8-2018

Applications of Adaptive Decision Making Under Risk in Health Contexts

Drew Morgan Link
Clemson University, drewlink@gmail.com

APPLICATIONS OF ADAPTIVE DECISION MAKING UNDER RISK IN HEALTH CONTEXTS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Human Factors Psychology

---

by
Drew Morgan Link
August 2018

Accepted by:
Dr. Leo Gugerty, Committee Chair
Dr. Richard Pak
Dr. Marissa Shuffler
Dr. Fred Switzer

ABSTRACT

Research in multi-attribute decision making and how people adapt strategy selection to changes in information suggest an influence of the task environment such as increases in task complexity, time pressure, or difficulty. Decisions made within a health context provide similar scenarios in which the environment can affect multi-attribute decision making strategies. This study sought to understand the influence of the seriousness and prevalence of a disease on decision outcomes and decision-making processes within the context of vaccination. Twenty-nine participants viewed eight hypothetical scenarios involving illnesses reported in the local area or associated with travel. In the scenarios, four illnesses were described that were either low or high in terms of the seriousness of the illness as indicated by the symptoms associated with them, and the scenarios either described an instance where there was a high or low prevalence of the illness in the area. Participants then used this information to evaluate a matrix displaying four possible vaccines as decision alternatives, each with four attributes that could be used to determine the benefits of the vaccine or the costs associated with them. A mixed-model analysis was used to examine the effects of seriousness and prevalence on choice and decision strategy. The hypothesis that high seriousness and prevalence would result in decisions favoring a more effective (and thus, more expensive) vaccine was supported. Additionally, the hypothesis that high seriousness and prevalence would lead to participants using strategies that focus on the beneficial attributes was also supported. However, this effect of prevalence was larger than predicted compared to seriousness.

TABLE OF CONTENTS

Table of Contents (Continued)

Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER ONE

INTRODUCTION

Objective

The purpose of this study was to examine multi-attribute decision making in a health context and how contextual changes in a task environment affect decision strategy selection and attention allocation. Contextual changes regarding the health context for the study included the seriousness (i.e., symptoms that represent stronger or weaker adverse effects on an individual's health) and prevalence (i.e., the base rate of the disease in the population) of an illness. Twenty-nine participants responded to scenarios by choosing among vaccines for diseases varying in seriousness and prevalence. The assumption is that more prevalent and serious diseases represent a higher risk to health. For each scenario, participants chose one of four vaccines, which varied across four attributes related to the vaccine itself (e.g., effectiveness, cost). The research question was whether people use adaptive strategy selection for preferential health decisions in response to changes in the task environment.

Theories of Decision Making

Overview. When presented with multi-attribute decisions, people can exhibit adaptive decision making by using multiple information processing strategies. Strategies are described as adaptive when they produce the most satisfactory outcomes in response to limiting factors within the individual or the task environment. Simon (1955) describes rational decision making as being bounded by these limiting factors (e.g., memory

retrieval, time constraints) and states that strategies in decision making may be selected in order to simplify the decision-making process when needed. Also, strategy selection may be either a conscious, meta-cognitive selection of a strategy as a method of solving a problem or a learned unconscious response to a problem. While these limiting factors may influence strategy selection, this study focused on factors related to *risk* in the task environment and how it affected strategy selection.

Single-Attribute Decisions and Prospect Theory. Decisions may involve outcomes that are certain or uncertain. In the context of health decision making, a certain outcome would include the known monetary cost of a medicine, and an uncertain outcome would be the probabilities of certain side-effects one may experience with the medicine. Therefore, uncertain outcomes are often expressed using probabilities or frequencies. An uncertain outcome has two or more potential outcomes, only one of which will occur; therefore the probabilities of the potential outcomes sum to 1. For example, 4 of every 100 patients taking drug X will experience side-effect A (and 96 will not). Expected utility theory (EUT) and Prospect Theory provide explanations of decision situations where multiple decision alternatives are compared on a *single attribute* (e.g. money won or, in the preceding example, getting side-effect A). So in the current example, each decision option, if chosen, will result in a *single outcome* (either getting or not getting side-effect A). However, before the decision is made, each option may have *multiple potential outcomes*, e.g., people taking drug X are predicted to have a 30% chance of getting side-effect A and a 70% chance of not getting it.

EUT was an early attempt to provide an explanation of how individuals ought to make these kinds of decisions. This normative approach states that each decision option would result in one or more potential outcomes, and that individuals may value (i.e., assign utilities to) the potential outcomes differently. For example, most people will assign different utilities to getting vs. not getting side-effect A. Additionally, EUT assumes that when people are faced with an uncertain outcome, they weight each of the potential outcomes proportionally to the probability of that outcome occurring. As such, each potential decision option would have an expected utility based on the probability and utility of the potential outcome; that is, the overall attractiveness of a decision alternative (d,p) when the outcome is less than certain is calculated by $u(d)*p$, where $u(d)$ represents the subjective utility of outcome d and p represents the objective probability of the outcome occurring. EUT assumes that people select the decision alternative with the highest expected utility. In EUT, a variety of utility functions were used to transform a particular objective outcome (e.g., experiencing side-effect A) to a number representing the subjective utility of that outcome.

When people make decisions involving uncertain outcomes, they often do so in a way that does not fit with EUT. Peoples' internal, subjective interpretations of probabilities and the utility of outcomes may fluctuate, even if the probabilities and outcomes are stated precisely in objective terms. Kahneman and Tversky (1979) addressed the validity issues with EUT with prospect theory. Prospect theory suggests that when people make decisions involving probabilistic outcomes (prospects), they evaluate these outcomes by determining the *subjective* utility for a potential outcome and

a *subjective* weighting of the probability of that outcome. In prospect theory, Kahneman and Tversky developed a specific utility function (u) for transforming objective information about outcomes into subjective utilities. The shape of this utility function depends on deviations from the reference point of 0 utility; i.e., the shape differs based on whether the utility of outcomes are framed as gains or losses. For gains relative to a reference point, the utility is represented as a concave shape. For losses relative to a reference point, the utility is represented by a convex and steeper shape. This results in a utility function similar to that shown in Figure 1. The different shapes of the utility function for gains and losses means that an objective gain of $10 (versus $0 beforehand) will yield a smaller change in utility than an objective loss of $10 (versus $0 beforehand).

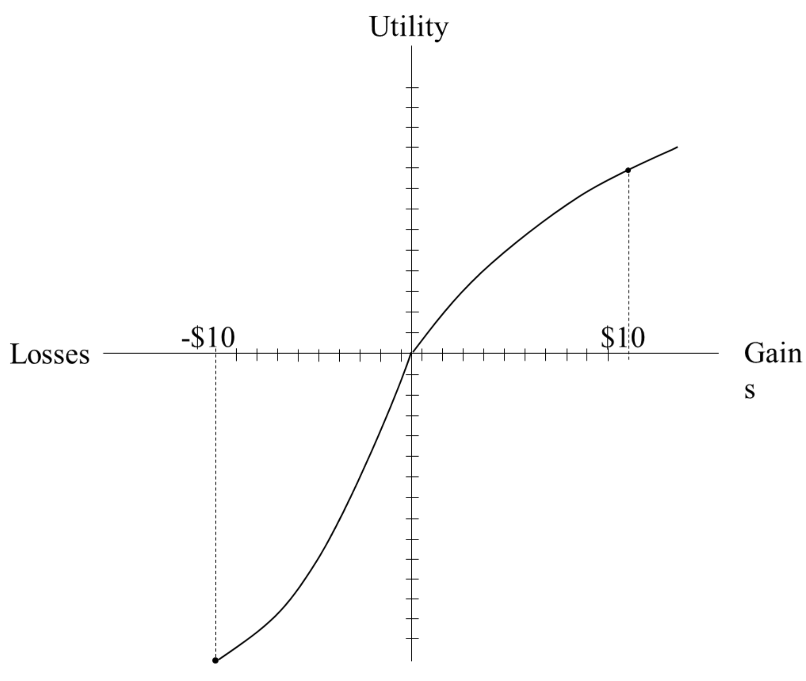


Figure 1: Kahneman and Tversky's (1979) proposed S-shaped function.

Prospect theory also differs from EUT in how probability information is used. According to prospect theory, use of probability information in a decision problem depends on subjective transformations of an objective probability rather than the objective probability. Kahneman and Tversky (1979) assume a probability transformation function (which they call a decision weight function, $\pi(p)$) that results in overweighting of unlikely outcomes (i.e., small objective probabilities are translated into slightly larger subjective decision weights) and underweighting of moderately- and highly-likely outcomes (i.e., moderate and large objective probabilities are translated into smaller subjective decision weights). Therefore, translating from objective to subjective probabilities does not reflect a linear function as would be used in EUT.

To illustrate how EUT and prospect theory applies in decision making, I will discuss a hypothetical decision task involving health. Suppose an individual (James) is getting a vaccination for the flu season. James is deciding whether or not to take a particular vaccine (A) based on a single attribute, the effectiveness of vaccine A in preventing flu. Based on information James has gathered, the prevalence of people getting the flu is expected to be 10/100. If James receives Vaccine A, the chance of getting the flu drops to 1/100. It is important to note that it is not necessary to have objective information regarding probability to use probabilities as a weight. Subjective assessments of the probability of getting the flu can be made. Also, in this decision, the possibility of getting the flu is not eliminated, therefore the outcome of taking the vaccine is less than certain. James' assessment of the effectiveness of vaccine A depends on his subjective perception of the negative consequences of getting the flu (i.e., the negative

utility James assigns to flu) and his subjective perception of the probability of getting the flu after receiving vaccine A (i.e., the subjective probability or decision weight James assigns to 1/100).

In EUT, James would maximize expected utility of a decision by calculating the weighted sum of the utilities of each potential outcome of each decision option with the objective probability of each potential outcome providing this weight, and then selecting the action with the maximum expected utility. In the flu example, if we assume that James assigns a subjective negative utility of -100 to getting the flu, then the expected utility of *not* taking the vaccine would be $u(d)*p$ = (-100)*0.10, i.e., the utility is multiplied by the objective prevalence. The expected utility of *taking* the vaccine would be (-100)*0.01, i.e., the utility is multiplied by objective probability of getting the flu if this vaccine is taken. The expected utility would be -10 and -1, respectively, therefore in order to maximize expected utility James would decide to receive the vaccine.

To illustrate the predictions of prospect theory for the manipulation of disease seriousness in this study, consider two hypothetical situations: One where James is deciding whether to take a vaccine for flu or another vaccine for typhoid, where each vaccine has an effectiveness such that 1/100 taking the vaccine still get the disease. In prospect theory, the calculation of the overall attractiveness of an outcome for a particular decision alternative, or *overall* expected utility, is represented as $u(d)*\pi(p)$, where $u(d)$ and $\pi(p)$ reflect the non-linear utility and decision-weight functions described earlier. With James' example, the reference point of 0 utility may be his current state of health.

This suggests that the assigned numerical utility is dependent on a state that may change as his health (and his reference point) changes. Given that James is healthy now and supposing that by some objective measure getting typhoid is three times as bad as getting flu, James may subjectively think about typhoid as six times worse than flu, because of the steep slope of the utility function for losses. In prospect theory, objective probabilities (p) are transformed based on a mental weighting function (π) that results in deviations of subjective from objective probability. However, in this example, the objective probability (1/100) does not change for the two decisions, so the subjective probability will not change either. Thus, prospect theory predicts that any objective difference in seriousness between flu and typhoid will be magnified by the steep slope of the utility function for losses.

EUT and prospect theory reflects single-attribute decisions, and the potential outcomes for a single attribute are mutually exclusive. James is basing his eventual decision on the probability of getting the flu, and he either gets the flu that season or does not get the flu. However, most decisions do not involve a single attribute that is associated with the alternatives. The vaccine may have an attribute associated with effectiveness, but other attributes that are important to the decision exists as well. James may need to consider the cost of the vaccine, potential side effects, or the availability of the vaccine. These decisions are referred to as multi-attribute decisions.

Multi-attribute Decisions. When faced with a decision involving multiple attributes and alternatives, a decision maker may use one of several potential strategies. Payne,

Bettman, and Johnson (1993) argue that these strategies are learned through training and experience. The decision strategy repertoire can be explicitly communicated, as is often the case with tools like patient decision aids, or even augmented through the use of external aids (e.g., pen and paper notes). These strategies range from cognitively demanding approaches that consider all of the available information to simpler heuristics that reduce cognitive effort. Considering these particular goals in strategy selection, Payne (1976) proposed that strategy selection is a process done to minimize cognitive effort while satisfying a certain degree of accuracy.

