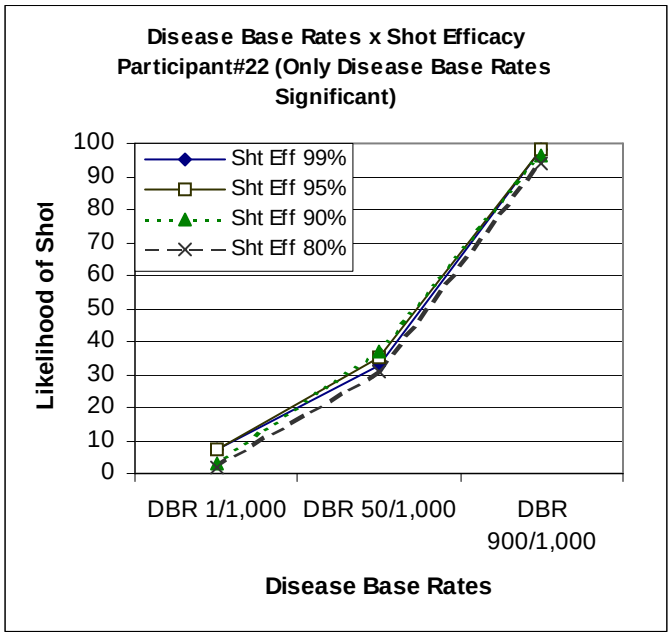


Figure 7.4 shows the pattern of results typical of these participants. As can be seen, 42% of participants focused only on disease base rates, ignoring immunization efficacy and neglecting to integrate the two pieces of information together. This is consistent with the large effect size seen for this variable across previous experiments (Experiments #1-#5). However, in those studies,

disease type encompassed disease base rate, disease severity, immunization side effect probabilities and immunization efficacy, which vary from disease to disease.

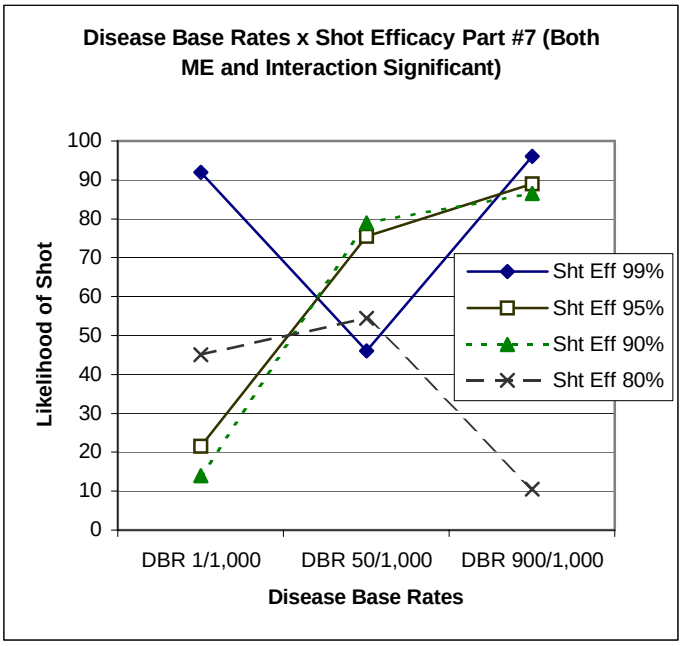
In this study, this effect is further clarified, showing that disease base rates account for much of this effect. Clearly, the variable that is most predictive of immunization behavior by most people is whether or not a disease is likely. Anecdotal illustrations of this are easy to obtain. Some illustrations of this were discussed in the chapters on theoretical background.

Figure 7.4 Typical pattern for individuals with only significant effect of disease base rates



There were a large number of individuals who had significant main effects for both variables and a significant interaction. Figure 7.5 shows the functional measurement pattern typical of these participants. As can be seen, when main effects are both significant and there is also a significant interaction, the picture is more difficult to interpret. In the present study, the interaction appears to involve shot efficacies of 99% and 80%, primarily with disease base rates

Figure 7.5 Typical pattern for individuals with significant main effects and significant interaction

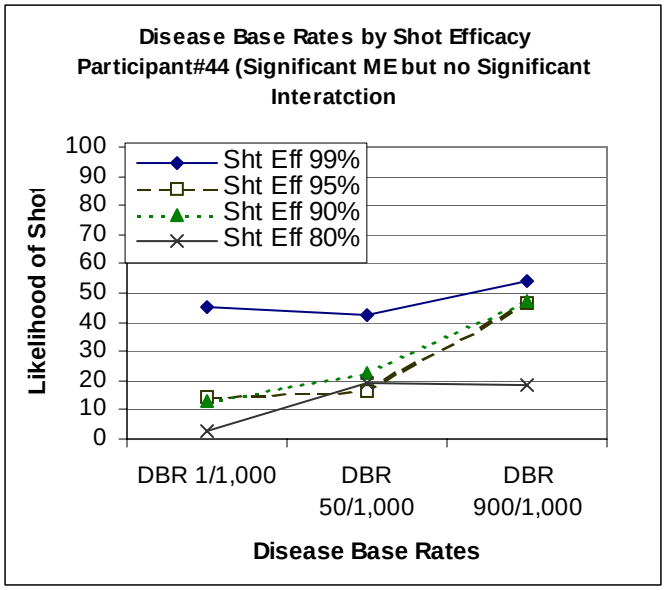


of 1/1,000 and 900/1,000. These are the extremes of these two variables. In the example shown here, it appears that when there is a high shot efficacy, this individual would likely get a shot if the disease was either very unlikely or very likely. When there was a very low shot efficacy, this individual was about 50% likely to get if the disease was unlikely and only 10% likely to get the shot if the disease was very likely. These extreme variations are very difficult to explain. The responses to the middle shot efficacies appear to be nearly identical to each other and similar to the response to disease base rate alone, seen in figure 7. 4.

There were also participants who showed significant main effects, but no interaction between disease base rates and shot efficacy (Figure 7.6). In this case, interpretation is easier. It is clear that disease base rates have an effect, with a general increase in willingness to accept immunization when base rates are high. However, there is much more willingness to accept immunization when shots are effective. Like Figure 7.5, shot efficacies of 99% and 80% show

much more variation than do shot efficacies of 95% and 90%. Also, this individual is overall less than 50% willing to accept immunization under any circumstance.

Figure 7.6 Typical pattern for individuals with only significant main effects and no significant interaction



However, 9% of individuals have no significant result. An example of the pattern of results seen for these individuals is shown in Figure 7.7. As can be seen, for this individual, interpretations of the results are difficult. This individual essentially answered with a high willingness to accept immunization in nearly all situations. While there is some variation, there is no distinct pattern.

