DECISION MAKERS' COGNITIVE BIASES IN OPERATIONS MANAGEMENT: AN EXPERIMENTAL STUDY

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This dissertation will focus on the first class, namely cognitive psychology. Cognitive psychology is further classified into heuristics and biases. Tversky and Kahneman (1974) discussed 3 heuristics and 13 cognitive biases that usually face decision makers. This dissertation is going to study 6 cognitive biases under the representativeness heuristic. The model in this dissertation states that cognitive reflection of the individual (Frederick 2005) and training about cognitive biases in the form of warning (Kaufmann and Michel 2009) will help decisions' makers make less biased decisions. The 6 cognitive biases investigated in this dissertation are insensitivity to prior probability, insensitivity to sample size, misconception of chance, insensitivity to predictability, the illusion of validity and misconception of regression. 6 scenarios in OM contexts have been used in this study. Each scenario corresponds to one cognitive bias. Experimental design has been used as the research tool. To see the impact of training, one group of the participants received the scenarios without training and the other group received them with training. The training consists of a brief description of the cognitive bias as well as an example of the cognitive bias. Cognitive reflection is operationalized using cognitive reflection test (CRT). The survey was distributed to students at University of North Texas (UNT). Logistic regression has been employed to analyze data. The research shows that participants show the cognitive biases proposed by Tversky and Kahneman. Moreover, CRT is significant factor to predict the cognitive bias in two scenarios. Finally, providing training in terms of warning helps participants to make more rational decisions in 4 scenarios. This means that although cognitive biases are inherent in the mind of people, management of corporations has the tool to educate its managers and professionals about such biases which helps companies make more rational decisions.

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CHAPTER 1

INTRODUCTION

Operations management is defined as "encompass[ing] the design and management of the transformation processes in manufacturing and service organizations that create value for society" (Chopra, Lovejoy and Yano 2004). A simple model of an operation system in which the transformation process occurs is shown in figure 1.

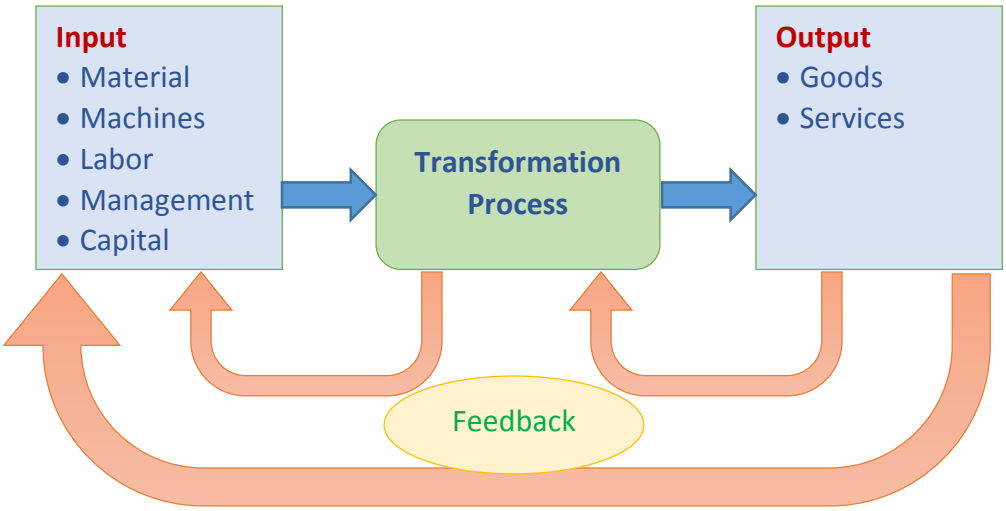

Figure 1: Operations management as a Transformation Process

In order to improve the efficiency of such operations systems, the field has traditionally used mathematical techniques such as optimization and simulation to solve diverse operational problems (Loch and Wu 2007). A classic example of the use of optimization is the solution of the inventory problem known as the economic order quantity (EOQ). This problem dates back to the 1920s (Chopra, Lovejoy and Yano 2004). In its simplest form, the organization faces a constant demand D of a certain product. The fixed cost of ordering is given as K and the annual holding cost per unit is given as h. The total cost modeled by an operations manager consists of

the sum of the ordering cost and the holding cost. The ordering, holding and total costs are depicted in figure 2