Previously, I discussed a scenario in which James needed to make a decision regarding a flu vaccine. Suppose that James now has information beyond the effectiveness of the vaccine, and knows the cost as well. Additionally, James has multiple vaccines to choose from. James needs to decide which vaccine to take, and the decision problem includes these elements:

- The vaccines James may select from (decision alternatives).
- The information that describes different aspects of each vaccine, such as effectiveness or out-of-pocket cost (decision attributes).
- The actual information regarding the magnitude of each potential outcome, such as cost in dollars for a particular vaccine (outcomes).
- James' subjective assessment of the utility associated with an attribute outcome (outcome utility).

- James' subjective assessment of the relative importance of each attribute (attribute weight).
- James' integration of the importance of the attribute and the utility of a particular outcome (weighted utility).

To elaborate on these elements, I will first refer to a strategy for multi-attribute decision making that uses all of these elements, which is called multi-attribute utility theory (MAUT) because it elaborates EUT to the multi-attribute situation. In this strategy, James would engage in several steps in order to calculate the overall expected utility of each alternative. Table 1 displays these steps, with each three-row panel (panels are separated by black rows) representing information associated with the problem at a particular step of using the MAUT strategy. Step 0 shows the initial information representing the decision. In Step 1, James would identify and assign utilities associated with each attribute outcome. These utilities determine the relevance and usefulness of the information within the cell. In Step 2, James would assign weights based on the relative importance of each attribute. This is where James' personal values and goals can affect his overall decision. If he is short on money, he will tend to place a relatively high weight on the cost attribute. If he is very concerned about getting ill, he will tend to place a relatively high weight on the effectiveness attribute. In Step 3, James would multiply each single-attribute utility by the attribute weight to determine the weighted utility for that cell (outcome). In Step 4, the weighted utilities would be summed across all cells (outcomes) for a single alternative. This sum is the overall utility for that alternative. These steps would be repeated for each alternative. As a final step, James would

compare these sums to determine which alternative has the best overall utility, which would be his final choice.

Table 1. Steps involved in the traditional approach to multi-attribute utility theory.

Step 0: Initial decision information	Vaccine A (alternative)	Vaccine B (alternative)
Effectiveness (attribute)	1/100 get the flu (outcome)	2/100 get the flu (outcome)
Cost (attribute)	$50 (outcome)	$25 (outcome)
Step 1: Assign utilities to outcomes	Vaccine A (A)	Vaccine B (B)
Effectiveness (Eff)	Utility for outcome Eff_A	Utility for outcome Eff_B
Cost (C)	Utility for outcome C_A	Utility for outcome C_B
Step 2: Assign weights to each attribute	Vaccine A (A)	Vaccine B (B)
Effectiveness (Weight of Eff)	Utility for outcome Eff_A	Utility for outcome Eff_B
Cost (Weight of C)	Utility for outcome C_A	Utility for outcome C_B
Step 3: Multiply weight and utility to get weighted utility.	Vaccine A (A)	Vaccine B (B)
Effectiveness (Weight of Eff)	(Weight of Eff) * (Utility for outcome Eff_A)	(Weight of Eff) * (Utility for outcome Eff_B)
Cost (Weight of C)	(Weight of C) * (Utility for outcome C_A)	(Weight of C) * (Utility for outcome C_B)
Step 4: Calculate overall utility for each alternative	Vaccine A (A)	Vaccine B (B)
Effectiveness (Weight of Eff)	(Weight of Eff) * (Utility for outcome Eff_A)	(Weight of Eff) * (Utility for outcome Eff_B)
Cost (Weight of C)	(Weight of C) * (Utility for outcome C_A)	(Weight of C) * (Utility for outcome C_B)
Overall utility for each alternative:	Weighted utility Eff_A + Weighted utility C_A	Weighted utility Eff_B + Weighted utility C_B

During Step 1 (determining the utilities for each outcome), it is important to note that the process would differ in this example for assignments of utility to effectiveness and cost. With cost, the outcome is certain. If James chooses Vaccine A, he will have to pay $50. Therefore, the subjective utility of cost is assumed to be based on the objective cost information and James' utility function for cost. With effectiveness, the outcome is uncertain. If James chooses Vaccine A, there is a less than certain chance of two mutually exclusive outcomes. Either he will get the flu or he will not get the flu. The process for effectiveness involves a sub-step in the strategy, where James must determine the overall utility for the cell outcome using prospect theory. To get the overall cell utility for Vaccine A, James would determine the subjective utility of getting the flu based on the objective outcome (getting the flu) and his utility function for flu, determine the subjective decision weight based on the objective probability of flu and his decision-weight function for probabilities, and then multiply the subjective utility by the decision weight. Multi-attribute decisions often incorporate attributes that have both certain outcomes and uncertain outcomes.

When using complex decision strategies associated with MAUT, James would need to integrate information across attributes for an alternative to determine the overall utility for that alternative, and repeat this for every alternative. However, multi-attribute decision making does not necessarily require the use of complex, algorithmic strategies like MAUT. James may choose to incorporate all information before making his decision or very little of the information. Strategies may vary in complexity, use of cognitive or attentional resources, and amount of information included in the decision process.

An example of a strategy that would use less information would be the lexicographic strategy (LEX). With this strategy, a decision maker would determine which attribute would be the most important for accomplishing his goal. In the example provided earlier, perhaps James considered vaccine effectiveness to be the most important attribute. Then each alternative would be compared to find the alternative with the highest utility for the effectiveness attribute (i.e., James would determine which vaccine was most effective at preventing the flu). In the strictest definition of the lexicographic strategy, no other attributes would factor into the decision. Choosing an alternative based on a single attribute reduces cognitive demand but may not result in a decision that would maximize expected utility across all attributes. For example, James may ignore the cost attribute. Although evaluating a problem based on the attribute you find most important can simplify the problem, James may not know the degree to which the prices differed. The cost may be prohibitively expensive for Vaccine A, and provided for free for Vaccine B. If the dispersion of the cost outcomes is high enough, the decision-maker might consider switching to a strategy that considers more attributes so trade-offs can be addressed (e.g., each alternative is best on one attribute and worst on another).

Some decision strategies may incorporate aspects of both heuristics-based strategies and more complex strategies. One such example would be elimination by aspects (EBA). This strategy begins in a similar fashion as LEX, where the most important attribute is identified. However, a cutoff value for this attribute is also determined. Any alternative that fails to satisfy the cutoff would be eliminated from

consideration. Afterwards, the decision maker would move to the next most important attribute and continue the process until one alternative remains.

Sometimes, decision-makers can combine strategies in a single decision. James may begin in a similar fashion as the traditional approach to MAUT. He may assign utilities to outcomes and determine weights for each attribute. However, before calculating weighted utilities or overall utilities, James may decide that he would be unwilling to accept a vaccine where 5/100 people who take it still get the flu. Any vaccines with this outcome or higher would be eliminated from consideration entirely. Then, after eliminations have occurred, James would evaluate the remaining alternatives based on the cost attribute. At this point, he may determine he is unwilling to pay more than $20 and would eliminate vaccines that cost more than this amount. If this process concludes and multiple vaccines remain, James may then use other strategies to evaluate the remaining alternatives or pick randomly from the remaining alternatives.

There are many more strategies that may be used by a decision maker, each differing in the amount of information considered for the decision, effort required to use the strategy, and the resulting accuracy in the outcome meeting a criterion of importance. This trade-off between the cognitive costs and the potential benefits has been identified as a contributing factor to how people adaptively change decision strategies in response to a task environment (Payne, Bettman, & Johnson, 1993). Thus, it is important to understand how the task environment may influence strategy selection.

Adaptive Strategy Selection. When studying adaptive decision making and strategy selection, it is important to study variables related to cognitive processes used during decision-making in addition to outcomes of decisions. If only decision outcomes are measured, it is difficult to understand why certain task, cognitive, or contextual constraints change an individual's decisions. For example, a study by Svenson and Edland (1987) showed that when participants made decisions regarding renting an apartment, the apartment with the lowest rent was chosen more frequently under a strict deadline than under a loose deadline, suggesting that the rent attribute value was weighted higher under time stress. When participants were not under a strict deadline, preferences reversed; decision outcomes tended to reflect apartments that were more expensive, but had a better overall utility when considering other attribute values.

These findings seem to indicate that elements of the task environment, such as time pressure, affect strategy selection. To examine whether this is true, process variables may be observed to provide additional information regarding the frequency and duration of evaluating attribute values in a decision problem. When the task or environment is altered in a way that increases cognitive load on a participant, he or she may respond by using a less cognitively demanding strategy such as the lexicographic rule. Measuring decision making solely through the outcomes of these decisions is insufficient to understanding these strategy shifts. Since the Svenson and Edlund (1987) study did not measure process variables, we are not sure about what strategies participants actually used. However, many studies have attempted to measure strategy

selection in response to changes in a task environment using a combination of process and outcome measures.

Process measures of strategy selection. A study that identified and measured strategy selection was conducted by Payne (1976). Payne manipulated task complexity by varying the number of alternatives and attributes provided in a decision problem. The decision problem involved multiple apartments for rent, where the number of apartments (alternatives) was either 2, 6, or 12, and the number of attributes (e.g., rent price, noise level) was either 4, 8, or 12. As the number of alternatives and attributes increased, the complexity of the task increased. Payne's primary interest was to determine which characteristics of a task environment changed strategy selection. He hypothesized that higher task complexity would result in simpler strategies that reduced cognitive load. He used process tracing techniques to understand the strategies used by the participants as well as their decision outcomes.

The procedure used by Payne involved the presentation of decision alternatives and outcomes on an information board, with note cards containing information regarding the attribute (e.g., rent) on one side and the outcome value (e.g., $170) on the other. An envelope was displayed on the board for each outcome for each attribute across the different apartment choices. Either 4, 8, or 12 attributes were displayed on the board. Therefore, in the condition where 6 alternatives were presented with 4 attributes, 24 envelopes were presented on the information board. A card within an envelope had the outcome for the attribute and its corresponding alternative written on it. Process tracing

was done by combining two techniques: explicit information search and verbal protocol. Information search was measured by recording the order in which cards were selected from envelopes of the respective alternatives. For example, a participant could look at the rent outcome for apartment 1, then the commute-distance outcome for apartment 2, and so on. The order of outcomes selected provided information regarding whether search was conducted within a single attribute but across alternatives or within an alternative across attributes, and when shifts between the two occurred. This method also provided information regarding whether certain attributes or alternatives were ignored. Verbal protocols were elicited by prompting the participants to "think aloud" as they evaluated their selections and how they were using this information to inform their decision. This provided information regarding how a final decision was made and the reason for multiple visits to a single outcome.

The results from this study confirmed Payne's hypothesis regarding the increased use of simpler heuristics as a function of task complexity. When the number of alternatives or attributes was higher, participants engaged in simpler decision strategies such as EBA more frequently. Verbal protocol indicated explicit statements that certain alternatives were being eliminated due to a cutoff not being met by the alternative. When there were two alternatives, participants much more frequently engaged in strategies that incorporated more information as suggested by the equal focus of within-attribute and within-alternative information processing.

Another study examining the effect of manipulating a task environment on strategy selection was conducted by Bettman, Johnson, Luce, and Payne (1993). In contrast to Payne's (1976) study, participants in this study made gambling decisions that allowed for varying degrees of monetary payoff. Each gamble (decision alternative) had outcome information that reflected potential monetary payoffs associated with the gamble. Each of these payoffs had a probability associated with it. For a simplified example, Gamble A may pay either $3, $4, $5, or $6 with respective probabilities of .18, .25, .28, and .29. Therefore, a participant will receive a single payoff as a result of choosing Gamble A, and each possible payoff has a specific probability associated with it. Since there was only one attribute for each alternative (amount of payoff), these were single-attribute rather than multi-attribute decisions. However, there were multiple potential outcomes within the single payoff attribute (i.e., four potential payoffs in the above example), so strategies used for multi-attribute decision making could be used. In other words, Bettman et al. treated a potential outcome of a gamble as a single decision attribute, so that, for the purposes of analysis of strategy use, a single-attribute decision was interpreted. They then considered how various multi-attribute decision strategies could explain performance on the task.

Intercorrelational structure was a variable manipulated to have two levels: Negatively correlated attribute values (compensatory decisions) and positively correlated attribute values (non-compensatory decisions). Negative correlation structures would involve decisions where the attribute values and probabilities involved a tradeoff that needed to be made, for example a gamble that had the highest potential payoff may have

the lowest probability associated with that payoff. A competing gamble may have a lower payoff, but a higher probability of that payoff happening. In these situations, no single gamble dominates all others in terms of probability or payoff. In positive correlation structures, one gamble dominates on all attributes. One gamble would have the highest payoffs relative to the other gambles, and these payoffs would increase as the probability increased.