Since functional measurement is the examination of the integration of two variables, this method is dependent on examining interactions. Individually, not quite half of participants demonstrated a significant interaction between disease base rate and immunization efficacy, as can be seen in Figure 7.8. This likely reflects the lower number of participants for whom

Figure 7.7 Typical pattern for individuals with no significant results

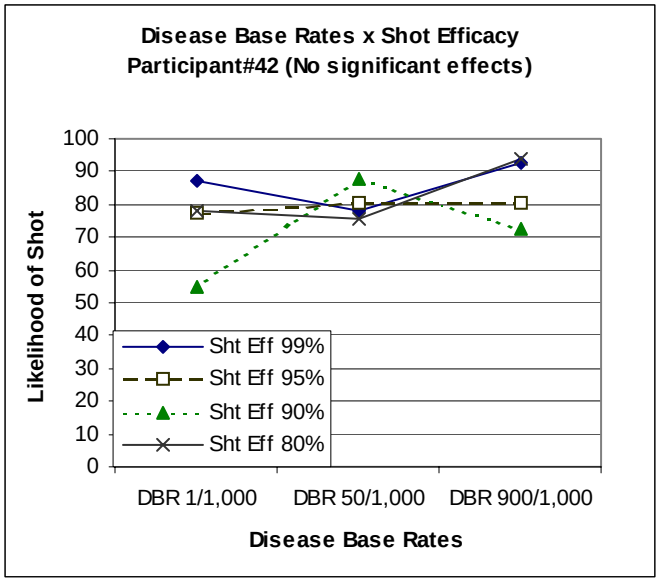
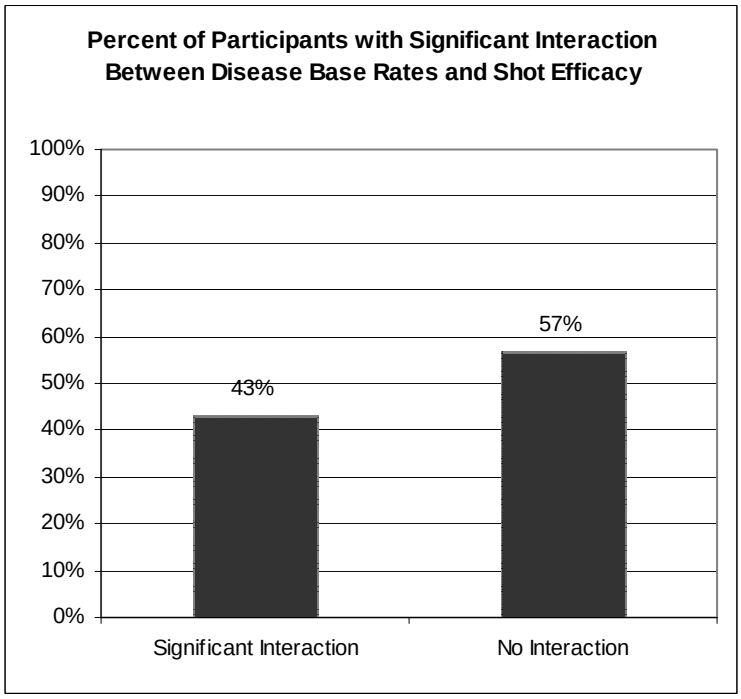


Figure 7.8 Percentage of individuals who showed a significant interaction between disease base rates and shot efficacy.



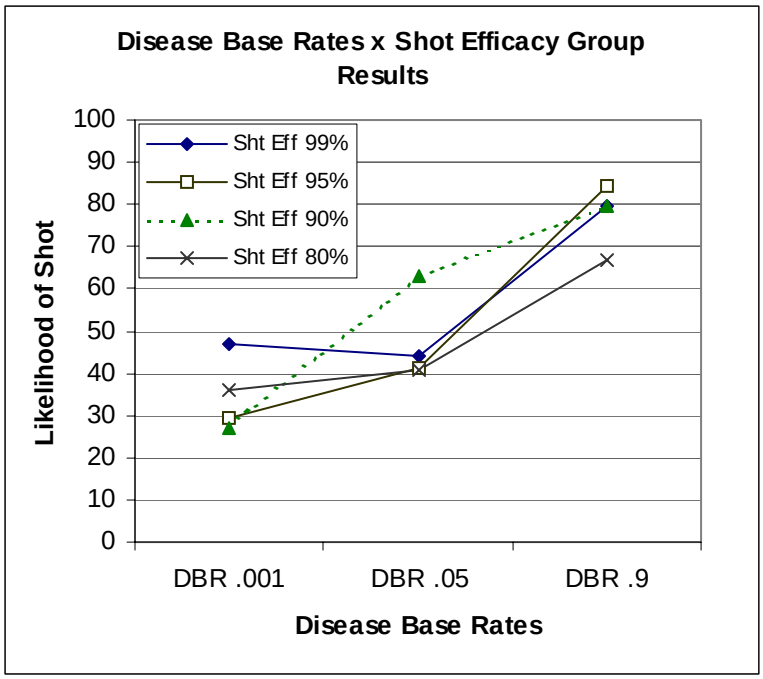
immunization efficacy influenced decision-making as well as low power for each individual. Clearly, there is considerable variation between participants in their response to the variables, except in the case of disease base rates. However, when pooled together individual differences in patterns of response can be masked. Nearly all individuals were influenced by disease likelihood. A little less than half were influenced by immunization effectiveness. There was a significant interaction between disease base rates and shot efficacy for just under half the participants. Since less than half of participants showed an interaction between the two variables, group data should be interpreted cautiously. With individual differences in mind, a group analysis was undertaken to examine overall trends in immunization decisions in response to the variables.

Group analysis: As expected, on the group level of analysis, there was a significant main effect of disease base rates ($F(2,114) = 131.67$, $p < .001$, $\eta^2 = .70$). The effect size is consistent with that found in earlier studies, so this is clearly a replicable effect. More than 60% of the variance is explained by the effect of disease base rates.

There was also a significant main effect of Shot Efficacy ($F(3,171) = 12.73$, $p < .001$, $\eta 2 = .19$). The effect size was much smaller for main effect of immunization efficacy (.19) than for disease base rates (.70). More importantly, interaction between disease base rates and shot efficacy was also significant ($F(6,342) = 20.11$, $P < .001$, $\eta^2 = .27$). This is consistent with earlier studies. The effect of shot efficacy is much better understood in light of disease base rates. The interaction between these two variables explains more than 25% of the variance in immunization behavior. This interaction is illustrated in Figure 7.9. The Linear-by-Linear contrast for the interaction is not significant. When the linear-by-Linear contrast is not significant, this rules out a multiplicative model. Highly contagious diseases, whether real

(Smallpox, Pertussis and Chickenpox) or hypothetical (Fibrilosis), appear to increase likelihood of immunization acceptance over less infectious diseases. Shot efficacy also impacts decisions, but to a lesser degree. There appears to be some suggestion of a systematic change in likelihood of immunization from the lowest level (1/1,000) of disease base rate to the next higher level of disease base rate (50/1,000) for all levels of shot efficacy. At 50/1,000 disease base rate, immunization efficacy appears not to matter at all. However, when disease base rate becomes very high, there is a suggestion of a systematic increase in interaction with shot efficacy. However, the fact that levels of both variables are not equally spaced may have affected the ability to identify clear patterns in the results.