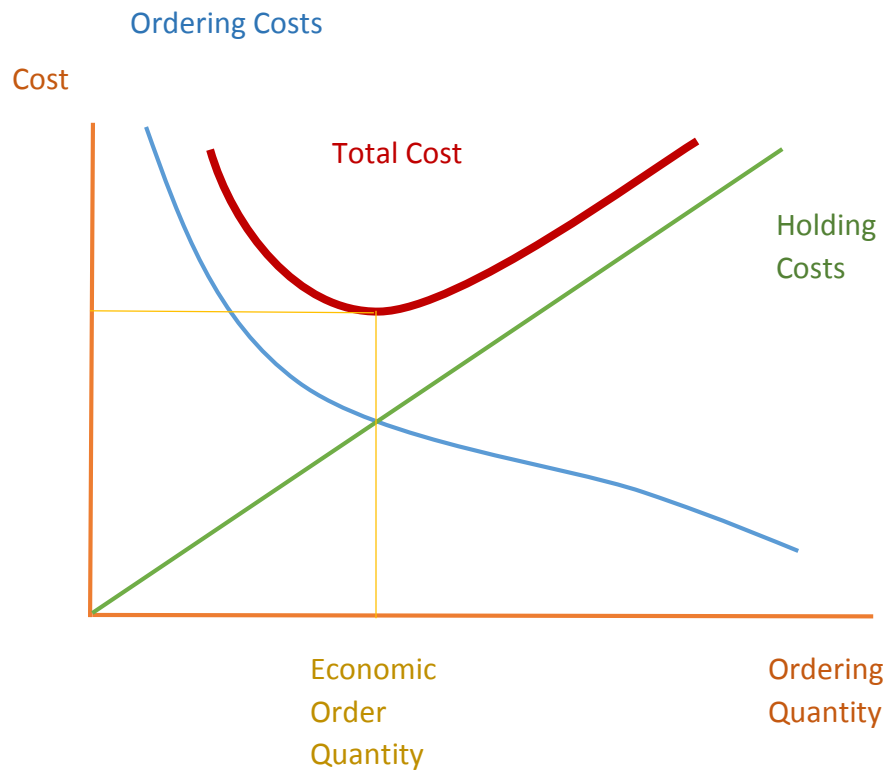

Figure 2: Costs Considered in the EOQ

The operations manager has to determine the optimal ordering quantity Q^* that minimizes the total cost. Calculus was used as an optimization technique to solve this problem. The optimal solution is given by the following formula:

$$Q^* = \sqrt{\frac{2*D*K}{h}} \qquad (1)$$

Where

Q*: the optimal ordering quantity

D: the annual demand quantity

K: the fixed ordering cost

h: the annual holding cost per unit

Variations of EOQ have been investigated and formulas for the optimal quantity have been developed. These formulas can be seen in classical OM books.

Another classic inventory problem is known as the newsvendor problem (Moritz, Hill and Donohue 2012). In this problem, the decision maker would like to determine the ordering quantity Q to satisfy a stochastic demand D for a single sales period. The distribution of the demand is given by the density function $f(D)$. The unit cost of the product is c and the selling price is p. Unsold units are salvaged at a price s. The decision maker would prefer to order exactly the demand of each day. However, since the demand is stochastic, the decision maker may face two situations. In the first one, the demand D is greater than the ordering quantity Q. In this case, the decision maker faces an opportunity loss. The opportunity loss equals c_u*(D-Q) where c_u is the underage cost which equals p-c. In the second case, the demand is less than the ordering quantity. In this case, the decision maker will face unsold units. The cost of this unsold units is c_o*(Q-D) where c_o is the overage cost which equals c-s.

The optimal solution to the newsvendor problem is to order a quantity Q^* that maximizes the total expected profit. The formula for this problem is

$$Q^* = F^{-1}\left(\frac{c_u}{c_u + c_o}\right) \qquad (2)$$

Where

$F^{-1}(.)$ is the inverse of the cumulative distribution function for demand D and $c_u / (c_u + c_o)$ is known as the critical ratio.

Operations management literature is full of operational problems in which optimization techniques have been used. Implementing these techniques has a positive impact on the operations of the companies. However, these optimization techniques focus on modifying the system parameters and pay little attention to the people who run the organization (Loch and Wu 2007). It is estimated that the mathematical solutions to the operations problems are used only 50 % of time (Loch and Wu 2007). Even if OM models explicitly include aspects of human behavior, they usually employ a simplified set of human behavior (Boudreau et al., 2003). These simplified set of assumptions are summarized as follows:

1. People are not an important factor. OM models focus on machines, materials, cars and trucks. These models largely ignore the humans who operate these objects.
2. People are deterministic and predictable. The dynamic nature of the people is usually ignored. So, people are assumed to be available to work with no break or absenteeism. Times of task are deterministic. There are no human mistakes or mistakes happen randomly. There is no variation among workers. This means workers have the same speed at work, have the same personal and work values and respond to the same incentives in the same way.
3. People behave independently. They are not affected by and they do not affect other people either physically or psychologically.
4. Workers are stationary. This means they do not learn and they do not get tired.
5. People are not considered part of the product or service. Workers are modeled as production units that make products and repair machines. Moreover, they are not considered a major part in satisfying customer needs. Therefore, the interaction between workers and customers is usually omitted.

6. People's emotions are usually ignored. They are assumed to be unaffected by pride, loyalty or embarrassment.
7. People can be observed perfectly. This means it is assumed that observing people in the workplace will not have an impact on their performance.

These assumptions are used to simplify the analysis of OM models. An explicit consideration of people in OM models will improve the practicality, richness and precision of such models (Boudreau et al., 2003). In fact, OM scholars are aware of the need to consider the behavioral aspects in OM (Boudreau et al., 2003; Chopra, Lovejoy and Yano 2004; Bendoly, Donhohue and Schultz 2005; Gino and Pisano 2008; Bendoly et al. 2010; Croson et al, 2012; Katsikopoulos and Gigerenzer 2013). This leads to the development of a branch in OM called behavioral operations management (BOM).