Bettman et al. (1993) hypothesized that compensatory decision problems would be more likely than non-compensatory problems to produce complex decision strategies to maximize potential gains. In the terminology described by Bettman et al., the strategy selected and decision context would be more effortful for complex decision strategies, but would also increase accuracy. When decision problems were non-compensatory, certain alternatives dominated others on all attribute (outcome) values and probabilities. As such, heuristics could be used to reduce effort while maintaining a satisfactory level of accuracy. Complex strategies would not be necessary to achieve a similar result.

Process variables were obtained in a similar fashion to Payne (1976). Each decision problem had four alternatives (gambles), and each gamble had four potential outcomes, with each potential outcome consisting of a payoff with its associated probability. All payoffs and probabilities were hidden from the participant. However, in this study a computer-based program was used (MouseLab). This program allowed for a similar interaction as the physical information board, with participants hovering over a payoff or probability for an outcome in order to see just that payoff or probability temporarily revealed. Process variables of explicit information search and patterns could

be recorded, as well as durations of attribute value views within a cell on a matrix in milliseconds. Thus, process variables were determined by frequency of cell acquisition (i.e., views) and the durations of these views. This computer program automated the collection of these variables in a reliable fashion, allowing for more precise behaviors regarding decision strategies to be recorded and analyzed.

Results regarding decision processes from this study were analyzed using durations of cell views to identify whether complex and more effortful strategies were being used as opposed to simpler heuristics. When decision problems involved negatively correlated task environments, participants confronted these tradeoff decisions in an adaptive fashion: They engaged in more effortful strategies to maximize potential gains, including strategies that evaluate all information across all alternatives. When decision problems involved positively correlated task environments, participants chose strategies that reduce cognitive effort while maintaining an acceptable level of accuracy regarding potential gains. Again, these results indicate that participants are adaptive in strategy selection. Participants attempt to maximize accuracy in decisions and only engage in cognitively demanding strategies when the task environment provided no clear dominating alternative.

Task Environment. The task environment may influence strategy selection in many more ways. One example includes the initial stage in MAUT of assigning utilities to outcomes. During this process, individuals often determine the importance of an attribute regardless of whether they will use complex or simple decisions strategies. This process is dependent on the task environment as well. Perceptions of the value and probability of

an attribute outcome can be affected both by incidental influences and relevant information regarding the problem.

Attribute weights can also be affected by aspects of the task environment. For instance, information displayed simultaneously or separately can affect weighting when making decisions related to emotional choices. Kahneman and Ritov (1994) found that when two hypothetical interventions (one involving providing free basic medical checkups to farmers, and one involving protecting endangered animals from hunters) were presented simultaneously, more weight was given to the intervention that benefits people, even if the circumstances were more mundane for that intervention. When these problems were presented separately, and individuals were asked to state how much they would be willing to pay to support these interventions, participants were more sympathetic to the endangered animal scenario and would allocate more money to this intervention to protect them. These examples highlight how initial judgments of attributes in a decision can be influenced by the way in which decision information is presented.

In the current study, participants saw scenarios in a potentially affectively-charged task environment. However, the task environment also reflected health decisions in which levels of seriousness and prevalence of an illness may influence how participants use information regarding alternatives and attributes in decision making.

Decisions in the health domain. Adaptive strategy selection can be observed with health as the task domain. However, to discuss how patients may be adaptive in their

strategy selection, it is important to identify the contexts in which these decisions would be made. The most relevant example would be a decision involving the selection of a treatment (e.g., medication) for an illness. In many health contexts, there are multiple potential treatments for an illness. When patients are gathering information about treatments, whether by speaking with physicians, researching on the web, or talking to other patients, they are building an array of potential treatment alternatives to consider.

Alternatives and their associated outcomes are integral in these decisions. In order to evaluate which alternative the patient will pursue, a patient will make predictions regarding various effects (outcomes) that the treatment will have. As mentioned in the previous discussion in strategies for single-attribute and multi-attribute decisions, people need to evaluate the utility of particular outcomes in order to make an overall decision. The patient may consider the following objective information while making a treatment decision: How effective a medication is reported to be, how much discomfort is associated with a medication's side effects, how much they will have to alter their routine in order to maintain treatment, or several other outcomes. These predictions are often uncertain, which means that they are presented to decision makers probabilistically. In this way, attributes and outcomes values reflect information similar to the design used in Bettman, Johnson, Luce, and Payne (1993), where particular outcomes are possible when making a decision, but are associated with varying probabilities.

Finally, as mentioned by Payne et al. (1993), these treatment alternatives all have potential utilities that can be perceived as negative or positive, and may often present

decision problems reflecting a tradeoff decision where no single alternative dominates all other on all attributes. A treatment may have a high probability of effectiveness, but also a high probability of exhibiting unwanted side effects. The degree to which one treatment alternative is preferred to another often depends not solely on probabilistic information, but on the patient's weighting of an attribute. Similar to the research discussed earlier, attribute weights are not necessarily stable and may be influenced by manipulations in the task environment. Even if outcomes remain unchanged for a given set of alternatives, it is reasonable to assume that subjective weights may change in response to a change in the task environment similar to studies such as Svenson and Edland (1987), where time pressures resulted in changes in preference in apartment choice.

Medical decisions that patients make also can be compensatory or non-compensatory. Depending on the value participants place on certain attributes, one alternative may or may not dominate others on different attributes. Multiple aspects of a task environment may alter an individual's strategy selection and use. These may include the source of information gathering (e.g., whether alternatives are gathered from a physician or through an individual's own research), time pressure, or the type of illness being treated. For the current study, I focused on manipulating the seriousness and the prevalence of a disease, to understand how these aspects of a task environment affect strategy selection and overall decisions.

Seriousness of disease and prevalence

In this study, I manipulated the type of illness presented in a scenario. The different illnesses varied in levels of seriousness (based on descriptions of the diseases and associated effects), and the prevalence of the illness in that scenario (based on hypothetical announcements regarding illness prevalence). Seriousness is defined as the overall negative impact a disease has on an individual's health, both in the long term and in the short term (i.e., latency before onset of symptoms, severity of symptoms, likelihood of hospitalization or long-term complications). Prevalence is defined as the base-rate probability of the disease in the immediate vicinity of an individual (i.e., local prevalence changes during a localized outbreaks).

Overview of the Current Study

The goal of the present study was to determine what effect seriousness and prevalence of an illness may have on participants' decision processes and choices. Seriousness of illness was manipulated by providing scenarios reflecting different illnesses with varying severity of symptoms and prognoses, and prevalence was manipulated in these scenarios by including information regarding localized outbreaks or lack of outbreaks.

The study presented participants with a multi-attribute decision-making task using a modified version of Mouselab (Johnson, Payne, Bettman, & Schkade, 1989). This program provided process and outcome data similar to that found in Bettman, Johnson, Luce, and Payne (1993). That is, the outcome for a cell is only visible while the

participant hovers over that that cell with the mouse; and the sequence and timing of cell visits is recorded. Decision outcomes (choices) were recorded for each decision (scenario), and measures of decision processes were based on the durations of visits (acquisitions) to individual cells in a decision matrix.

The study included decision scenarios that varied in seriousness and prevalence of diseases. Seriousness was manipulated by providing information regarding four illnesses (i.e., seasonal influenza, mumps, meningitis, and typhoid fever). As previously stated, each of these diseases varies in terms of expressed symptoms and prognosis, some more debilitating or potentially fatal than others. Information regarding negative consequences of getting the disease are communicated in textual scenarios provided to participants. Results from a pilot survey suggested that influenza and mumps would be comparable and low in evaluations of seriousness. Meningitis and typhoid were roughly equal in high evaluations of seriousness.

Prevalence was manipulated by including information regarding outbreaks in the area or by travel to a country where the risk of contracting the disease is higher. High prevalence is indicated by a scenario mentioning that there is an outbreak or large number of the local campus population being hospitalized or treated for the disease (i.e., influenza, mumps, meningitis) or a hypothetical situation where the participant imagines he or she is traveling to a high-risk country for a disease (i.e., typhoid). Low prevalence is indicated by a scenario mentioning there is no concern for an outbreak on campus or that the participant would be travelling to a country with low risk of typhoid. Thus, scenarios were presented to participants in a 2 (seriousness high vs. low) x 2 (prevalence

high vs. low) within-subjects design. Since there are 2 examples of each level of seriousness, this yields 8 scenarios.

CHAPTER TWO

PRESENT STUDY: EVALUATION OF DECISION PROCESS AND OUTCOME IN MEDICAL CONTEXT

Research in strategy selection in multi-attribute decision contexts suggests that individuals respond to changes in task environments, increased cognitive demand, and contextual changes in the decision problem. In a healthcare context, I argue that the concept of subjective utility applies to medical decisions in terms of patients' (and physicians') evaluations of the general risk of negative or adverse effects associated with a disease. So patients would be expected to assign higher negative utility to a more serious illness than a less serious one. Additionally, I equate the concept of base-rate probability of contracting an illness with prevalence. Base-rate information will not be explicitly stated in a numerical form, rather the information will be provided in a manner that is more likely to exist in a medical context (e.g., the presence or absence of a local outbreak on campus).

The decisions regarding vaccinations included four alternative vaccines and four attributes, as well as the associated outcomes for each alternative. The outcomes for two attributes presented uncertain or probabilistic information (e.g., 2/100 experience side effects) and the outcomes for the other two attributes presented certain outcomes (e.g., cost of vaccine). There were two attributes associated with benefits (i.e., strains and effectiveness), and two attributes associated with costs (i.e., cost and side effects). In addition, in every scenario presented, the two beneficial attributes were always positively

correlated with each other and the two cost attributes were always positively correlated with each other. Finally, across the four alternatives, benefits and costs were always positively correlated, so that the most beneficial vaccine was the most costly and the least beneficial was least costly. A summary of each attribute is provided in Table 2. Table 3 shows the correlational structure of each attribute across the 4 alternatives.

Table 2. Attribute information for the present study.

Attribute information

Attribute	Type of outcome	Example
Effectiveness	Uncertain	"1/100 take the vaccine and still get the flu"
Strains protected	Certain	"Vaccine protects against 4 strains of the virus"
Side effects	Uncertain	"4/100 experience mild side effects from the vaccine"
Out of pocket Cost	Certain	"$20 out of pocket cost"

Table 3. Example problem showing correlational structure of vaccine alternatives for the present study.

	Vaccine 1	Vaccine 2	Vaccine 3	Vaccine 4
Effectiveness	1/100 still get flu ++++	2/100 still get flu +++	3/100 still get flu ++	4/100 still get flu +
Strains	4 strains ++++	3 strains +++	2 strains ++	1 strain +
Side Effects	8/100 have side effects +	6/100 have side effects ++	4/100 have side effects +++	2/100 have side effects ++++
Out of Pocket Cost	$75 +	$50 ++	$25 +++	0 ++++

Note. + refers to levels of utility of outcome, with ++++ being the highest and + being the lowest. The pluses were not present in the problems shown to participants.

Hypotheses Regarding Seriousness. I hypothesized that as the scenarios change from low to high seriousness, people will increase the amount of time attending to effectiveness and strains, and decrease the amount of time attending to cost and side effects.

In addition to this quantitative hypothesis regarding shifts in attention allocation, I also assessed strategies associated with the attention shifts. With high seriousness being reflected in high negative utility, process data may indicate an increase in strategies that reflect the lexicographic (LEX) method with effectiveness and/or strains being the most important attribute(s). With low seriousness, effectiveness attributes may become less important due to the decrease in negative utility associated with the type of illness. Therefore, weights may begin to become more even across attributes. The decision problem then becomes one in which the strategy may not be to choose the most effective alternative, but to choose an alternative that satisfies other criteria as well. Therefore, decision processes would reflect strategies such as EBA. Participants may still consider effectiveness to be the most important attribute, but they no longer simply make their decision based on a single attribute, as when LEX is used with the effectiveness attribute. They would eliminate alternatives that do not meet certain requirements for effectiveness, and then move to the next most important attribute (e.g., cost). Then, a decision would be made whether any of the remaining alternatives should be eliminated due to an undesirable cost.

Finally, I hypothesized that as diseases change from low to high seriousness, vaccine choices would shift towards vaccines that are optimal in terms of the effectiveness attribute (i.e, vaccines with the lowest probability of getting the disease) or the strains attribute, which has a correlation of +1.0 with effectiveness. With low disease seriousness, participants were expected to more often choose a vaccine that balances effectiveness and cost attributes, which would result in a choice in between the most effective and highest cost vaccine and the least effective and lowest cost vaccine. With high seriousness, participants are expected to base their choice mainly on the effectiveness attribute, thus leading to more choices of the most effective and highest cost vaccine

The rationale for these predictions was that, as the illness increases in perceived losses in relation to an individual's health (i.e., in seriousness), people should give more weight to attributes related to the individual's best chance of avoiding those losses. From the perspective of MAUT, an increase in the seriousness of an illness should lead people to assign greater attribute weights for effectiveness and strains. However, an increase of seriousness should *not* be associated with increased attribute weights for costs or side effects. As such, for scenarios where there is a higher potential to experience serious symptoms, the most important attribute would be identified as effectiveness of the vaccine or how many strains it protects against (which have a correlation of +1.0). Process data would reflect this with higher percentages of time dedicated to visits to these two attributes. In the LEX method, the alternative would be determined by the attribute with the highest chance of being effective at preventing the illness.