Figure 7.9 Group results for functional measurement of disease base rates x shot efficacy



The results show an unexpected spike in response to the cell containing the probabilities associated with Hepatitis B. Exactly why this is the case is unknown. However, it is known that there are current campaigns to immunize various groups, including college students, against

Hepatitis B. It is possible that current immunization campaigns targeting college students and suggesting all students be immunized against Hepatitis B, familiar to the participants in this study, made this disease more salient than would otherwise be the case. This possibility could be examined by replicating the study with a population who had not been recently targeted in an immunization campaign. Another method of checking would be to change all disease names to a hypothetical name and examine the resulting pattern or response.

It should be remembered that, since the design was based on disease base rates and immunization effectiveness from real diseases (with fillers to complete the matrix), the design was constrained by these realities. It appears that, overall, the effect of disease base rates is the most important effect.

Some participants said that there was not much difference between levels 1 and 2 of Disease Base Rates. The increase from 1/1,000 to 50/1,000 (levels 1 and 2 of Disease Base Rates) may appear small in comparison to 900/1,000 (level 3 of this variable). In fact, there is a 50 fold (1 x 50) increase between level 1 and level 2 of disease base rate, which across the population of a city of 40,000, would translate to an increase from 40 cases (1/1,000) to 2,000 cases (50/1,000). Participants can more easily understand the impact of the larger percentage (900/1,000 =36,000 cases in a city of 40,000), especially in comparison to the smaller numbers. This issue will be further examined in the discussion section.

Although participants were not asked directly for their interpretation of shot efficacy, their response to 1/1,000 and 50/1,000 disease base rates was very similar. They appear not to recognize that an immunization only protects that segment of the population who would have gotten the disease if they did not get the immunization. That segment is computed from the disease base rate rather than from the overall population. Thus, if the disease base rate is

50/1,000, and shot efficacy is 900/1,000, shot efficacy translates to a disease rate *reduction* of 45/1,000 from the original 50/1,000. 5/1,000 would likely still get the disease after being immunized (a *reduction from* 50/1,000 *to* 5/1,000). None of the participants appeared to have done this kind of calculation. This is an important issue. Follow up exploration of this possibility will be discussed below.

Individual differences based on demographics: Individual difference variables may be helpful in identifying how participants were influenced by factors other than the variables on which this study focused. Pilot studies suggested that demographic factors such as age, gender, parenthood status, training as a healthcare provider or personal health factors may influence decisions about accepting immunization. Although these variables were not the focus of this study, results of post hoc analyses of these variables may suggest directions for future research. Only gender (in interaction with the two independent variables), parenthood status and health care training yielded interesting results.

Age of participant may be a marker for life experience with the variables of interest. Participants were divided into two age categories: traditional college student (N = 31, age range 18-21, Mean =19) and non-traditional student (N = 27, age range 24-62, Mean 36.44). There was no significant effect of age on immunization decision-making ($F (1, 56) = .494$, $p = .485$, $\eta^2 = .009$). However, specific life experiences might play a bigger role in immunization decision-making.

Gender is an individual difference variable that may also be a marker for different experiences. Therefore, gender was examined to see if this variable could predict differences in immunization decision-making. Eighteen male students and forty female students participated in the study. There was no main effect of Gender on immunization decisions ($F (1, 56) = .738$, $p =$

.394, $\eta^2 = .013$). However, there is a three-way interaction between gender and the two primary variables of disease base rates and immunization effectiveness ($F(6,336) = 2.734$, $p < .05$, $\eta^2 = .047$). Figures 7.10 and 7.11 show that the general pattern of response is similar for both

Figure 7.10 Disease Base Rates by Immunization Efficacy for Males

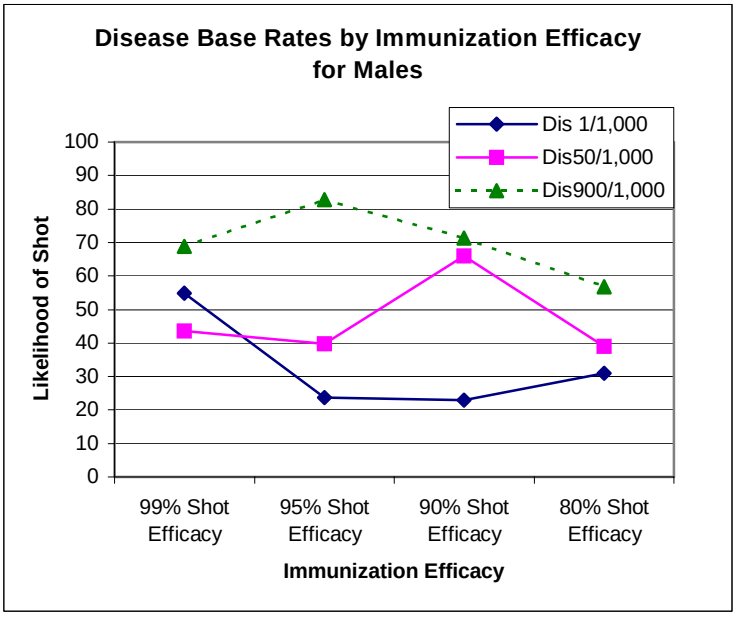
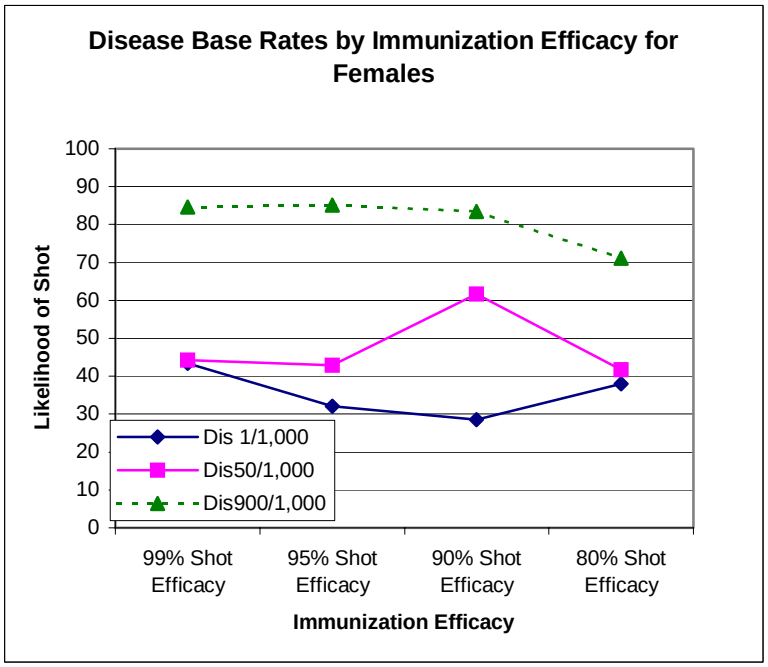