Behavioral Operations Management (BOM)

BOM is defined as:

> OM [..] concerned with the study of the design and management of transformation processes in manufacturing and service organizations, building mathematical theory of the phenomena of interest and testing the theory with field data (derived from surveys, databases, experiments, comparative case studies, ethnographic observations, etc.) Behavioral Operations Management is a multi-disciplinary branch of OM that explicitly considers the effects of human behavior in process performance, influenced by cognitive biases, social preferences, and cultural norms. (Loch and Wu 2007).

This definition explicitly encourages researchers to incorporate cognitive, social and cultural aspects of the humans in the OM models.

An attempt to classify the BOM is accomplished by Bendoly et al. (2010). In this paper, BOM was classified into 4 areas which are cognitive psychology, social psychology, group dynamics and system dynamics. The classification is shown in figure 3.

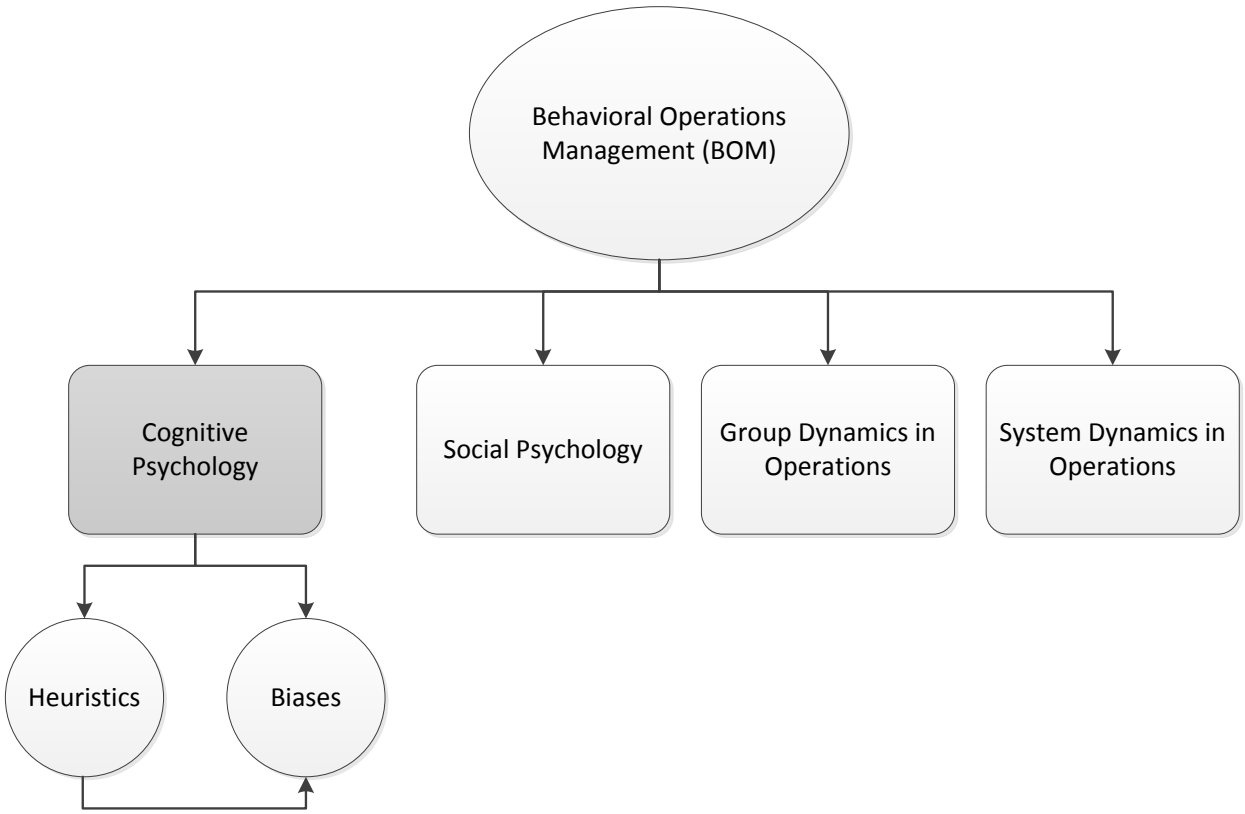

Figure 3: Classification of Behavioral Operations Management

A comprehensive discussion of these 4 areas can be read in the paper by Bendoly et al. (2010). However, a brief description of these areas is shown below:

1. Cognitive Psychology: Cognitive psychology refers to a body of knowledge which is concerned with judgment and decision making performed by individuals. The major point of interest to researchers in BOM is to find the discrepancy between decisions made by the individuals and decisions suggested by normative theory. This discrepancy can grow into a systematic pattern which is classified as either heuristics or biases. A heuristic is a rule of thumb used by people to make decisions. A bias is an observed systematic deviation in decision making. Some heuristics may cause certain biases. However, not all heuristics and biases have this relationship (Bendoly et al. 2010). A more elaborate discussion of heuristics and biases is presented in the literature review chapter.

2. Social Psychology: Social psychology has a huge impact on the choices and decisions people make. One social construct that has an impact on conscious and unconscious decisions is the motivation held by individuals. Motivation in turn is affected by peoples' goals, the feedback they receive and the way they interact with other people. These 3 aspects of goals, feedback and interdependence are shaped by the organization of work. OM models are mainly concerned with changing the way operations are conducted without much concern on the consequences on peoples' motivation and subsequent results. Because of this neglect, the outcomes of the proposed changes may not match the desired results (Bendoly et al. 2010).