Hypotheses Regarding Prevalence. I hypothesized that as the scenarios change from low to high prevalence, people will increase the amount of time attending to effectiveness and strains, and decrease the amount of time attending to cost and side effects.

Similar to the effects of seriousness, I predicted that increasing prevalence may result in an increase in the use of the LEX strategy. When a disease increases in prevalence, participants may spend more time evaluating benefits (i.e., effectiveness and strains) of the vaccine relative to the costs. As prevalence decreases, time may be more evenly distributed among the benefits and the costs, suggesting an EQW strategy.

Finally, I hypothesize that as diseases change from low to high prevalence, vaccine choices (overall decision outcomes) will shift towards vaccines that are optimal in terms of the effectiveness attribute (i.e, vaccines with the lowest probability of getting the disease) or the strains attribute, which is has a correlation of +1.0 with effectiveness.

The rationale for predicting that increasing disease prevalence will lead to these shifts in attention allocation, strategies and vaccine choice is the same as for the seriousness hypotheses. That, as the illness increases in perceived risk to an individual's health (i.e., in prevalence), people should give more weight to attributes related to the individual's best chance of avoiding this risk (i.e., to the effectiveness and strains attributes). However, an increase of prevalence should *not* be associated with increased attribute weights for costs or side effects. The increased weight given to effectiveness and strains will be associated with increased attention to these attributes and to choices based only on these attributes.

CHAPTER THREE

METHODS

Participants

Participants were 29 (17 female, 12 male) undergraduate adults recruited from Clemson University. Participants were assigned to all combinations of levels of seriousness and prevalence of diseases.

A power analysis was conducted using the software application G*power that reflected a conservative estimation for repeated measures ANOVA with interaction. The sample size was calculated assuming a Cohen's d effect size of 0.25. Using the output from this power analysis, the number of participants deemed necessary was 24, including the 4 levels of seriousness and 2 levels of prevalence repeated within subjects. To facilitate detecting effect sizes smaller than 0.25, we set a goal of 30 participants prior to data collection.

Design

The study was a 4 (disease type: influenza[F], meningitis[Men], mumps[Mu], typhoid[Typ]) x 2 (prevalence: high, low) within-subjects design. In total, 8 decision problems involving vaccinations were presented to each participant.

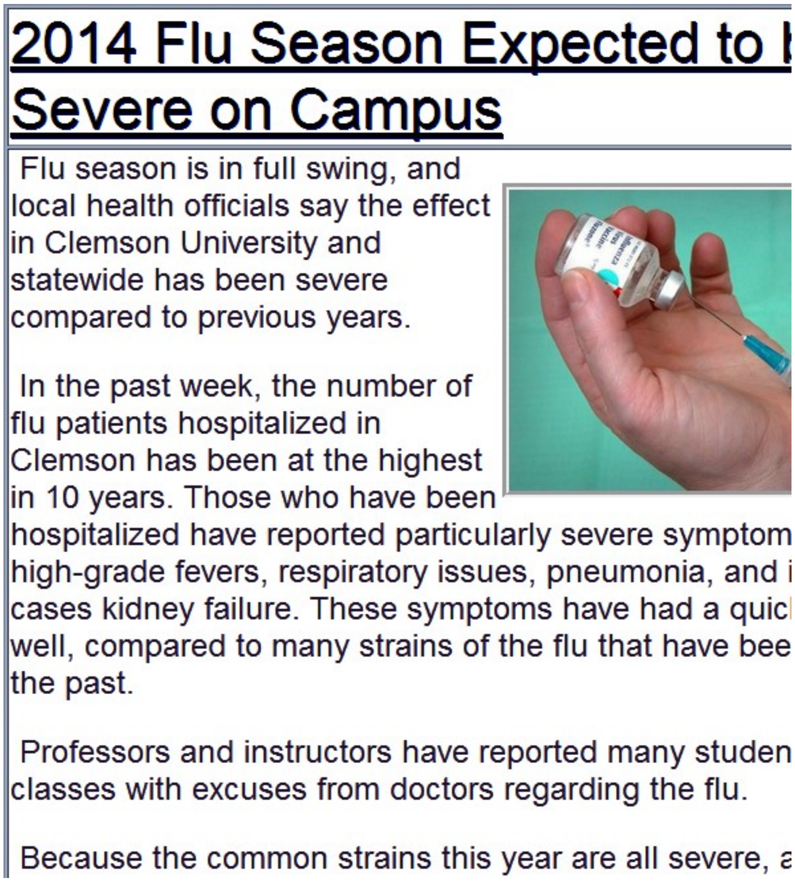
The quantitative dependent measures were decision outcomes, (i.e., vaccine choices), and decision processes, (i.e., time attending to particular attributes). Vaccine choice had four levels: the vaccine that represents the highest benefits and costs, second

highest benefits and costs, third highest benefits and costs, and lowest benefits and costs. (Remember that across alternatives, high benefits are always associated with high costs, and vice versa.)

Qualitative variables describing decision-making strategies were coded from the Mouselab data on the sequence, frequency and duration of visits to cells of the decision matrix during each problem. In some analyses, the strategy variables were dependent variables and prevalence and seriousness were the independent variables.

Materials and Tasks

Disease seriousness and prevalence were manipulated in these scenarios by mock news articles regarding the disease. These news articles were presented to the participant, along with a headline detailing synopsis of the illness and its prevalence. The participants also read the article below the headline detailing the specifics of the illness and prevalence. These details were designed to manipulate the participants' impression of the seriousness of the illness. After reading the scenario, participants responded to a comprehension question about the topic of the preceding article in order to determine if the article was read and that the participants were considering the illnesses and prevalence when making a decision regarding a vaccine. The example scenarios for each level of prevalence and seriousness are included in Appendix A.



2014 Flu Season Expected to
Severe on Campus

Flu season is in full swing, and local health officials say the effect in Clemson University and statewide has been severe compared to previous years.

In the past week, the number of flu patients hospitalized in Clemson has been at the highest in 10 years. Those who have been hospitalized have reported particularly severe symptom high-grade fevers, respiratory issues, pneumonia, and cases kidney failure. These symptoms have had a quic well, compared to many strains of the flu that have bee the past.

Professors and instructors have reported many studen classes with excuses from doctors regarding the flu.

Because the common strains this year are all severe,

Figure 2: Sample scenario (Flu / high prevalence) article.

Equipment. Participants used a modified version of Mouselab on desktop computers for all aspects of the study. Participants used computers for the entire duration of the study, and did not be have the option of using any external aids.

Questionnaires. Participants provided demographic information at the beginning of the experiment. In addition, participants reported their typical compliance with immunizations. This survey was given at the conclusion of the study. This compliance survey was added due to responses from an initial pilot test in which some participants stated that they would have chosen not to take a vaccination if that had been a possible choice. Therefore, the inclusion of this question was to determine if participants' responses were affected by their beliefs about vaccinations.

A manipulation check was conducted to determine whether the seriousness manipulation was sufficient, and whether the chosen example illnesses of flu and the mumps were interpreted as lower seriousness compared to meningitis and typhoid fever. This check was conducted at the conclusion of the study in the form of 8 questions regarding each illness. The list of specific questions can be found in Appendix C.

Additionally, the conclusion of the study included a questionnaire to assess awareness of the manipulation or hypothesis, as well as a 20-item inventory measuring risk-taking in health and safety with the inclusion of the medical risk-taking subscale from the Domain-Specific Risk Taking (DOSPERT) Inventory (Blais, & Weber, 2006; Butler, Rosman, & Seleski, 2012). The DOSPERT was given to determine if there were any individual differences associated with risk-taking behaviors that may have contributed to a participant's decisions regarding vaccinations.

Procedure

An experimental session overall lasted approximately 30 minutes. The participant read an information letter including basic information about psychological research. Then the experimenter provided training for the participant in the form of a decision-making task in the same format as the experimental condition, but using a topic associated with online shopping rather than a health decision scenario. Then the participant practiced on a second similar decision-making task. The experimenter informed the participant that the selection of a vaccine was necessary for each scenario, but information about each vaccine was hidden behind each cell on the page, and in order to view information that may be helpful in making a decision, the participant would need to move the mouse cursor over each cell to reveal the information.

At the beginning of the experimental session, the Mouselab program randomly displayed an illness type within one of the two blocks. One block included all low prevalence scenarios, and the other block included all high prevalence scenarios. Every scenario began with the mock news article shown in Figure 4 detailing the illness and prevalence, followed by a short comprehension question regarding the topic of the article. After moving past these two pages, the multi-attribute decision matrix with the four vaccine alternatives and attributes were displayed. Refer to Figure 5 for an example. The order of the vaccines and attributes on each scenario was randomized, and the vaccine names differed depending on the illness. Each name provided no clues of the quality of the drug, and names were fabricated with the intention of reducing bias or

name recognition across trials. Additionally, the attribute information was displayed in each scenario so the participant could read more detailed information about the definition of each of the four attributes by hovering over those attribute names. Cell views and time were recorded when participants interacted with cells in the matrix. A summary description of the article from the previous page was displayed at the top of the window as a reminder of the relevant information for the current decision task (see Figure 5). The text emphasized the values of the independent variables for the current scenario in bold (seriousness and prevalence).

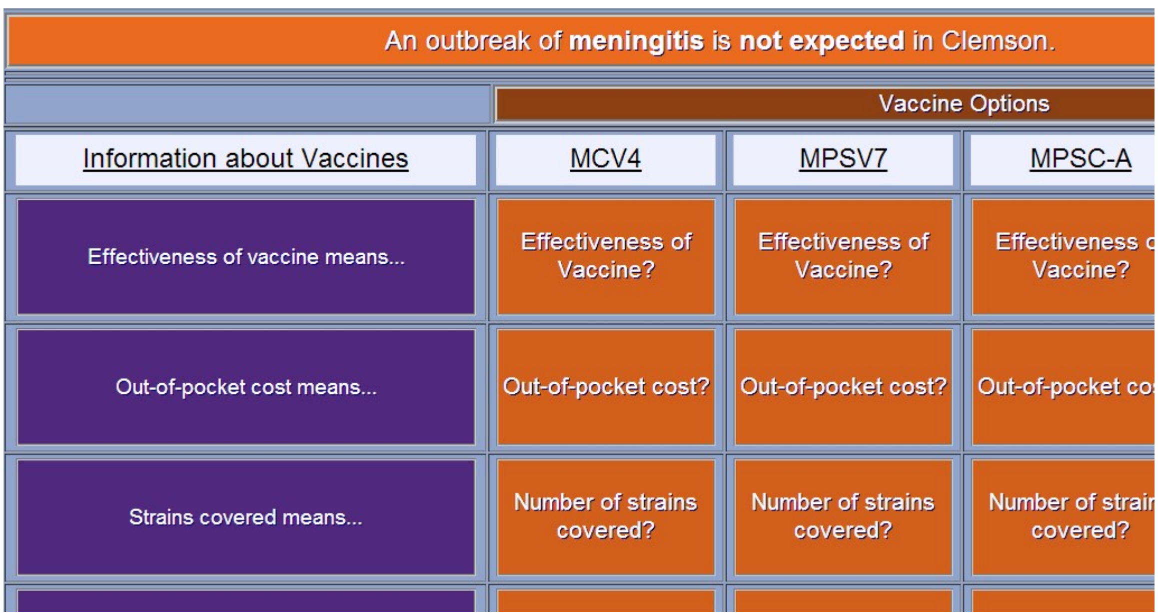


Figure 3: Sample multi-attribute decision matrix. Each cell has information regarding the outcome hidden. Moving the cursor over a cell reveals this information, and records process data.

After the decision was made and confirmed, participants repeated the process 7 more times, with a break between blocks. At the conclusion of the decision-making

scenarios and tasks, participants responded to questionnaires regarding the study and were debriefed.

CHAPTER FOUR

RESULTS AND DISCUSSION

Manipulation Check

To use the four illnesses adequately manipulated participant's perceptions about disease seriousness, a manipulation check was conducted based on two post-test questions. For each of the four diseases, participants were asked "how afraid" they were of getting the disease and "how bad it would be (in terms of debilitation, amount of time spent in recovery, and risk to long-term health)" if they were diagnosed with the disease. Participants responded using Likert scales ranging from 1 to 7, with 1 represented less fear or concern associated with the illness while 7 represented high fear or concern of the illness and its effects. We averaged participants' responses to these questions to estimate their perceived seriousness for each disease. Participants perceived the flu and mumps as less serious, mean rating of 3.57 (SD = 0.92) and meningitis and typhoid fever as more serious, mean rating of 5.34 (SD = 1.09). This difference was significant, $t(56) = 1.77$, $p < .001$. This represented a large effect size, Cohen's $d = 1.75$. Thus, the four diseases adequately manipulated perceived seriousness.