Figure 7.11 Disease Base Rates by Immunization Efficacy for Females



genders, but the magnitude is greater for females at the lowest level of disease base rate and at

the highest level of disease base rate. It appears that females may be a little more likely to accept immunization than males. Males appear to be more likely to accept immunization when shot efficacy is high (99%) and disease likelihood is low (1/1,000). Females appear to be more likely to accept immunization when disease likelihood is high, regardless of immunization efficacy. This apparent interaction deserves further study.

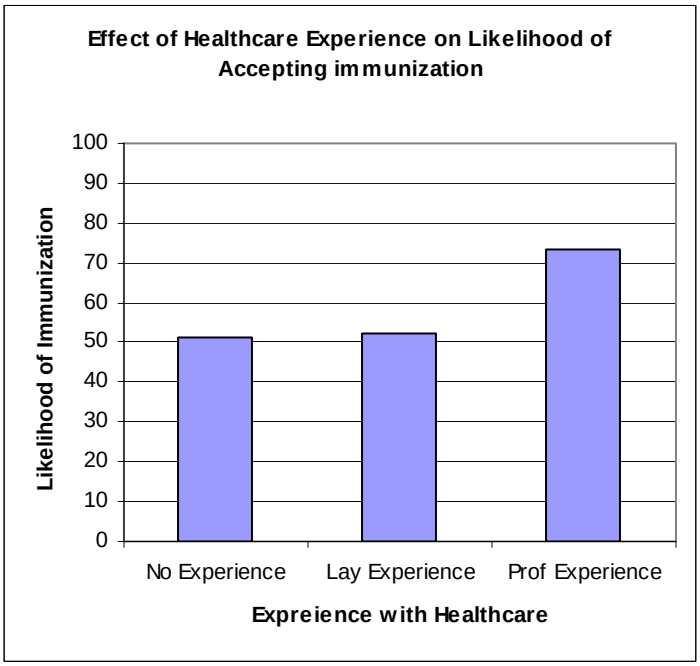
Most parents would agree that having a child changes one's perspective on life. This change may include how one views such preventive medicine decisions as immunization. Therefore, whether or not a participant had at least one child (of any age) was examined to see if this might contribute to prediction of immunization decisions. Fourteen participants reported having at least one child and forty-four reported no children. Children ranged in age from toddlers to adults in their 30s. There was no significant effect of being a parent on likelihood of accepting immunization for oneself. ($F (1, 56) = 3.262$, $p = .076$, $\eta^2 = .055$) and there was no interaction between this variable and any of the other variables. However, with a more balanced pool of participants (half parents of dependent children and half not parents) this variable might be shown to have a significant effect.

An earlier pilot study suggested that people training in healthcare provider experience may view immunizations with less skepticism or may view disease with more fear than the general public. Therefore, experience and training in healthcare was collected as a demographic variable. Healthcare experience was divided into three categories. No experience at all ($N = 41$), lay experience ($N = 12$), and professional experience ($N = 5$).

The professional healthcare provider group included people with nurses' training, one person with medical school training, a person with veterinary medicine training and others with similar professional training including being a certified nursing assistant. There was a

significant effect of healthcare experience ($F(2,55) = 3.181$, $p < .05$, $\eta^2 = .104$). As can be seen in Figure 7.12, this effect was entirely due to an increase likelihood of accepting immunization if the participant had professional healthcare experience. The fact that significant results, with a moderate effect size was obtained with such a small number of participants in the health care professional category suggests that this variable is worth further study.

Figure 7.12 Main effect of healthcare training on likelihood of immunization acceptance.



CHAPTER 8 - Limitations

There are a number of limitations to this study. First, it should be remembered that participants were in a lab setting. An effort was made to include accurate information in designing this experiment. However, this experiment remains artificial in that participants are only presented with information about disease and immunization frequencies and are asked to make an estimate of their likelihood of accepting an immunization. They are not given background information about the situation. They are also not actually making the decision to accept or reject a real immunization, since the experiment is done in a lab setting. However, the fact that there were main effects and interactions that were replicable over several experiments and which had large effect sizes is encouraging. It remains unknown whether these finding will generalize to a situation in which one is faced with a real disease and offered a real immunization.

Secondly, only one interaction between disease (disease base rates) and one immunization variable (effectiveness) are explored in Experiment #6. The initial experiments explored more of the variables from the HBM. There are several interesting interactions that deserve more study. These include disease severity and disease base rates, disease severity and immunization efficacy to name a few. Although immunization side effects are limited in statistical impact in the designs used for this series of studies, this variable is one reliably identified as a factor in qualitative research on immunization. Therefore, this variable also should be further studied. The discussion section discusses this variable in more depth. Other variables, such as cost, the individual's physical condition and environmental variables such as season could also be included in future designs. The disease base rates used for the present study

were averaged across some of these other variables. If base rates were made more situation specific, this would likely affect individual decisions in those situations. How such situational and personal variables interact should be explored.

If one is to systematically manipulate the variables in a laboratory experiment, the number of variables used must be limited. To do otherwise would be to confuse participants. Therefore, after extensive initial testing, the selected variables were examined systematically. These results do not preclude the possibility that other variables influence immunization decision-making. However, these studies suggest that the ones used in the final study are key variables.

Numerous survey studies of immunization beliefs suggest that many variables can influence actual acceptance of medical advice to immunize. These include the advice of peers, the advice of trusted (and trust of) medical personnel, and personal or vicarious experience with disease or immunization. Analysis of demographic variables suggests that medical training and being the parent of a child also impacts willingness to be immunized. Other demographic variables, such as age and gender and ethnicity were not significantly linked to immunization decisions in this study.

Age groups in this study were nearly equally divided between younger, traditional students and older, non-traditional students. Results suggest that age by itself does not significantly affect likelihood of immunization acceptance. However, age does reflect certain kinds of experience, such as becoming a parent or engaging in training and practice of healthcare. Therefore, it is worthwhile to recruit non-traditional participants for future studies of immunization decisions.