3. Group Dynamics in Operations: Group dynamics studies how people in groups behave and interact with each other to reach a group decision rather than an individual decision.

Any operations context in which interaction and interdependence exist among people can be studied under this category. Project management, quality circles and new process implementation are some examples of operations contexts in which group dynamics can be investigated. Group dynamics can be studied under 3 main areas: groupthink / Abilene paradox, blame and breakdown spirals (Bendoly et al. 2010).

4. System Dynamics in Operations: System dynamics studies how system design and structure impact individuals' behavior and suggests ways to enhance performance. Factors affecting system dynamics include feedback mechanisms, time delay, stocks and flows, and nonlinearity. Research shows that the quality of decisions decreases in environments having significant feedback delay (Sterman 1987, 1989a), feedback complexity (Diehl and Sterman 1995, Schweitzer and Cachon 2000, Sterman 1989a, 1989b) and changing conditions (Kleinmuntz and Thomas 1987). Hogarth (1981) argues that the decisions are still suboptimal in dynamic environments even if there is a chance for the decision maker to correct his decision. A major cause for suboptimal performance in system dynamics is the misperception of feedback. There are two types of feedback misperception: (1) structure and (2) dynamics. Misperception of feedback structure results from mental maps which cannot adequately represent the complexity of the real system. An example of this misperception is when a decision maker cannot detect an important feedback process in the system. Misperception of feedback dynamics results from the inability of the mental models to interpret the system behavior over time. An example of misperception of system dynamics is the

misunderstanding of accumulation phenomenon in inventory control (Bendoly et al. 2010).

Significance of the Study

Scholars in OM have invited researchers to study behavioral OM. As discussed in the above section, there is a vast area of research in which human factors could be incorporated in OM models. This dissertation will study cognitive biases related to cognitive psychology. Specifically, this study will investigate the 6 cognitive biases under the representativeness heuristic. These cognitive biases are:

1. Insensitivity to prior probability
2. Insensitivity to sample size
3. Misconception of chance
4. Insensitivity to predictability
5. The illusion of validity
6. Misconception of regression

Cognitive psychology is selected for study because people are the end point in the decision making process. Although social factors and environmental parameters play a major role in the decision making process, decisions are ultimately made by people. So, understanding some aspects of the cognitive process in people will help OM literature to develop models that closely relate to the human mind. Moreover, there is a gap in the literature that investigates the cognitive biases in OM context. Table 1 shows the articles published in journals interested in OM problems which investigate cognitive biases. The journals considered are Production and Operations Management, Management Science, Journal of Operations Management, Decision

Sciences, International Journal of Production Economics, Journal of Forecasting, International Journal of Forecasting, Omega-The International Journal of Management Science, and Manufacturing & Service Operations Management.

Table 1: Number of Articles Published in OM Related Journals Studying the 6 Cognitive Biases (CB)

Bias	Article Count
CB 1	1
CB 2	0
CB 3	1
CB 4	0
CB 5	1
CB 6	2

Table 1 contains a review of 29 articles studying cognitive biases using survey or experimental research (Ancarani, Di Mauro & D'Urso 2013; Bloomfield & Kulp 2013; Budescu & Du2007; Dilts & Pence 2006; Doerr & Mitchell 1998; Fox & Clemen 2005; Lawrence & O'connor 1995; Lawrence & O'Connor 2000; Looney & Hardin 2009; Mantel, Tatikonda & Liao 2006; Reimers & Harvey 2011; Rudi & Drake 2014; Schiffels et al. 2014; Strohhecker & Größler 2013; Su 2008; Gavirneni & Isen 2010; Gavirneni & Xia 2009; Croson & Donohue 2006; Tokar et al. 2014; Schweitzer & Cachon 2000; Bearden, Murphy & Rapoport 2008; Feng, Keller & Zheng 2011; Connolly & Dean 1997; Sarin & Weber 1993; Croson & Donohue 2002; Moritz, Hill & Donohue 2013; Bolton & Katok 2008; Bostian, Holt & Smith 2008 and Kocabiyikoglu, Gogus & Gonul 2015). Some of these articles study cognitive biases other than the 6 cognitive biases studied in this dissertation. Among these 29 articles, only 5 articles discussed some of these 6 cognitive biases. Since the gap is obvious in this area of research, this dissertation will try to fill such a gap.

In order to study cognitive biases in decision making in OM, experimental design will be used as the research tool. Six different scenarios of operations management will be presented to the participants. Each scenario corresponds to one cognitive bias. The titles of these scenarios are shown in Table 2.

Table 2: Scenarios Used to Study the 6 Cognitive Biases

No	Cognitive Bias	Title
1	Insensitivity to Prior Probability	Restaurant
2	Insensitivity to Sample Size	Gas Station
3	Misconception of Chance	Truck
4	Insensitivity to Predictability	Sport
5	The Illusion of Validity	Copy Center
6	Misconception of Regression	Forecast

This study is significant because:

1. Cognitive biases are inherent in people's mind. When faced with a new situation, an operations manager may use his experience to make a good decision. However, even with experience, the operations manager may make a biased decision. One initial step to reduce the impact of cognitive biases is to be aware of their existence. This study provides scenarios in which cognitive biases could occur when an operations manager makes decisions. Tversky and Kahneman (1974) discussed 3 heuristics and 13 cognitive biases. This dissertation studies the 6 cognitive biases under the representativeness heuristic. By presenting OM scenarios addressing these cognitive biases, it is hoped this dissertation will open areas for future research.