Predicting choice by prevalence and seriousness of disease.

After data collection, it was found that one participant viewed one of the combinations of prevalence and seriousness twice due to a computer error, therefore this participant's data were not included in the final analyses. The independent variables in this study were seriousness of disease and prevalence. The dependent variable measure was vaccine choice, coded as a variable ranging from 1 to 4. A response of 4 reflects the

decision alternative that is highest in effectiveness, and a response of 1 reflects the alternative that is lowest in effectiveness. This analysis assesses whether changes in seriousness or prevalence affected whether participants were more likely to choose a more effective option. For the analysis, decision outcomes were recorded as ranging from the vaccine with the highest benefits and costs (choice value of 4) to the vaccine with the lowest benefits and costs (1). The hypotheses were that as seriousness and prevalence of the disease increased, the vaccine with maximum benefits would be more likely to be chosen despite its high costs, resulting in choice responses closer to 4 rather than 1. When seriousness and prevalence were low, it was expected that participants would focus less on benefits and more on costs (or on both), which would lead to choosing vaccines that were not maximally effective but had lower costs.

A mixed-model analysis was run using the SPSS Mixed Model Analysis procedure. These models incorporated both independent variables of seriousness and prevalence as fixed variables. Effect sizes were calculated using R^2. Starting with the null model, hierarchical regression models added one variable at a time and R^2 was calculated based on the difference of residuals in the current and prior models. Cohen's (1992) standards whereby R^2 of .01, .06, and .15 represents small, medium, and large effect sizes, respectively, were used for interpretation.

Figure 6 shows the effect of prevalence and seriousness on participant's choices. The mean choice increased from 2.09 (*SD* = 1.09) when prevalence was low to 3.31 (*SD* = 0.89) when prevalence was high. This effect was significant, $F(1,1) = 54.190$, $p = .000$.

The mean choice increased from 2.47 (*SD* = 1.17) for low seriousness to 2.92 (*SD* = 1.12) for high seriousness, suggesting the predicted main effect. This effect was significant, $F(1,1) = 27.542$, $p = .000$. These two main effects support the hypothesis that higher levels of seriousness and prevalence of illness would lead to participants weighting benefits over costs and thus choosing vaccines that were higher in effectiveness. Finally, there was no significant interaction between prevalence and seriousness, $F(1,1) = 2.079$, $p = .152$.

By comparing a prevalence only model with the null model, $R^2 = 0.402$, suggesting a large effect size for prevalence. When seriousness was added to the prevalence model, $R^2 = 0.054$, suggesting a medium effect size for seriousness. Thus, although prevalence and seriousness showed the predicted main effects, the prevalence effect was much larger than the seriousness effect, contrary to predictions.

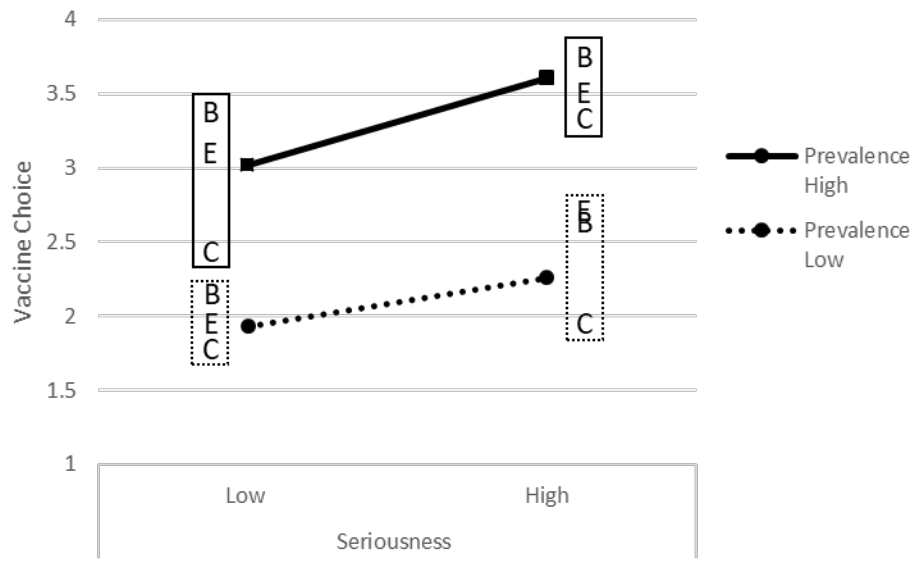


Figure 4. Prevalence and seriousness of illness plotted as a function of vaccine choice ranging from lowest in effectiveness and cost (1) to highest effectiveness and cost (4). The mean response for vaccine choice for each strategy at each level of prevalence and seriousness for benefits-focused (B), equal-weighting (E), and cost-focused (C).

Calculation of process variables

Decision-making strategies were measured using Mouselab data on how frequently participants visited cells within the decision matrix time and the sequence and duration of cell visits. These measures allowed for the testing of the hypotheses regarding how varying seriousness or prevalence affected strategy use. The strategy analysis focused on identifying when participants were using decision-making strategies that involved scanning within attributes (e.g., lexicographic) vs. within alternatives (e.g., satisficing) and, if they were scanning within attributes, whether they prioritized certain attributes or considered all of the attributes more equally. When recording the measure associated with duration of within-attribute visits, any durations less than 200 ms for a

single cell view were dropped from analysis, as this short duration could be reasonably interpreted as cursor movement over cells without intention to read (Johnson, Payne, Schkade, Bettman, 1989).

A visit to a particular attribute was coded when a participant sequentially revealed cells within that attribute without revealing cells outside of the attribute. The rationale was that participants revealing information regarding a single attribute across alternatives were making comparisons within that attribute. The identity of the attribute was recorded along with the duration of the visit. This allowed calculating the number and duration of visits to particular attributes. An analogous process was used to calculate number and duration of visits to each alternative.

Initially, process data were used to determine to what degree participants viewed information within attribute compared to within alternative. This was calculated by adapting the Search Index (SI) formula from Payne (1976). The SI is determined by the duration of viewing within alternatives compared to the duration viewing within attributes, as indicated by the following ratio.

$$SI = \frac{Talternative - Tattribute}{Talternative + Tattribute} \qquad (1)$$

The index ranges from -1.00 to 1.00, indicating a complete attribute focus to a complete alternative focus, respectively. The mean SI for participants in this study was -0.271 (*SD* = 0.461), suggesting that participants engaged in within-attribute comparison of information more than within-alternative comparison. Therefore, the primary analysis of the effects of prevalence and seriousness on strategy selection focused on evaluations of within-attribute strategies, e.g., lexicographic vs. equal-weighting.

In order to test the hypothesis regarding whether participants were evaluating all attributes with equal weight or giving different weights to attributes related to benefits (vaccine effectiveness; strains) or costs (side-effects; out-of-pocket price) of the vaccine, the following process variable was calculated for each decision problem a participant completed.

$$TimeATT = \frac{Tbenefits - Tcosts}{Tbenefits + Tcosts}$$

(2)

where *Tbenefits* and *Tcosts* represented the duration spent visiting the two benefits attributes and the two cost attributes, respectively.

TimeATT describes whether a participant focuses on benefit vs. cost attributes. The values of TimeATT range from -1 to 1. A value of -1 means that for a particular problem, the participant only compared attributes associated with costs, and never did any within-attribute comparisons for benefits, whereas a value of 1 means that the participant only engaged in within-attribute comparisons for benefits. In both of these cases, the strategies match the lexicographic decision-making strategy, where an attribute is determined to be the highest priority and therefore the individual only looks at that specific attribute. Figure 7 shows the distribution of the 232 problems in terms of TimeATT. This variable has a mean near 0 (-.06) and a large *SD* (0.63). The variability is large because participants focused exclusively on costs for 41 problems, and on benefits for 31 problems.

I identified two codes for the lexicographic strategy, depending on whether the vaccines' benefits or costs are the most important. When TimeATT is near 0, the

participant is dedicating roughly equal attention to costs and benefits. For the purpose of this study, a participant was deemed to weight benefits and costs on a problem approximately equally (EQW) when TimeATT was between -.25 to .25. Any values that were between -1 and -.25 were coded as a cost-focused strategy (COST), and values between .25 and 1 were coded as a benefits-focused strategy (BENEFITS).

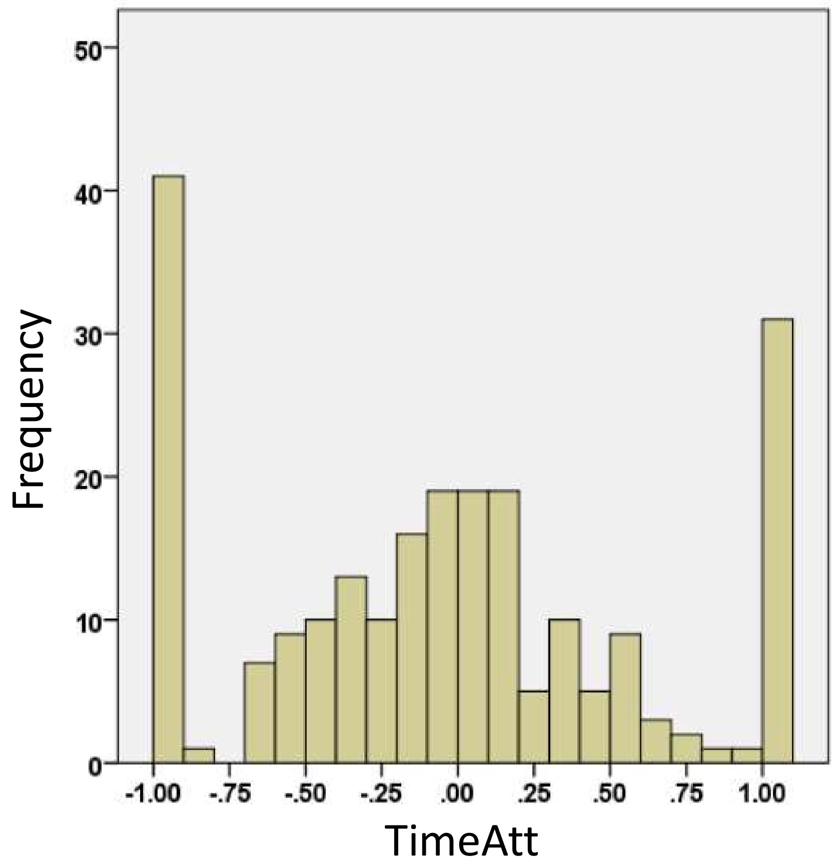


Figure 5. Histogram for TimeATT

Prevalence and seriousness of illness and decision-making strategy

I hypothesized that higher seriousness and prevalence would be associated with an increased use of the lexicographic strategy with the participants identifying the benefit

attributes as the most important attributes. When illnesses were low in prevalence and seriousness, I predicted that participants would engage in a strategy more similar to EQW, where they generally give equal attention to benefits and costs.

Table 3 shows the frequency of using each strategy for the four combinations of prevalence and seriousness averaged across all participants. The problems where prevalence and seriousness were both high or were both low provide the clearest test of the hypotheses. When prevalence and seriousness were both high, participants seemed to use the benefits strategy more than EQW, as predicted, and also more than the costs strategy. When prevalence and seriousness were both low, participants used the benefits strategy less and instead used the EQW strategy more, as predicted, or the costs strategy. I did not predict that participants would focus strongly on costs on these problems. However, this finding is consistent with the idea that when avoiding the negative utility of contracting a disease is less important, participants do not need to focus as much on beneficial attributes that allow avoiding the disease. Thus, the cost-focused and the EQW strategy are similar in that both are plausible ways to weight attributes when focusing on benefits is not required.

A multilevel-model analysis was run using the SPSS Mixed Model Analysis procedure, with the strategy used as the dependent variable and prevalence and seriousness as the fixed variables. Using strategy selection as a dependent variable, a value of 3 represents a benefits-focused strategy, 2 represents an EQW strategy, and 1 represents a cost-focused strategy. Starting with the null model, hierarchical regression

models added one variable at a time and R^2 was calculated based on the difference of residuals in the current and prior models.