Healthcare training appears to increase immunization acceptance. Healthcare training influences likelihood of immunization acceptance only if the individual has substantial formal healthcare training. Unfortunately, the number of participants in this study who were formally trained in healthcare was small. It seems important to explore this effect further.

There was a small group of participants who were parents. The fact that there was a near significant result for this group suggests that the effect of parenthood on immunization decisions made by a parent for himself or herself should be further explored with a more targeted study.

The majority of participants were Caucasian. Little can be inferred about immunization decision making in other ethnic groups based on this study. It may be that there would be little difference in factors influencing immunization decisions between this, largely Caucasian group and groups of other ethnicities. Discovering any difference based on ethnicity would require a study targeting ethnic minorities in numbers large enough for a valid comparison.

Socio-economic status of participants in this study was obviously high enough that they were able to attend college. It is unknown to what extent results might be generalizable to other socio-economic groups.

As noted in the method section, the probabilities used for this study are fixed. In actuality, probability of disease is affected by numerous variables including host immunity, organism virulence and vector factors, and life style behaviors. Immunization effectiveness is likewise not a straightforward probability. However, for the purpose of decomposing the problem and identifying how these variables affect immunization decision-making, it is useful to present them as fixed numbers.

There appear to be various framing effects in the display of information to the decision maker. Only one frame of reference was used for the final study. As noted in discussion of

framing effects, exploration of how information is presented may increase magnitude of likelihood of accepting immunization. However, it does not appear to affect the pattern of response to different variable values relative to response to other variable values. If it has any effect, it is just to increase all responses uniformly. This is an issue of risk communication and should be further explored.

CHAPTER 9 - General Discussion

Economic Theory has been attractive as a model of decision making largely because of the ability to mathematically model options and clearly determine the best choice. However, this is unlikely to reflect how people think. No amount of training in EV, EU, or SEU will enable people to choose one correct option every time in every real world situation. This is especially true when the environment in which the decision maker is working is dynamic with time pressured or when the decision is unique with little opportunity to even identify all the potential payoffs, let alone estimate probabilities. Therefore, although Economic Theory may be useful in recommending decision strategies in some situations, it is not useful in understanding most situations. Therefore, Economic Theory is ill suited for the study of immunization decisions.

The focus of the Heuristics and Biases approach has been to identify thinking errors that lead to poor decision making. Omission Bias (Ritov & Baron, 1990) in particular has been used to describe immunization decision-making. However, there are two problems with this approach. In the first place, this description of immunization behavior is little more than a recitation of the well-known medical edict to "do no harm". In the second place, the methodology used has been called into question (Connolly & Reb, 2003). While the heuristics and biases literature tends to use artificial scenarios (e.g. "600 will be saved and 200 will die"), the present study used more representative scenarios developed from careful review of the medical literature. While the study of heuristics and biases may be useful in terms of showing pitfalls to be avoided, it has not proved helpful in improving decision making in everyday situations. In fact, base rate neglect, a principle finding in the heuristics and biases literature, is

not found in the present study. It may be that the finding of base rate neglect is an artifact of the design of most Heuristics and Biases studies.

Gigerenzer and Selten (1999) offer an alternative to heuristics and biases by describing heuristics that are adaptive. Although this is much closer to the approach that Simon (1956) had in mind, it still fails to provide useful guidance in many situations. Fast and Frugal Heuristics (F&F) (Gigerenzer & Selten, 1999) can be described, but do not provide for generalizable knowledge of how to identify exactly which key variables to include for best results. The results of this study, however, suggest that one variable, disease base rates, appears to dominate immunization decision-making. This lends strong support to the F & F model of decision-making.

Hammond's Lens Model (2000) recognizes the need to select ecologically valid stimuli by carefully assessing the cues in the environment in which the participant will make a decision. However, this model assumes, but does not test for, how these cues are cognitively combined to make a decision. Although this is a useful model, it is not consistent with systematic manipulation of variables as would be done in a factorial design.

The HBM (Rosenstock, 1974) is descriptive without any quantitative data to provide reliable predictive power. This model has considerable face validity. It is used extensively in some areas of medical decision-making. However it is vague in application. Each researcher seems to add to or subtract from the model and to make ad hoc interpretations of results. The HBM appears to be useful in generally identifying variables for further study. The present study takes the HBM from a qualitative model and begins to develop a quantitative model of health behavior.

Each of these approaches adds something to the understanding of decision-making. But, like the blind men and the elephant, each reveals only one part of the whole picture. One way to get a better handle on the problem is to combine approaches to both identify key variables that influence decision-making and to quantify their contribution. None of the experimental approaches appear to accommodate inclusion of other approaches, such as the HBM.

Functional Measurement, (Anderson, 1981) offers a way to use the findings of the HBM to not only identify which information contributes to the decision, but also to determine how that information is cognitively combined to make a decision. By using FM to examine the interaction of HBM variables and by using ecologically valid stimuli as suggested by Hammond (2000), a step can be taken toward the goal of predicting immunization behavior under different circumstances.

Results of early studies suggest that there is a reliable effect of disease factors such as severity and base rate as well as a reliable effect of immunization efficacy on immunization acceptance. These findings are consistent with both the survey literature from medicine and with the HBM (Becker, 1974). Immunization side effects appear to significantly affect immunization decisions only when they are most severe. The main effect of immunization side effect severity is not significant when immunization efficacy is systematically manipulated.

The finding that manipulation of immunization efficacy resulted in no main effect of immunization side effect severity was surprising. Qualitative studied generally have supported immunization side effect as a reason given for avoiding immunization. There are several reasons that might explain the present finding. First, qualitative data does not explore interaction of variables. When other variables are systematically manipulated, immunization side effects

interact with some of those variables, most notably, with disease base rate and disease severity. It seems likely that this interaction might be important to explore.

The swine flu epidemic in 1976 provides an good example of how this interaction might work. In that year, preventive medicine authorities predicted an epidemic of an unusually deadly strain of influenza. They provided a flu shot to prevent infection and launched an extensive information campaign to encourage individuals to get that immunization. Early in the flu season, however, reports began to be published about an unusual and very serious side effect from the immunization again swine flu, Guillian-Barre Syndrome. Shortly after those reports surfaced, the rate of immunization fell off sharply and the government ceased its immunization campaign for the general public. Side effects of the Swine Flu shot have been cited as the reason for this public health debacle. The fact that is less reported is that, at the same time that serious side effects were being reported, the actual rate and seriousness of flu was found to be much less than had been forecast. Therefore, it is possible that the failure of the Swine Flu campaign is due to an interaction of disease factors and immunization side effects rather than a main effect of immunization side effects. Exploration of this interaction may therefore much more important than exploration of side effects alone.

Overall, the variable of disease type seems to contribute the largest amount of the variance in immunization decisions. More importantly, this variable interacts reliably with the other variables in the HBM. Exploration of these interactions may provide predictive power to the HBM.