2. Although cognitive biases are inherent in people's mind, the second step after identifying these biases is to counteract their negative impact. One way to combat cognitive biases is to give people training about them. In this dissertation, the training provided to participants consists of simple warning statements including description of the bias and an example of it. If a simple training about cognitive biases helps decision makers to overcome the negative impact of cognitive biases, a more careful design of training should have an even more positive impact on operations managers.

3. This study investigates the impact of some personal traits that can predict the cognitive biases. The three main traits investigated are cognitive reflection, delayed gratification, and risk-taking. By considering these personal traits, it can be shown that individual differences play a critical role in making biased decisions.

Conceptual Framework

The conceptual framework has been an integration of several aspects of cognitive psychology. The first and most important aspect is the existence of cognitive biases in the human mind. Since a decision maker is usually faced with several tactical and strategic decisions, the first step in improving the quality of decision making is to identify the possible cognitive biases in the decision making process. Once these biases are identified, possible ways to reduce their impact are due. This is captured by the debiasing strategies proposed in the literature. In this study, only one debiasing strategy is employed, which is to train decision makers to be aware of the cognitive biases and therefore make decisions that are more rational. The third aspect is the identification of antecedents of cognitive biases in the individuals' mind. Cognitive reflection is

used in the literature to predict the extent of cognitive biases in individuals. As the Cognitive reflection of an individual increases, his or her cognitive biases are expected to go down. The conceptual framework is shown in figure 4.

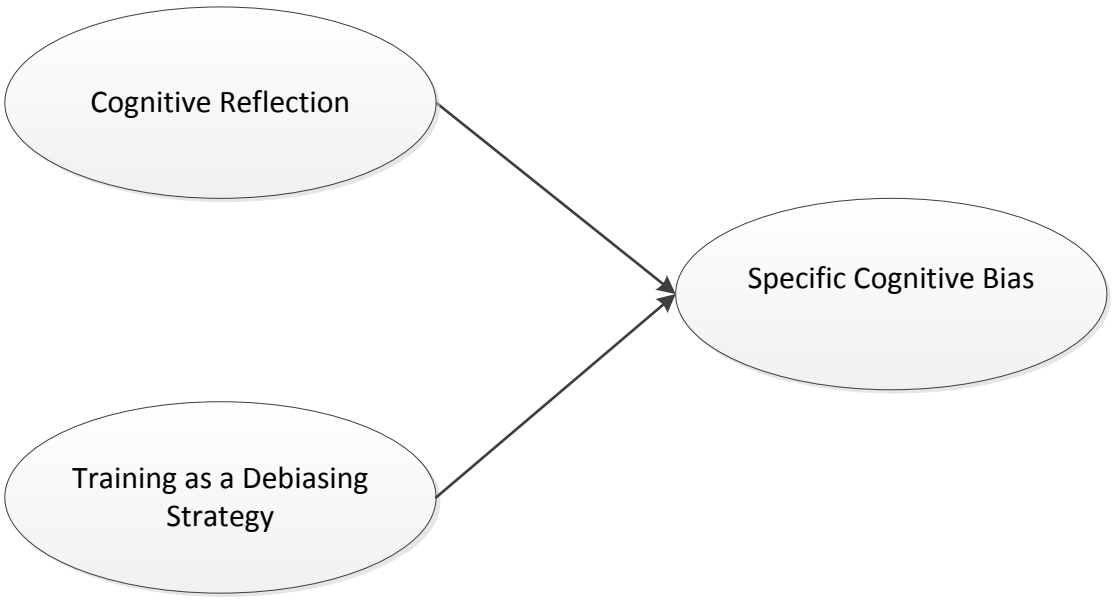

Figure 4. Conceptual Framework

Purpose of the Study

The purpose of this dissertation is to develop a set of training in terms of warning about the existence of cognitive biases designed to address specific corresponding cognitive biases, as they arise in an OM decision-making context.

Research Questions

In response to the call by many scholars in OM field, this empirical study has been designed to determine the extent of cognitive biases in decision making related to OM scenarios. This study is concerned with identifying 6 cognitive biases facing OM managers. In this context, this study was guided by the following research questions:

1. In an Operations Management context, given a situation that triggers the representativeness heuristic, do we observe the six cognitive biases introduced by Tversky and Kahneman?
2. Could these cognitive biases be reduced by providing some training in terms of warning to the operations managers?
3. Can some personal traits such as cognitive reflection be used to predict the six cognitive biases studied in this research?

Research Hypotheses

In order to answer the questions of this research, 12 hypotheses are proposed. These hypotheses are:

H1: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"Insensitivity to Prior Probability"* bias.

H2: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"Insensitivity to Sample Size"* bias.

H3: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"Misconception of Chance"* bias.

H4: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"Insensitivity to Predictability"* bias.

H5: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"The Illusion of Validity"* bias.