Figure 6 shows that the mean strategy selected changed from 1.76 (*SD* = 0.812) when prevalence was low to 2.21 (*SD* = 0.825) when prevalence was high, suggesting that participants favored a benefits-focused strategy more when prevalence was high and a cost strategy more when prevalence was low. This effect was significant, $F(1,1) = 9.741$, $p = .004$. By comparing a prevalence only model with the null model, $R^2 = 0.073$, suggesting a moderate effect size for prevalence. The mean choice was 1.964 (*SD* = 0.825) for low seriousness, and 2.005 (*SD* = 0.812) for high seriousness, indicating no main effect of seriousness, $F(1,1) = 0.029$, $p = .866$. The main effect of prevalence supports the hypothesis that higher levels prevalence of illness would lead to participants using a lexicographic strategy that focuses on benefits. However, the lack of a main effect of seriousness of illness does not match my hypothesis that seriousness would have a similar effect on strategy selection. Finally, there was no significant interaction between prevalence and seriousness, $F(1,1) = 0.618$, $p = .435$.

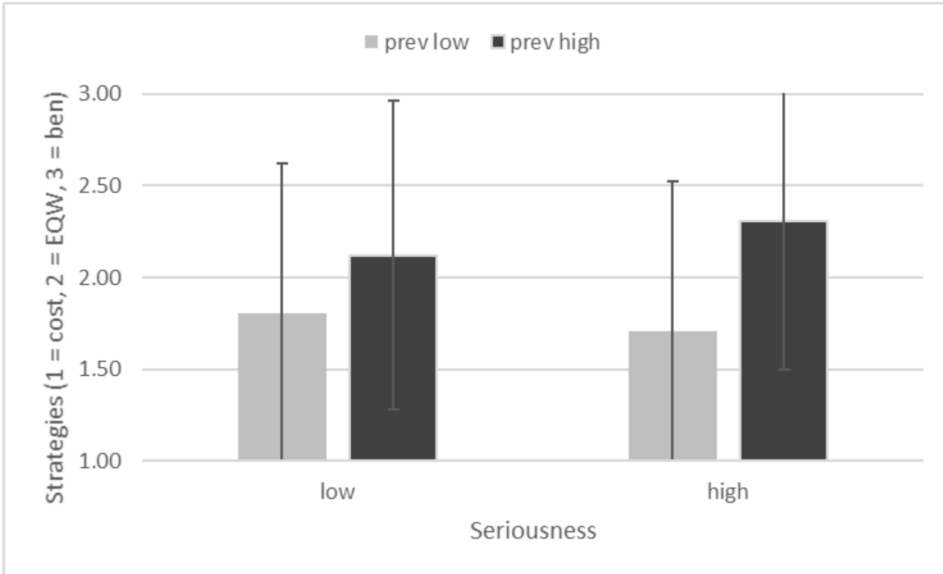


Figure 6. Seriousness and prevalence by strategy selection for cost-focused strategies (1), EQW (2) and benefits-focused strategies (3). Error bars represent standard deviations.

In addition, the model above was run with the strategy selection dependent variable represented by a dichotomous variable of whether participants chose a benefits-focused strategy or not. The same tests were applied and found the same results regarding effect sizes and significance. The three-level variable provided more precision in describing how participants allocated attention to different attributes; therefore, this variable was used to frame the results of this portion of the study.

Table 4: Average per problem percentage of strategy use by the level of prevalence and seriousness of the illness. *SD's* are in parentheses. Of the 232 decisions made by the 29 participants, 3 decisions were dropped due to matching an alternative-based processing strategy (satisficing). This is why the percentages do not sum to 100 for some of the four problem types.

	Prevalence			
	Low		High	
Seriousness	Low	High	Low	High
Benefits	24.1 (36.9)	22.4 (31.6)	41.4 (44.4)	50.0 (40.1)
EQW	31.0 (33.9)	25.9 (31.7)	29.3 (39.0)	25.9 (31.7)
Costs	43.1 (34.7)	51.7 (36.6)	29.3 (41.2)	20.7 (34.1)

How decision-making strategy affects choice.

I had no original hypothesis on how decision-making strategy would specifically affect vaccine choice, as my primary hypotheses were related to how the manipulation of seriousness and prevalence would influence strategy use and whether participants chose vaccines that were more effective based on these manipulations. However, in an exploratory analysis, I investigated whether using the benefits, EQW or costs strategy affected choice. Strategy use is an observed variable that was shown in the previous analyses to be correlated with prevalence and seriousness. Therefore, one cannot test whether strategy use predicts choice outside of the context of prevalence and seriousness. Because of this, strategy use was added as a predictor to the best multilevel model where

prevalence and seriousness predicted choice (i.e., prevalence and seriousness as main effects).

Figure 6 shows the relationship between strategy use and vaccine choice for the four combinations of prevalence and seriousness. Using the benefits strategy resulted in vaccine choices closer to maximum effectiveness, while a costs-focused strategy resulted in choices that minimized effectiveness but also costs. In the model with prevalence, seriousness and strategy use as predictors of choice, there was a significant effect of strategy use, $F(1,1) = 6.02$, $p = .018$, and $R^2 = 0.015$, indicating a small effect size, and prevalence, $p < .001$, and seriousness, $p < .001$, remained significant.

Individual Differences in Strategy Use

Results from this study have shown an overall effect of seriousness and prevalence on vaccine choice, as well as some indication that seriousness and prevalence influence strategy selection when considered on average across participants. However, it is also important to examine how each participant responded to changes in prevalence and seriousness, and whether participants on an individual level engaged in adaptive decision-making based on changes in prevalence and seriousness. This section focuses on individual differences regarding strategy use across each level of prevalence and seriousness.

Table 4 shows the proportion of problems where each participant used a benefits-focused strategy, a costs-focused strategy, or an EQW strategy for each four combinations of prevalence and seriousness. The participants are reordered in this table to group them in four distinct patterns of adaptation to the changing scenarios.

Table 4: Proportion of strategies used across four combinations of prevalence and seriousness per participant. Participants are grouped based on similar patterns regarding how they adapt to the changes in prevalence and seriousness.

	Low Prev. / Low Ser.			Low Prev. / High Ser.			High Prev. / Low Ser.			High Prev. / High Ser.		
ID	Ben	Cost	EQW	Ben	Cost	EQW	Ben	Cost	EQW	Ben	Cost	EQW
Group 1 – strongly fits hypothesis												
1	***0***	0.5	0.5	0	0.5	0.5	1	0	0	***1***	0	0
2	***0***	0.5	0.5	0.5	0	0.5	1	0	0	***1***	0	0
20	***0***	0.5	0.5	0	1	0	1	0	0	***1***	0	0
22	***0***	0.5	0	0	1	0	1	0	0	***1***	0	0
4	***0***	0	1	0	0.5	0.5	0	0.5	0.5	***1***	0	0
5	***0***	0	1	0	1	0	0	0.5	0.5	***1***	0	0
Group 2 – partly fits hypothesis												
21	0.5	0	0.5	0.5	0.5	0	0	1	0	***1***	0	0
25	0.5	0.5	0	0.5	0.5	0	0	1	0	***1***	0	0
29	0.5	0.5	0	0.5	0.5	0	1	0	0	***1***	0	0
7	***0***	0	1	0.5	0	0.5	0	0	1	0.5	0	0.5
13	***0***	1	0	0.5	0.5	0	1	0	0	0.5	0	0.5
27	***0***	1	0	0.5	0.5	0	1	0	0	0.5	0	0.5
18	***0***	0.5	0.5	0	0	1	1	0	0	0.5	0.5	0
15	***0***	0.5	0.5	0	0.5	0.5	0.5	0	0.5	0.5	0.5	0
10	***0***	0.5	0.5	0	0	1	0	0	1	0.5	0	0.5
6	***0***	0.5	0.5	0	0.5	0.5	0	1	0	0.5	0	0
Group 3 – partly opposite of hypothesis												
9	***1***	0	0	0.5	0.5	0	0	0	1	0.5	0	0.5
24	***1***	0	0	0	0.5	0.5	0.5	0.5	0	0.5	0	0.5
28	***1***	0	0	0	0.5	0.5	1	0	0	0.5	0.5	0
23	***1***	0	0	0	1	0	0.5	0.5	0	***0***	1	0
16	0.5	0	0.5	1	0	0	0	0	1	***0***	0	1
8	0	0.5	0.5	0.5	0	0.5	0.5	0	0.5	***0***	0	0.5
17	0.5	0.5	0	0	1	0	0	0	1	***0***	0.5	0.5
12	0	1	0	0	1	0	0.5	0	0.5	***0***	0	1
Group 4 – never focused on benefits												
3	***0***	0.5	0.5	***0***	0.5	0.5	***0***	1	0	***0***	0.5	0.5
14	***0***	1	0	***0***	0.5	0.5	***0***	1	0	***0***	1	0
26	***0***	0.5	0.5	***0***	1	0	***0***	1	0	***0***	1	0
11	***0***	1	0	***0***	1	0	***0***	0.5	0.5	***0***	0.5	0.5
Group 5 - unclassified												
19	0.5	0.5	0	1	0	0	0.5	0	0.5	0.5	0	0.5

Group 1 includes six participants who always engaged in a benefits-focused strategy when both prevalence and seriousness were high. When both prevalence and seriousness are low, these participants engage in a combination of cost-based strategies and EQW, but never show a benefits-focus. These participants most closely match my hypotheses that an increase in seriousness and prevalence would be accompanied by a shift in strategy to focus on attributes that involve the effectiveness of the vaccine, i.e., benefits.

Group 2 consists of 10 participants who partially supported the hypothesis, but less strongly than Group 1. This generally means that the participant at least once used a benefits-focused strategy when viewing a high prevalence and seriousness scenario, and may or may not have used a benefits-focused strategy when making a decision in a low prevalence and seriousness scenario.

Group 3 includes eight participants who engaged in behaviors that were opposite what I predicted in my hypothesis regarding strategy selection. These participants either never used a benefits-focused strategy when prevalence and seriousness were high, always used benefits strategies when prevalence and seriousness were low, or both.

Group 4 includes four participants who never used a benefits-focused strategy when choosing a vaccine, regardless of the prevalence and seriousness associated with the scenario. These participants also did not support the hypothesis that participants would focus on benefits when prevalence or seriousness were high. Group 5 consists of 1 unclassified participant.

These notable differences between the strategy selection associated with the three groups could help explain why the hypothesis that prevalence and seriousness affects strategy selection only provided a few simple-effects associated with the use of benefits-focused strategies when prevalence and seriousness was high. The individual differences indicate generally that participants changed decision-making strategies across the eight scenarios, but in a manner that only sometimes matched the hypothesized strategy selections.

Risk Taking and Strategy Use. The DOSPERT survey of health risk taking was included to further investigate what potential effects individual differences may have had on the results. High DOSPERT scores indicated greater aversion to health-related risk taking. The responses on the survey for each participant were correlated with overall proportion of strategy use. There was a positive correlation between the DOSPERT score and of the frequency (proportion) of using a benefits-focused strategy, $r(27) = .512$, $p = .005$, and a negative correlation between the DOSPERT score and the average use of costs-focused strategy, $r(27) = -.571$, $p = .001$. These correlations suggest that participants who were more risk-averse regarding their health were more likely to focus on benefits of the vaccines and disregard costs. There was no correlation between the DOSPERT score and the EQW strategy, $r(27) = .121$, $p = .533$.

These results of the DOSPERT inventory may provide an additional explanation for why certain groups in Table 4 seemed to respond to the tasks in the study in a consistent fashion. As indicated by Group 4, some participants never incorporated a benefits-focused strategy in their decision making regarding the scenarios provided. The

results from the DOSPERT analysis suggests that individual comfort regarding health risk-taking may influence strategy use and decisions more so than variances in prevalence or seriousness of illness.

CHAPTER FIVE

GENERAL DISCUSSION

The purpose of this study was to examine multi-attribute decision making and how contextual changes in a health-based task environment affect decision strategy selection and choice. Figure 7 summarizes the findings regarding how the prevalence and seriousness manipulations affected strategy selection and choice. I hypothesized that as prevalence and seriousness increased, vaccine choices would be higher in benefits, represented in Analysis 1. Secondly, I hypothesized that as prevalence and seriousness increased, participants would use lexicographic strategies that focus on the attributes associated with benefits more than costs. Additionally, I hypothesized that lower prevalence and seriousness would be associated with equal weighting across all attributes. These two hypotheses were tested in Analysis 2. Finally, I had no specific hypotheses regarding the relationship between strategy selection and choice, represented in Analysis 3.

As indicated in Figure 7, Analysis 1 showed a large effect of prevalence on choice, and a moderate effect of seriousness on choice in the direction hypothesized. Analysis 2 showed that that prevalence had a moderate effect on strategy selection, in that higher prevalence was associated with strategies that focused on benefits and not costs. Finally, Analysis 3 showed that there was a small effect of strategy selection on choice, such that strategies that emphasized benefits were associated with choices of vaccines that maximized benefits while increasing costs. Overall, my hypotheses were

supported, with the exception of the low effect size of prevalence and the lack of an effect of seriousness on strategy selection.