Experiment #6 is based on analyzing the interaction between disease base rates with immunization efficacy. This interaction is significant and has an appreciable effect size (η^2 = .267). Thus, the effect is not additive. However, the linear by linear contrast for this interaction

is not significant. This suggests the integration rule used by participants is more complex than a multiplicative model for the integration of the two variables. There is a significant residual. This residual suggests the complexity of the integration rule, but does not specify a model. Without specification of the integration rule, development of a scale for the variables can't be accomplished.

There appears to be an overall clustering of immunization acceptance below 50% (range 35.81 - 46.98) for the lowest level of disease base rates, a clustering (40-60) around 50% for the next higher level of disease base rate, and a clustering of immunization acceptance above 50% (range 66.68 - 79.75) for the highest level of disease base rates. The interaction of these two variables, while significant, appears not to be nearly as important as disease base rates. The threshold for significant impact of disease likelihood in immunization acceptance may be the most important issue. Variables that interact with disease base rates appear to interact, but the impact of those variables is small. One could compare the impact of disease base rates to immunization efficacy as the difference between an elephant and a mouse.

However, there is one case in the final study that has an unusually large increase not characteristic of the general pattern seen for the interaction. This cell is the one for Hepatitis B. It may be that, since participants were all college students and that there is a campaign targeting college students to accept immunization against this disease, these participants believed they were particularly vulnerable to Hepatitis B. Results for Hepatitis B for this particular study are consistent with the article (Practice Notes, 2004) describing an all out flu immunization campaign that greatly increased flu immunization in one Health Maintenance Organization for one year. However, whether or not the effects of such a campaign would generalize to other years or other immunization has not been tested. The results found in this study can be examined

by replicating the experiment with a different population. Other than the response to Hepatitis B, the pattern of response suggests that there is a general additive effect of shot efficacy and to disease base rates.

The present series of studies develops a methodology for careful examination of the variables of the HBM (Rosenstock, 1974) using a representative design (Hammond, 2000) to identify how variables are cognitively integrated (Anderson, 1974) to predict behavior in an immunization decision. Using this methodology, the HBM (Rosenstock, 1974) can be modified to predict as well as describe behavior.

Research based on this approach can suggest ways in which both patient education and decision support materials can be developed. For instance, the finding that participants did not find a noticeable difference between the 1/1,000 and 50/1,000 levels of disease base rate suggests that a decision support program might place these likelihood estimates within a context familiar to the individual, such as "in a city of 40,000, 40 would get this disease" (for 1/1,000) or "in a city of 40,000, 2,000 would get this disease" (for 50/1,000). Other methods of providing immunization effectiveness information might be: (1) telling subjects the relative reduction in disease base rates to expect from an immunization (e.g. "reduce the relative likelihood of disease from 900 to 50"), (2) report the absolute reduction in disease base rates due to immunization (e.g. "a reduction of 850 people"), (3) report shot efficacy as a ratio (e.g. "only 50/900 people exposed will get the disease, if they are vaccinated"). Decision tools to help people make better-informed decisions might be developed using the present approach to identify how display information about the disease and immunization affect decisions.

CHAPTER 10 - Summary

This series of studies call into question how the HBM is viewed. It appears from these results that decision makers do not equally weight all of the variables in the HBM. Specifically, disease base rates appear to explain the largest amount of variance. This is a robust effect. Immunization efficacy appears to be more important than immunization side effects. Immunization efficacy cannot be interpreted by itself, but interacts additively with disease likelihood. Previous experiments indicate that disease severity is important primarily because of its interaction with other disease variables such as shot efficacy. This deserves further attention.

The only demographic variables that appeared to have an effect on results were gender and professional healthcare training. There was a suggestion that parenthood might increase likelihood of accepting immunization, but the number of participants in this category was small and the results did not reach significance at the .05 level.

The major contribution of this study is the development of a methodology that takes the HBM (Rosenstock, 1974) beyond a description of variables influencing healthcare decisions to enable development of predictive models of health behavior. This method uses stimuli from a representative design (Hammond, 2000), but goes beyond the Lens Model approach. Use of a representative design provided generalizability. Use of a factorial design and examination of the nature of significant interaction using FM as described by Anderson (1974) provides predictive power.

Using the experimental approach developed here, other interactions between disease variables can be explored. One important question that might be asked is: How effective must a treatment be in relation to a disease variable for an individual to accept that treatment? This question applies not only to immunization decisions, but also to decisions about other healthcare

decisions, such as diabetic management (e.g. tradeoff between disease management strategies such as diet changes and complication avoidance) and cancer treatment decisions (e.g. how much chemotherapy side effect will one tolerate in order to "buy" time to live longer). In health maintenance, the present approach could be used to examine people's diet and/or exercise decisions (e.g. what kind of exercise would a person be willing to do under different payment distance to facility or time constraint circumstances?). In the health maintenance arena, it may be helpful to use qualitative data on the barriers to healthy behavior and systematically examine how each barrier affects diet or exercise behavior.

This approach could also be used for decisions outside of healthcare. In business, the question could be asked, how much of a profit must be made on a good in order to see it as worth manufacturing (tradeoff between cost and sale price). In military strategy, the question could be asked: How much resource should be put into an operation in order to achieve an objective? (Tradeoff between sacrifice and military goals).

In general, it is useful to not only identify the variables that appear to influence decisions, but also to explore how those variables interact. Knowledge of the interaction can help both with understanding behavior and with design of effective decision aides. The present study demonstrates one way to combine previous research findings to develop an approach to answering those questions.

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Appendix A - Immunity and Types of Immunization

Immunization is an invasive medical procedure aimed at preventing an individual from being infected by a disease. It is invasive because it puts a foreign substance into the body. The body has two primary mechanisms for fighting infectious disease: cellular immunity and humoral immunity. Cellular immunity is accomplished by what are commonly called the white blood cells, but is initiated primarily by the T family of lymphocytes (a type of white blood cell). Cellular immunity includes the memory component of immunity. That is, the ability of the body to recognize a foreign substance to which it has reacted in the past. Humoral immunity is noncellular substances such as antibodies produced by interaction of B and T lymphocytes. The whole system of immune defense is complex with several cells interacting to produce substances in response to identification of a "non-self" substance in the body. The procedure of immunization takes advantage of the body's natural responses to the introduction of a foreign substance by introducing a non-disease producing substance closely related to the infectious organism so that the body learns to identify the disease and rapidly mounts its defenses when the actual disease is introduced. In essence, immunization involves developing a cell based memory system to activate defenses against infectious disease (see Appendix A for detail).