H6: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the *"Misconception of Regression"* bias.

H7: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*Insensitivity to Prior Probability*" bias

H8: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*Insensitivity to Sample Size*" bias

H9: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*Misconception of Chance*" bias

H10: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*Insensitivity to Predictability*" bias

H11: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*The Illusion of Validity*" bias

H12: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "*Misconception of Regression*" bias

Methodology

In order to test the 12 hypotheses, a survey has been used as the research instrument. It contains 6 scenarios addressing the 6 cognitive biases. Moreover, the survey has parts related to cognitive reflection, delayed gratification and risk taking perception of the participants. Finally, the survey asks for some demographic information. Since it is important to investigate the impact of training, experimental design has been adopted as the research tool. The participants have been grouped into 2 groups. The first group is the control group in which the 6 scenarios are presented without training. The second group is the experimental group who is given the 6 scenarios with training. By using experimental design, cause and effect relationship can be established.

Logistic regression has been used to analyze the data collected. For each scenario, the dependent variable is binary, indicating whether or not the participant selects a biased option.

Limitations

1. The population of this study consists of undergraduate and graduate students at UNT. Although these students are enrolled in business majors and expected to work in business after graduation, the results may not be easily generalized to other contexts. However, the scenarios provided here can be used as a starting point and be distributed to managers in business to see how they may respond to such scenarios.

2. The 6 scenarios represent high cognitive load on participants. Because each scenario addresses one cognitive bias, it may be difficult for the participants to think deeply and

reach the correct solution. Future research may address how much cognitive load a participant can sustain and at the same time make rational decisions.

Definition of Terms

The following terms are used in this study:

Behavioral Operations Management: OM is concerned with the study of the design and management of transformation processes in manufacturing and service organizations, building mathematical theory of the phenomena of interest and testing the theory with field data (derived from surveys, databases, experiments, comparative case studies, ethnographic observations, etc.). Behavioral Operations Management is a multi-disciplinary branch of OM that explicitly considers the effects of human behavior in process performance, influenced by cognitive biases, social preferences, and cultural norms." (Loch and Wu 2007).

Heuristic: a rule of thumb used by people to make decisions. (Bendoly et al. 2010)

Bias: an observed systematic deviation in decision making. (Bendoly et al. 2010)

Representativeness Heuristic: People's tendency to assume commonality between objects of similar appearance (Gino and Pisano 2008)

Insensitivity to Prior Probability Bias: A bias resulting from the use of the representativeness heuristic in which the base rate or prior probability of an outcome is ignored when the probability of such outcome is estimated (Tversky and Kahneman 1974).

Insensitivity to Sample Size Bias: A bias resulting from the use of the representativeness heuristic in which the sample size is ignored when estimating a parameter of a population (Tversky and Kahneman 1974).

Misconception of Chance: A bias resulting from the use of the representativeness heuristic in which people believe that a random process should be represented by random outcomes even in a local range (Tversky and Kahneman 1974).

Insensitivity to Predictability: A bias resulting from the use of the representativeness heuristic in which a future event such as the value of a stock or the demand of a commodity is predicted by how favorable is the description of the company (Tversky and Kahneman 1974).

The Illusion of Validity: A bias resulting from the use of the representativeness heuristic in which a person may have unjustified confidence in an option, due to the fit between the predicted event and input of the processor information. (Tversky and Kahneman 1974).

Misconception of Regression: A bias resulting from the use of the representativeness heuristic in which the average of scores of sequence of samples regresses toward the mean of the process (Tversky and Kahneman 1974).

Cognitive Reflection: The ability or disposition to resist reporting the response that first comes to mind (Fredrick 2005).

Debiasing Strategies: The approaches and sets of actions aimed at reducing the detrimental influence of decision biases and as such to enhance the rationality and effectiveness of decisions (Kaufmann, Michel and Carter 2009).

Summary

This chapter introduces behavioral operations management (BOM) and its importance to OM literature. It identifies the 4 classes of BOM which are cognitive psychology, social psychology, group dynamics and systems dynamics. The study focuses on the first part which is cognitive psychology. Specifically, it is going to consider the 6 cognitive biases under the representativeness heuristic. Moreover, the chapter presents a conceptual framework and stated the purpose of the study, the significance of the study, research questions, and hypotheses.

CHAPTER 2

LITRETURE REVIEW

Introduction

Decision making scholars approach the decision making process in two ways. The first way is the rational or normative approach. Under this approach, the decision maker is assumed to formulate the problem clearly. Then he identifies all possible alternatives to solve the problem. The outcomes of each alternative with its probability is known to the decision maker. The decision maker is assumed to use some mathematical techniques to reach a solution that produces the optimal solution. Although this approach seems plausible, it has some limitations. First, the decision maker may not have the mental capability to consider all the alternatives. Second, it is difficult to evaluate the possible outcomes with their probabilities. Therefore, the estimated outcomes may be subjected to an error and therefore the proposed optimal solution may not be the real optimal solution.

For this reason, decision making scholars adopt another practical approach. This approach calls for studying how the decision making process actually is taken by decision makers. This approach accepts the fact that people have limited cognitive capabilities and they have bounded rationality. Tversky and Kahneman are among the pioneers to this approach. They have conducted a series of experiments to see how people take decisions especially in gambling. Their approach to decision making is called heuristics and biases. A heuristic is defines as a rule of thumb used by people to make decisions (Bendoly et al. 2010). A bias is an observed systematic deviation in decision making (Bendoly et al. 2010). Heuristics sometimes but not always lead to systematic biases.