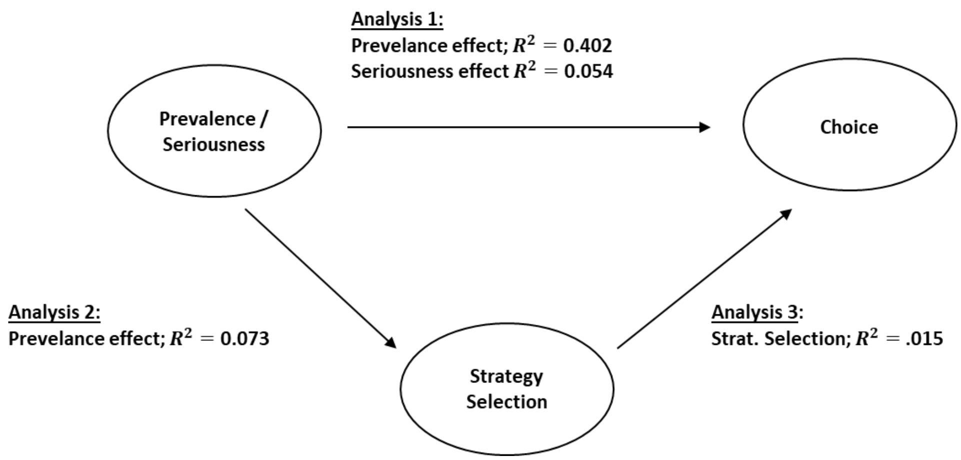


Figure 7. Illustration of the three analyses conducted in the study. Only significant effects are shown.

Factors that affect objective and subjective health risks

This section discusses the independent variables manipulated in this study, the efforts made to ensure the strength of the manipulation of the levels of the variables, and the extent to which this was successful.

Seriousness and prevalence of disease. Seriousness and prevalence of disease were manipulated in this study to provide differences associated with health risks in regard to the magnitude of the negative utility and the probability, respectively. There were no specific predictions regarding the difference of effect size associated with these two manipulations.

As prevalence and seriousness of a disease increased, participants were significantly more likely to make a choice that maximized effectiveness but also increased costs. However, the effect size was much stronger for prevalence than strength.

In other words, the likelihood of experiencing the negative utility associated with the disease seems to affect decision making more than the magnitude of the negative utility. When considering the reasons for this difference, it should be noted that the four diseases intended to manipulate perceived seriousness actually did so (d = 1.75 for the difference between seriousness ratings of the nominally low- vs. high-seriousness diseases). The difference in effect size associated with prevalence and seriousness could be due to the nature of losses resulting in a larger change in utility than gains. Each of the four diseases used to manipulate the degree of seriousness may have been interpreted by participants as having objectively different symptoms that reflect differing degrees of negative utility, but each of those diseases would still be associated with some degree of perceived loss. Thus, the likelihood of contracting any of the four diseases may have had a stronger effect due to the change in probability being larger than any difference in negative utility associated between the different illnesses.

Implications for multi-attribute decision making

The current findings suggest that participants were sensitive to changes in the task environment, incorporated multiple decision-making strategies, and generally responded to prevalence such that higher prevalence of illness was associated with spending more time attending to benefits and less to costs and making choices that prioritized higher benefits at the expense of cost. These results support the idea that elements of the task environment can influence decision processes and outcomes. Payne and Bettman (2004) discussed the impact that task environment can have on decision processes, such as task complexity or time constraints leading to individuals switching from a more

comprehensive processing strategy to a heuristics-based strategy. While evidence from the present study suggest participants incorporate different decision strategies in response to a change in task environment, the variables manipulated in this study did not affect task complexity or time pressure. The primary purpose for the manipulation of seriousness and prevalence of illness was to create a task environment that could affect participants' decision making and strategy selection by providing a potentially harmful consequence associated with the decision.

Bettman, Luce, and Payne (1998) discussed the implications of prior research on adaptive decision-making and how individuals adapt decision strategies based on changes in the task environment. They conclude that deploying multiple strategies, including more logical controlled evaluative strategies and heuristics-based strategies, can be beneficial to people in a consumer context. The authors also identify topics for future research on choice. One particular topic concerns decision-making involving the minimization of negative emotion. These scenarios may involve decisions where a trade-off involves an unwanted outcome, consideration of alternatives with ethical or moral implications, or the potential that a decision may yield an immediate benefit followed by some unwanted consequence associated with the decision in the future. Specifically, the authors suggested that emotion-laden decision scenarios would likely lead to higher attribute-focused processing with specific attention given to attributes that allow the individual to avoid negative consequences. The present study provides unique data that addresses this need in research. The scenarios provided outcomes where the primary goal is to avoid a negative event, where the method of reducing the likelihood of experiencing

the event is by making a decision regarding a vaccine that includes both costs and benefits associated with the attributes. The results from the present study support the assumption that an emotionally-laden decision would result in more selective processing that may result in sacrificing costs within some attributes in order to maximize the benefits, thus, minimizing the negative emotion potentially experienced after the decision is made.

Not all aspects of the task environment in the present study led to adaptive decision-making that would support the concept of adaptation to reduce potential for negative outcomes. Seriousness of illness had a moderate effect on decision outcomes in the hypothesized direction, but this aspect of the task environment had no effect on strategy selection. Participants were much more sensitive to changes in prevalence than they were to seriousness, despite survey responses indicating that participants perceived flu and mumps as lower in seriousness, while meningitis and typhoid fever were perceived as higher in seriousness. Based on the assumption that emotion-laden choices would result in adaptive decision-making to focus on attributes that would reduce the negative consequences, it would seem that both prevalence and seriousness of illness would have this effect.

One potential explanation for the discrepancy in effect sizes for seriousness and prevalence could be that seriousness of illness had descriptions that were absolute in nature: Each disease had clear symptoms associated with them. Appendix A shows the descriptions of each of the eight scenarios. In each, the disease includes descriptions of symptoms associated with them. The prevalence manipulation was much more

probabilistic in nature, as was intended. However, participants may have approached this uncertainty with more caution and therefore were more likely to adapt their decisions to favor vaccines that would reduce the likelihood of contracting the diseases. For instance, the low prevalence meningitis scenario mentions meningitis outbreaks in the country, but not locally. The early symptoms of meningitis are then provided including stiff neck, vomiting, sensitivity to light, with additional information stating that meningitis can be fatal if left untreated. The high prevalence scenario, conversely, specifies that an outbreak is suspected locally for meningitis. Participants may have interpreted the low prevalence scenario as a near certainty that meningitis would not be a concern, and the high prevalence scenario as a much more immediate cause for concern. Unfortunately, prevalence was manipulated primarily by using language from sample CDC reports and a manipulation check was not conducted for this variable. Additionally, the manipulation of prevalence was done with the purpose of minimizing the frequencies used to describe the attributes with probabilistic values (e.g., Effectiveness of vaccine = 1/100 people still get meningitis after receiving vaccine). The goal with the manipulation was to communicate that prevalence was probabilistic, but not one that required complex computations using the information provided with the vaccine attributes.

Implications in health domain

The results from this study could have implications regarding how people perceive general health risks and, potentially, how health risks may be best communicated to individuals, how to increase compliance with vaccinations, and how to increase general understanding regarding the potential threats related to outbreaks of

diseases. As noted, one of the more interesting findings in the study was the way prevalence of disease influenced decision-making strategies and overall choice more than the seriousness of the illness.

The illnesses used in the study ranged from a perception of relatively low concern to severely debilitating, both in the severity of symptoms associated with the disease and the perception of the effect of these symptoms on participants. Despite this, participants were not as likely to change their decision strategies or choose the most effective vaccine as when information was provided in the scenarios that indicated the immediacy of the risk associated with prevalence in the environment. These findings could be used to aid in the communication and education of potential risks associated with illnesses. For instance, current information regarding the flu available at the Centers for Disease Control and Prevention's (CDC, 2017) website presents the importance of getting a flu vaccination based largely on the complications associated with flu symptoms. The current findings suggest that framing the importance of receiving a flu vaccination in terms of the prevalence of the virus may be more effective at ensuring compliance than framing the importance by discussing the effects of the disease. Information regarding the adverse effects of influenza should clearly still be available, but highlighting the importance of the vaccine by communicating the prevalence of the illness in a given flu season may aid in the compliance of individuals with receiving the vaccine.

Limitations

While the present provides additional insights into how decision-making processes and outcomes may be affected by multi-attribute decision-making scenarios

that involve applications of negative utility, there are areas that could be improved in future studies.

Generalizability. While many efforts were made to ensure the strength of the manipulation with regard to its effect on negative utility, there is still a difference in a hypothetical description of the probability and negative utility of an event and an actual event involving disease outbreaks or prevalence associated with travel to other countries. Participants read and responded to the scenarios as if they were true, but knowledge of the scenarios could have a different impact than what was observed. This could be observed in the relatively large effect of prevalence on decision making in the study. The Centers for Disease Control and Prevention (CDC, 2017) found that despite whether a flu season is reported as being more or less problematic for a given year, vaccine coverage has remained the same since 2010 and seems to vary more due to vaccine shortages than information regarding the prevalence of influenza for a given year.

The current study also provided a decision-making context involving a forced-choice. Essentially, each scenario was presented with four vaccine choices. However, participants never had the option to navigate to the next scenario without choosing one of the four available alternatives. As such, situations in which a participant would choose not to receive a vaccination were not included as a part of this study. As part of the post-test questionnaire, participants were asked about their estimated history regarding flu vaccination. Responses from this question indicated that all of the participants in the study had been vaccinated in past flu seasons, and that none of the participants selected the option that they never get vaccinated for the flu. This question was asked regarding

the flu vaccine, which is typically available from year to year. However, vaccinations due to diseases that have been associated with localized outbreaks or travel to specific countries were not included in the questionnaire due to the fact that many participants in the study would likely not have experienced these specific circumstances.

Conclusion

Despite limitations involving the health-care context and the specifics of the manipulations of seriousness and prevalence, this study provided further evidence of scenarios that can influence decision-making and how people may adapt their decision-making by using different strategies to evaluate decision attributes and alternatives. While individual differences exist regarding overall strategy use in decision-making within the context studied, there were still notable overall effects of prevalence and seriousness of an illness on the decisions of participants, and on what strategies were used to evaluate the decision alternatives provided. Future studies could build on this study by deploying different methodologies to capture the decision-making processes (e.g, eye-tracking methods), or focusing on the application of these results in understanding decision-making in other health-care contexts.

APPENDICES

Appendix A

Scenarios for each combination of seriousness and prevalence

Low prevalence – Flu

Headline: 2018 Flu Season Expected to be Mild on Campus

Flu season is in full swing, and local health officials say the effect in Clemson University and statewide has been mild compared to previous years.

In the past week, the number of flu patients hospitalized in Clemson has been at the lowest in 10 years. The number of students who have received vaccinations this year is also very high, indicating that the likelihood of a rapid increase in individuals contracting the influenza virus is very low.

Many professors and instructors have also commented on the sharp decrease in students missing classes due to influenza.

Despite the mild flu season, a flu vaccination is still recommended. While it is not as urgent, supplies of the vaccination are high and students will have many different options to choose from that can protect against any potential increase in the number of people who report getting the flu.

Low prevalence – Mumps

Headline: Clemson University Officials Not Concerned Regarding Mumps Outbreak

While three campuses in the US have reported on-campus mumps outbreaks, Clemson University is not expected to be as vulnerable according to officials.

Due to the high proportion of students who have documented mumps immunizations that protect against the particular strains that have been detected, and high turnout for flu vaccinations, the chance of mumps spreading to the degree of a large-scale outbreak is very slim.

Officials caution that mumps can lead to hospitalization and potentially be fatal if left unmanaged, with early symptoms such as swelling of salivary glands, nausea, dry mouth, and in serious cases loss of voice. If not caught, mumps can cause organ failure and in rare cases, infertility.

However, outbreaks of mumps are extremely rare. Nevertheless, MMR booster vaccinations are available and are required for additional strains of mumps. Students will have a choice of which booster they would like to receive.

Low prevalence – Typhoid

Headline: Traveler's Notice Regarding Risk of Typhoid in Australia

Despite the increasing trend of travelers contracting Typhoid Fever in various countries, individuals planning a trip to Australia and/or New Zealand, region officials state that there is very little risk of contracting the bacterial disease.

Typhoid fever is a systemic disease of varying severity, with common symptoms being high fever, nausea, fatigue, extreme loss of appetite, and insomnia. Without treatment, patients may develop gastrointestinal infections, pneumonia, and may become chronic carriers of the disease. Typhoid fever is spread through consumption of food and water.