The immune system is a system of cells and cell products that protect the body from foreign substances, like germs, via several different actions and through interaction. There are four basic methods of immunization (Mandel, Bennett, and Dolin (2000). The first method is vaccination. Vaccination is accomplished by introduction of an altered form of an organism to prompt an immune response that generalizes to the more virulent form of the organism. Vaccination uses on of three methods: 1. live, attenuated organisms, 2. killed organism or a

partial form of the organism, such as protein from the organism. The second method of immunization is the use of a toxoid, an attenuated product of the organism. The third method of immunization is use of pooled serum treated to have a high titer of IgG, one of the important components of humoral immunity. This is called "immune globulin". The forth method is similar to the third, except that it is specifically treated to have a high titer of defense to a specific disease, such as rabies. Use of both vaccination and toxoid administration are considered *active* immunization because both methods induce the body to create it's own natural defense to specific infectious organisms. Immunglobulin and specific immunglobulin are called *passive* immunization because these methods introduce immune components already generated by another host to the disease and do not invoke an immune response in the individual.

Health and government personnel have been exploring ways to convince the public of the efficacy and safety of immunizations since the smallpox vaccine was first introduced in England by Jenner in 1796 (Brannon, 2005). The response to these efforts has been variable. There is good reason for skepticism on the part of the public. Although introduction of substances into the body to evoke an immune response can prevent serious illness, debility and death, the procedure is not without risk. Hypersensitivity of an individual to the immunization substance or to a component of the mixture used to produce or to carry the substance is one of the primary risks of immunization. For instance, persons allergic to eggs or chickens should not receive immunizations that are manufactured using eggs as a growth medium. However, contamination or inadequate manufacturing procedures can also introduce risk. Persons whose immune systems are not normal for one reason or another also have increased risk of adverse responses to immunization. Healthcare personnel take all these issues into consideration when planning and administering immunizations, but unforeseen problems do

arise and are the stuff of urban legends, such as the belief that routine childhood immunization is responsible for autism (Mandel, Bennet, and Dolin, 2000; U.S. Department of Health and Human Service, NIH, 2003 and Seattle and King County Public Health Department, 2005)

Figure A.1 Methods and types of immunization used today:

Active via Vaccination	Active via Toxoid	Passive via General Ig	Passive via Specific Ig
1. Live, attenuated organism 2. Killed organism 3. Partial organism(e.g. protein from organism)	Some organisms produce toxins. A toxoid is a toxin that has been treated so that it can no longer produce disease, but still contains the proteins needed to induce immunity	Immune Globulin Pooled serum from healthy people with immune factors against diseases in general.	Specific immune globulin Serum derived from people who have recovered from specific diseases, such as Tetanus or Rabies. An immune fraction, called IgG is recovered from the serum.

Appendix B - Response Form

Figure B.1 Response Form

Card Code:_____

Under these circumstances, I would:

Never get a shot — Always get a shot

_____

Card Code:_____

Under these circumstances, I would:

Never get a shot — Always get a shot

_____

Card Code:_____

Under these circumstances, I would:

Never get a shot — Always get a shot

_____

Card Code:_____

Under these circumstances, I would:

Never get a shot — Always get a shot

_____

Appendix C - Demographics

Age_____

Gender: (Circle) Male Female

Ethnic group: _____Caucasian (Non-Hispanic)
_____Hispanic (Mexican heritage)
_____Hispanic (Caribbean heritage)
_____Hispanic (other heritage..specify)
_____African American
_____(by birth)
_____(by immigration)
_____Middle Eastern (specify ethnic group)_____
_____Asian (specify group)_____
_____Native American (specify tribe)_____
_____Other (specify if you wish)_____

Occupation: Healthcare/Medicine (specify)_____
Non-Healthcare (Specify)_____

Do you have children? Yes No

If yes, ages and Number:
_____0-2
_____3-5
_____6-10
_____11-13
_____14-18.

Does your religion take any position on the use of immunizations?

_____No religious affiliation

_____No

_____Yes: (explain)

Health Risks:

_____Chronic respiratory disease and/or asthma (specify):

_____Chronic renal disease

_____Diabetes

_____Chronic heart disease: (specify):

_____Regularly take medication that suppresses the immune system (such as prednisone, or chemotherapy for cancer)

_____Have a condition that affects the immune system.

_____Other chronic disease (specify):

_____Have you ever had a severe neurological disease such as Guilian-Barre`?

Immunization and disease history

Have you had your routine childhood immunizations? Yes No

When did you last have a tetanus shot?

Never had one _____

Less than a year ago: _____

2-4 years ago: _____

5-10 years ago: _____

It's been so long, I don't remember: _____

Do you usually get a flu shot

Nearly every year _____
Sometimes _____
Seldom/never _____

Have you ever been immunized against smallpox? Yes No
If yes, when was the last time?
If yes, have you ever had a bad reaction? Yes No

Have you ever had a bad shot reaction from the flu shot? Yes No
If yes, explain

Have you ever had a bad shot reaction from the tetanus shot? Yes No
If yes, explain

Have you ever had a bad reaction to any immunization? Yes No
If yes, please explain

Have you ever had a severe case of the flu? Yes No

Appendix D - Post Experiment Interview

Review the following information from the experiment and describe how you thought about the information and made your decision:

1.

There is a 1/1,000 chance of people getting Bacterial Meningitis, if exposed to it. The immunization against Bacterial Meningitis is effective in 999/1,000 cases. However, there is a 1/1,000 chance of a serious side effect of the shot.

Please describe how you thought about the information above:

2.

There is a 50/1,000 chance of people getting Rachmani's Hubritis, if exposed to it.

The immunization against Rachmani's Hubritis is effective in 800/1,000 cases.

However, there is a 1/1,000 chance of a serious side effect of the shot.

Please describe how you thought about the information above:

3. How likely do you think you would be to be exposed to each of the following diseases?

Bacterial Meningitis

I'd never get this disease — I'm very likely to get this disease

_____

Casalosis:

I'd never get this disease — I'm very likely to get this disease

_____

Neches River Fever:

I'd never get this disease — I'm very likely to get this disease

_____

Pneumonia:

I'd never get this disease — I'm very likely to get this disease

_____

Verde's Disease:

I'd never get this disease — I'm very likely to get this disease

_____

Black Spot Fever:

I'd never get this disease — I'm very likely to get this disease

_____

Hepatitis B:

I'd never get this disease — I'm very likely to get this disease

_____

Appalachian Pharyngitis:

I'd never get this disease — I'm very likely to get this disease

_____

Fibularosis:

I'd never get this disease — I'm very likely to get this disease

_____

Smallpox:

I'd never get this disease — I'm very likely to get this disease

_____

Chickenpox:

I'd never get this disease — I'm very likely to get this disease

_____

Pertussis:

I'd never get this disease — I'm very likely to get this disease

_____

Which of these diseases look real to you? Explain:

4. Were the instructions clear?

If not, what wasn't clear?