Tversky and Kahneman (1974) identified 3 heuristics. These heuristics are representativeness, availability and adjustment and anchoring.

1. Representativeness: This heuristic is usually used to answer the question "what is the probability that item A belongs to category B?" or "what is the probability that event A results from process B?" These questions are usually solved by the representativeness heuristic. So, in the first question if item A highly represents category B, then the probability that item A belongs to category B is assumed to be high. On the other hand, if event A does not represent process B, the probability given to event A is estimated to be low. Tversky and Kahneman (1974) said that this heuristic could lead to 6 cognitive biases. These biases are:

- Insensitivity to prior probability of outcomes
- Insensitivity to sample size
- Misconception of chance
- Insensitivity to predictability
- The illusion of validity
- Misconception of regression

2. Availability: This heuristic is used to estimate the probability or frequency of an event A by considering how easy the mind can retrieve instances in which event A occurs. If it is easy to imagine that event A occurs, the event is given high probability. For example, to estimate the probability of lung cancer, the person may use the availability heuristic. This person will rate the probability to be high if it is easy for him or her to remember people who developed lung cancer. The availability heuristic is useful because a decision maker

can remember large and frequent classes better than small and rare classes (Tversky and Kahneman 1974). In spite of its advantages, the availability heuristic may lead to some cognitive biases such as:

- Bias due to retrievability of instances
- Bias due to the effectiveness of a search set
- Bias of imaginability
- Illusion correlation

3. Adjusting and Anchoring: In this heuristic, people start from an initial anchor and adjust this anchor to reach the final decision. The anchor or starting point is usually chosen based on the problem formulation or some computations. This chosen anchor is adjusted but the final decision is usually close to the anchor. So, different anchors may results in different decisions (Tversky and Kahneman 1974). This heuristic can cause some cognitive biases such as:

- Insufficient adjustment
- Bias in the evaluation of conjunctive and disjunctive events
- Anchoring in assessment of subjective probability distribution

The 3 heuristics and their related cognitive biases are shown in figure 5. The six cognitive biases under representativeness heuristic studied in this dissertation are in gray color.