If you are planning to travel to any of these countries*, the risk of contracting Typhoid Fever is very low. However, doctors still suggest considering taking the vaccine booster as a precaution.

*Note: In this example, you are planning to travel to Australia for six months.

<u>Low prevalence – Meningitis</u>

Headline: Clemson University Officials Not Concerned Regarding Meningitis Outbreak

While two campuses in the US have reported local meningitis outbreaks, Clemson University is not expected to be as vulnerable according to officials.

Due to the large number of students who have up-to-date meningitis vaccination records and have turned out across campus for flu vaccinations, the chance of meningitis spreading to the degree of a large-scale outbreak is very slim.

Officials remind that meningitis is a very serious disease that can lead to hospitalization and potentially be fatal, with early symptoms such as stiff neck, vomiting, and sensitivity to light. If not caught, meningitis can lead to gangrene, possibly requiring amputation. However, outbreaks of meningitis are extremely rare. Nevertheless, booster vaccinations are available and are required for additional strains of bacterial meningitis. Students will have a choice of which booster they would like to receive.

<u>High prevalence – Flu</u>

Headline: 2018 Flu Season Expected to be Severe on Campus

Flu season is in full swing, and local health officials say the effect in Clemson University and statewide has been severe compared to previous years.

In the past week, the number of flu patients hospitalized in Clemson has been at the highest in 10 years. Those who have been hospitalized have reported particularly severe symptoms, including high-grade fevers, respiratory issues, pneumonia, and in some cases kidney failure. These symptoms have had a quick onset as well, compared to many strains of the flu that have been detected in the past.

Professors and instructors have reported many students missing classes with excuses from doctors regarding the flu.

Because the common strains this year are all severe, and many students are already being hospitalized, most officials recommend getting the flu shot as soon as possible.

High prevalence – Mumps

Headline: Clemson University Officials Concerned Regarding Mumps Outbreak

While three campuses in the US have reported on-campus mumps outbreaks, Clemson University is not expected to be as vulnerable according to officials.

Due to the high proportion of students who have documented mumps immunizations that protect against the particular strains that have been detected, and high turnout for flu vaccinations, the chance of mumps spreading to the degree of a large-scale outbreak is very slim.

Officials caution that mumps can lead to hospitalization and potentially be fatal if left unmanaged, with early symptoms such as swelling of salivary glands, nausea, dry mouth,

and in serious cases loss of voice. If not caught, mumps can cause organ failure and in rare cases, infertility.

However, outbreaks of mumps are extremely rare. Nevertheless, MMR booster vaccinations are available and are required for additional strains of mumps. Students will have a choice of which booster they would like to receive.

High prevalence – Typhoid

Headline: Traveler's Notice Regarding Risk of Typhoid in Southeast Asia

For individuals planning a trip to Thailand, Laos, Vietnam, Indonesia, and other areas in south Asia, officials are warning of an increase in reported cases of Typhoid Fever in both animals and humans in the regions.

Typhoid fever is a systemic disease of varying severity, with common symptoms being high fever, nausea, fatigue, extreme loss of appetite, and insomnia. Without treatment, patients may develop gastrointestinal infections, pneumonia, and may become chronic carriers of the disease. Typhoid fever is spread through consumption of food and water. If you are planning to travel to any of these countries*, it is highly advised you take one of the four new vaccine boosters available.

*Note: In this example, you are planning to travel to Thailand for six months.

High prevalence – Meningitis

Headline: Clemson University Officials Concerned Regarding Meningitis Outbreak

This season, two campuses in the US have reported local meningitis outbreaks. Clemson University now makes a third.

Due to the fact that many students have not received the booster vaccine in addition to their standard required vaccines, the chance of meningitis spreading to the degree of a large-scale local outbreak is increasing.

Officials remind that meningitis is a very serious disease that can lead to hospitalization and potentially be fatal, with early symptoms such as stiff neck, vomiting, and sensitivity to light. If not caught, meningitis can lead to gangrene, possibly requiring amputation. Additionally, meningitis can be transmitted quite easily. People can be carriers for the disease and never exhibit symptoms.

Booster vaccinations are available and are required for additional strains of bacterial meningitis. Students will have a choice of which booster they would like to receive.

Appendix B

DOSPERT HEALTH AND SAFETY QUESTIONNAIRE

People often see some risk in situations that contain uncertainty about what the outcome or consequences will be and for which there is the possibility of negative consequences. However, riskiness is a very personal and intuitive notion, and we are interested in **your gut level assessment of how risky** each situation or behavior is.

1.) Giving blood

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

2.) Participating in a clinical trial to determine whether a new drug is effective

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

3.) Taking daily medication in preparation for allergies

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

4.) Getting knee replacement surgery to treat arthritis

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

5.) Receiving general rather than local anesthesia when having a wisdom tooth removed

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

6.) Drinking heavily at a social function

1	2	3	4	5	6	7

Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

7.) Driving a car without wearing a seatbelt

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

8.) Riding a motorcycle without a helmet

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

9.) Walking home alone in an unsafe area of town

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

10.) Sunbathing without sunscreen.

1	2	3	4	5	6	7
Not at all Risky	Slightly Risky	Somewhat Risky	Moderately Risky	Risky	Very Risky	Extremely Risky

Appendix C

Seriousness of illness manipulation check

Please rate using the 1 to 7 scale below your response of, in general, how **afraid you would be of getting:**

1.) The Flu

1	2	3	4	5	6	7
Not at all Afraid	Not very Afraid	Slightly Afraid	Neutral	Somewhat Afraid	Very Afraid	Extremely Afraid

2.) The Mumps

1	2	3	4	5	6	7
Not at all Afraid	Not very Afraid	Slightly Afraid	Neutral	Somewhat Afraid	Very Afraid	Extremely Afraid

3.) Meningitis

1	2	3	4	5	6	7
Not at all Afraid	Not very Afraid	Slightly Afraid	Neutral	Somewhat Afraid	Very Afraid	Extremely Afraid

4.) Typhoid Fever

1	2	3	4	5	6	7
Not at all Afraid	Not very Afraid	Slightly Afraid	Neutral	Somewhat Afraid	Very Afraid	Extremely Afraid

For each of the diseases below, please rate using the 1 to 7 scale your perception of **how bad it would be (in terms of debilitation, amount of time spent in recovery, and risk to long-term health) if you were diagnosed with:**

1.) Flu

1	2	3	4	5	6	7
No problem at all	Not very Problematic	Slightly Problematic	Neutral	Somewhat Problematic	Very Problematic	Extremely Problematic

2.) The Mumps

1	2	3	4	5	6	7
No problem at all	Not very Problematic	Slightly Problematic	Neutral	Somewhat Problematic	Very Problematic	Extremely Problematic

3.) Meningitis

1	2	3	4	5	6	7
No problem at all	Not very Problematic	Slightly Problematic	Neutral	Somewhat Problematic	Very Problematic	Extremely Problematic

4.) Typhoid Fever

1	2	3	4	5	6	7
No problem at all	Not very Problematic	Slightly Problematic	Neutral	Somewhat Problematic	Very Problematic	Extremely Problematic

REFERENCES

Bettman, J. R., Johnson, E. J., Luce, M. F., & Payne, J. W. (1993). Correlation, conflict, and choice. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(4), 931.

Blais, A. R., & Weber, E. U. (2006). A domain-specific risk-taking (DOSPERT) scale for adult populations. *Judgment and Decision Making*, *1*(1), 33-47.

Bradley, I. (2003) The representative bettor, bet size, and prospect theory. *Economics Letters 78* 409-413.

Butler, S., Rosman, A., Seleski, S., Garcia, M., Lee, S., Barnes, J., & Schwartz, A. (2012). A medical risk attitude subscale for DOSPERT. *Judgment & Decision Making*, *7*(2).

Centers for Disease Control and Prevention. (2017). *National Early-Season Flu Vaccination Coverage.* Retrieved from: https://www.cdc.gov/flu/fluvaxview/nifs-estimates-nov2017.htm

Charles, C., Gafni, A., & Whelan T. (1999). Decision-making in the physician-patient encounter: revisiting the shared treatment decision-making model. *Social Science in Medicine, 49* 651-661.

Ding, D. K., Charoenwong C., Seetoh, R. (2004) Prospect theory, analyst forecast, and stock returns. *Journal of Multinational Financial Management, 14* 425-442.

DiMatteo, M. R., Lepper, H. S., & Croghan, T. W. (2000). Depression is a risk factor for noncompliance with medical treatment: meta-analysis of the effects of anxiety and depression on patient adherence. *Archives of internal medicine*,*160*(14), 2101-2107.

Edwards, A., & Elwyn, G. (Eds.). (2009). *Shared decision-making in health care: Achieving evidence-based patient choice*. Oxford University Press.

Ende J., Kazis L., Ash A., Moskowitz M. (1989) Measuring patients' desire for autonomy: decision making and information-seeking preferences among medical patients. *Journal of General Internal Medicine, 4* 23-30.

Farber, N. J., Jordan, M. E., Silverstein, J., Collier, V. U., Weiner, J., & Boyer, E. G. (2008). Primary care physicians' decisions about discharging patients from their practices. *Journal of general internal medicine*, *23*(3), 283-287.

Ferguson, T., Frydman, G. (2004) The first generation of e-patients: these new medical colleagues could provide sustainable healthcare solutions. *British Medical Journal 328*(7449) 1148-1149.

Gibson, C. J., & Hobson, F. W. (1983). Policy capturing as an approach to understanding and improving performance appraisal: a review of the literature. *Academy of Management Review*, *8*(4), 640-649.

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: models of bounded rationality. *Psychological review*, *103*(4), 650.

Holmes-Rovner, M., Nelson, W. L., Pignone, M., Elwyn, G., Rovner, D. R., O'Connor, A. M., & Correa-de-Araujo, R. (2007). Are patient decision aids the best way to improve clinical decision making? Report of the IPDAS Symposium. *Medical Decision Making*, *27*(5), 599-608.

Johnson, E. J., Payne, J. W., Bettman, J. R., & Schkade, D. A. (1989). Monitoring information processing and decisions: The mouselab system (No. TR-89-4-ONR). Duke University Durham NC Center for Decision Studies.

Jullien, B., & Salanié, B. (2000). Estimating preferences under risk: The case of racetrack bettors. *Journal of Political Economy*, *108*(3), 503-530.

Kardas, P. (2002). Patient compliance with antibiotic treatment for respiratory tract infections. *Journal of Antimicrobial Chemotherapy*, *49*(6), 897-903.

Levy, J. S. (2003) Applications of prospect theory to political science. *Synthese 213*(2) 215-241.

Loomes, G., & Sugden, R. (1987). Some implications of a more general form of regret theory. *Journal of Economic Theory*, *41*(2), 270-287.

Milkman, K. L., Chugh, D., & Bazerman, M. H. (2009). How can decision making be improved?. *Perspectives on Psychological Science*, *4*(4), 379-383.

Montori, V. M., Gafni, A., & Charles, C. (2006). A shared treatment decision-making approach between patients with chronic conditions and their clinicians: the case of diabetes. *Health Expectations*, *9*(1), 25-36.

Mullan, R. J., Montori, V. M., Shah, N. D., Christianson, T. J., Bryant, S. C., Guyatt, G. H., ... & Smith, S. A. (2009). The diabetes mellitus medication choice decision aid: a randomized trial. *Archives of internal medicine*, *169*(17), 1560-1568.

Payne, J. W. (1976) Task complexity and contingent processing in decision making: an information search and protocol analysis. *Organizational Behavior and Human Decision Processes, 16,* 366-387.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge University Press.

Sabaté, E. (Ed.). (2003). *Adherence to long-term therapies: evidence for action*. World Health Organization.

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of risk and uncertainty*, *1*(1), 7-59.

Samuelson, W., Zeckhauser, R. (1988) Status quo bias in decision making. *Journal of Risk and Uncertainty 1* 7-59.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological review*, *63*(2), 129.

Sokol, M. C., McGuigan, K. A., Verbrugge, R. R., & Epstein, R. S. (2005). Impact of medication adherence on hospitalization risk and healthcare cost.*Medical care*, *43*(6), 521-530.

Svenson, O., & Edland, A. (1987). Change of preferences under time pressure: Choices and judgements. *Scandinavian Journal of Psychology*,*28*(4), 322-330.

Wallace, C., Leask, J., & Trevena, L. J. (2006). Effects of a web based decision aid on parental attitudes to MMR vaccination: a before and after study. *BMJ: British Medical Journal*, *332*(7534), 146.

Wyatt, J., & Spiegelhalter, D. (1991). Field trials of medical decision-aids: potential problems and solutions. In *Proceedings of the Annual Symposium on Computer Application in Medical Care* (p. 3). American Medical Informatics Association.