5. Would you recommend changes in how this experiment was conducted?

If so, please elaborate.

6. Was the method of reporting your decision (the response form) understandable and usable? If not, please make suggestions.

7.Do you have any additional comments?

Appendix E - Debrief Statement

Thank you for participating in this experiment. Your participation provides valuable information on how people make decisions in disease and health. With this information, we can make better treatment decisions and medical personnel can discuss treatment options with people more effectively.

This experiment looks at how a person makes decisions about accepting immunizations for disease. Different people may think about immunization diseases and immunizations differently based on their experience. This study helps us understand the issues that should be considered. If we were to conduct an immunization campaign, issues in this study would need to be thought about in order to know we were doing the right thing. In addition to immunization, the results of this study may be useful in thinking about how people make other healthcare decisions.

Psychologists in the field of judgment and decision-making study how people consider variables to make a good decision. One area of decision psychology is dedicated to medical and healthcare decisions making. This study is an example of a medical decision making study.

You may wonder if the information from the experiment was correct. The following up-to-date information is provided for your review:

The Following are real diseases. The actual incidence of these diseases and the effectiveness of immunization are included for your information (source: *Epidemiology and Prevention of Vaccine-Preventable Diseases, 9th Ed.):*

Meningitis: This is a bacterial disease. Although the incidence of disease in 18-23 year olds in general is only 1.4/100,000, the incidence in college freshmen is 1.9/100,000 and the incidence in college freshmen who live in dormitories is 5.1/100,00.

There is an immunization against bacterial meningitis. The Meningococcal Conjugate Vaccine has the ability to effectively protect against this form of meningitis in 98% of the cases.

Pneumonia: This is a bacterial disease. There are an estimated 3,000 to 6,000 cases per year of this disease in the US. There is an immunization against this disease. Although one type of vaccine is only about 60-70% effective, the other, Pneumococcal Conjugate Vaccine, is estimated to be effective 90% of the time.

Hepatitis B: This is a viral disease. An estimated more than 200 million people are chronically (continuously) infected with this virus worldwide. About 78,000 new infections/year are reported in the US. There is a vaccine to prevent infection with this disease. It is 80%-100% effective in preventing infection.

Pertussis: This is a bacterial disease also called "Whooping Cough". It is highly contagious. The incidence of this disease has been increasing since the 1980s. in 2004, about 60% of cases were among those 11 or older. There is a vaccine against pertussis, which is 70%-90% effective.

Chickenpox: This is a viral disease. It is highly contagious. It is estimated that people who have never had the disease and never been vaccinated are 90% likely to get the disease, if exposed to it. A vaccine has been developed to prevent this disease. It is estimated to be 65%-100% effective in preventing the disease.

Smallpox: This is a highly contagious viral disease. If a person has never been vaccinated against this disease and are exposed to it, they are more than 90% likely to get the

disease. No common source cases of smallpox exist, but the disease is one of several likely to be used for bioterrorism. 91%-97% of people who have evidence of vaccination are protected against the disease for up to 10 years.

The other diseases in the experiment are based on hypothetical disease probability statements. To our knowledge, you would be unlikely at this time to encounter diseases for which there are immunizations and that fit the exact frequency profile of those diseases.

Appendix F – Distracter Task

Code B1

You are a patient in a local hospital. You have been very ill and had surgery from which you are now recovering. You have several tubes attached including two for intravenous administration of medications and fluids and one for draining fluids. You need assistance to get out of bed, but have been able to sit up for a couple of hours each of the last two days. Your nurse today is Ms. Jones. She comes into your room with some equipment and looks at your arm where the intravenous tube enters. She checks your armband and asks you how you are feeling today. She examines the intravenous equipment. Ms. Jones tells you that the doctor has ordered a new antibiotic for you and she is adding it to your intravenous solution. She hangs the new bag of fluid and adjusts the pump.

How do you judge Ms. Jones' competence as a nurse? Make a mark on the line below to show how competent you think Ms. Jones is as a nurse:

Worst Nurse I ever met — Best Nurse I ever met

_____

Code A2

You are a patient in a local hospital. You have been very ill and had surgery from which you are now recovering. You have several tubes attached including two for intravenous administration of medications and fluids and one for draining fluids. You need assistance to get out of bed, but have been able to sit up for a couple of hours each of the last two days. Your nurse today is Ms. Jones. She comes into your room with some equipment and looks at your arm where the intravenous tube enters. She checks your armband and asks you how you are feeling today. She examines the intravenous equipment. Ms. Jones tells you that the doctor has ordered a new antibiotic for you and she is adding it to your intravenous solution. Ms. Jones consults her hand held computer before hanging the new bag of medication. She tells you that she uses the computer to ensure that everything is correct and that there are no problems that have been overlooked. She hangs the new bag of fluid and adjusts the pump.

How do you judge Ms. Jones' competence as a nurse? Make a mark on the line below to show how competent you think Ms. Jones is as a nurse:

Worst Nurse I ever met — Best Nurse I ever met

_____

Appendix G – Raw Data

Click here for comma separated value file of Raw Data

Codes used for data:

BM = Bacterial Meningitis

VD = Verde's Disease

FI = Fibrularosis

CA = Casalosis

BSF = Black Spot Fever

SM= Smallpox

NRF= Neches River Fever

HB = Hepatitis B

PE = Pertussis

PN = Pneumonia

AP = Applicacian Pharyngitis

CPX= Chickenpox

IFZ = Influenza

HA = Hepatitis A

TAS = Tarsallsis

After each disease name code is the card number associated with it (used as a second check that the correct disease information was associated with the score).

R1 = replicate #1

R2 = replicate #2

BGA is the learning control A at beginning of the first pack of cards

PTA is the learning control A at the end of the second pack of cards

BGB is the learning control B at the beginning of the first pack of cards

PTB is the learning control B at the end of the second pack of cards

BGC is the learning control C at the beginning of the first pack of cards

PTC is the learning control C at the end of the second pack of cards

---

Demographics:

Part = participant random number code (to marry up different hard copy data)

Age = participant age

Child = Does participant have any children (they actually listed ages and number, but this was coded as yes (they do have children) /0 (they don't have children)

Gender:

F = Female

M = Male

Ethnic:

Cauc = Caucasian

Hisp = Hispanic

Middle East = any Middle Eastern ethnic group

Chinese = Chinese

African = African American

NatAmer = Any Native American (American Indian) group

Hlthcrx = health care experience, specified (CNsA = Certified Nursing Assistant)

Health Risks:

Dep = Depression

Anx = Anxiety

High BP = High blood pressure

MS = Multiple Sclerosis

GERD = Gastro-esophageal reflux Disease

Others are spelled out