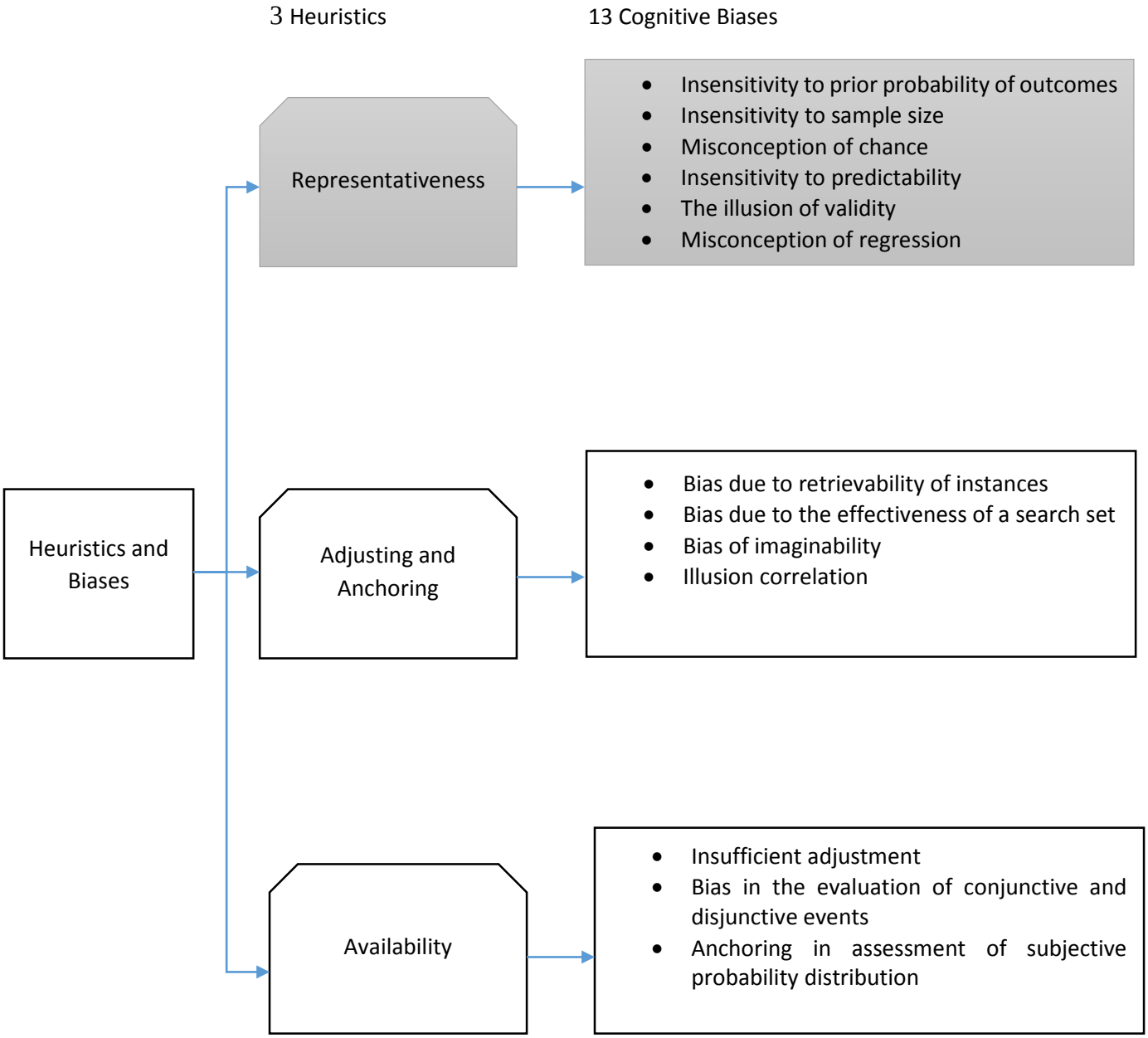

Figure 5. Heuristics and cognitive Biases

Six Cognitive Biases Caused by Representativeness Heuristic

This dissertation will study the 6 cognitive biases resulting from the use of the representativeness heuristic. A brief discussion of these cognitive biases are shown below:

1. Insensitivity to Prior Probability

When a decision maker faces a situation in which he needs to determine the probability of an outcome, he should consider the base-rate frequency or prior probability of this outcome. However, since some people use representativeness heuristic to estimate the probability of the event, they may ignore the prior probability. This is especially true if the problem is formulated to elicit some stereotypes. An example was given by Tversky and Kahneman (1974) as *"Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail"*.

Subjects are asked to determine if Steve is more probable to be a farmer or a librarian. Since the description of Steve represents a stereotype of a librarian, many people say Steve is more probably a librarian. However, a major factor that should be considered is the base-rate frequency or the prior probability of both farmers and librarian in the society. Since the rate of man farmers to man librarians is 20 to 1, it should be more probable that Steve would be a farmer rather than a librarian. This is in contrast to the resemblance of Steve's description to a librarian stereotype. Experiments show that if subjects are not given a description that elicits the representativeness heuristic, they tend to use the prior probability more efficiently (Tversky and Kahneman 1974).

2. Insensitivity to Sample Size

When people are asked about the probability of a specific parameter of a sample, they usually use the representativeness heuristic. If the parameter of the sample represents the population, they will provide higher probability. People may ignore the sample size although it plays an important role in determining the probability. For example, the following scenario was given by Tversky and Kahneman (1974) *"A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such days?*

- The larger hospital (21)

- The smaller hospital (21)

- About the same (that is, within 5 percent of each other) (53)

The values in parentheses are the number of undergraduate students who chose each answer."

So, more than half of the respondents chose the third option. That is there is no difference between big and small hospitals in getting more than 60% boys in a given day. This is because the two events are described by the same statistic and this statistic is assumed to represent the population. According to statistical theory, the right answer is small hospital because it has more volatility and therefore is more probable to have more than 60% boys. On the other hand, large hospital has more probability to stay close to the

nominal value of 50%. This shows that some people ignore the sample size in such decisions (Tversky and Kahneman 1974).

3. Misconception of chance

People believe that a random process should be represented by random outcomes even in a local range. For example, when tossing a fair coin, the outcome H-T-H-T-T-H is considered more probable than the sequence H-H-H-T-T-T because the former outcome is more representative of the random process. Moreover, the first outcome is considered more likely to occur than the outcome H-H-H-H-T-H because the last outcome does not represent the fairness of the process. So, people believe that the feature of the process should be represented both globally and locally.

Because of this bias, people usually, commit the gambler fallacy. If the gambler observes that a set of red appear on roulette wheels, he will continue hoping that black will occur next because this will balance the process and it will be more representativeness.

Another fault related to misconception of chance is usually committed by researchers. This phenomenon is called “low of small numbers”. Sometimes a researcher may conduct a study with a small sample size. If the results are significant, the researcher may pay less attention to the small size and overestimate the research results (Tversky and Kahneman 1974).

4. Insensitivity to Predictability

People usually predict a future event such as the value of a stock or the demand of a commodity. In such situations, people may predict based on the representativeness

heuristic. For example, a person may be asked to evaluate the future profit of a company, if the description of the company is favorable, a high profit is given to that company. Conversely, a less attractive description will induce people to give low profits. So, the profit of the company is represented by the description. However, the description may not be a reliable or accurate source for predictability. In normative statistics theory, the extremeness and range of prediction should depend on predictability. If predictability is zero, the same outcome such as the average profit should be given to all companies irrespective of its description. On the other hand, if predictability of outcome is 1, then the prediction should be the same as the outcome although this is rare. In general, as the predictability increases, the range of outcomes should be wider (Tversky and Kahneman 1974).

5. The illusion of validity

As discussed above, people use representativeness heuristic to determine the likelihood of an outcome. If the outcome is highly representing the process, people will be more confident in their prediction. For example,, the description of Steve is highly representative of a librarian. Therefore, people are more confident to predict that Steve is a librarian. There are other factors to be considered when predicting the outcome of a process. However, these factors are usually ignored. The illusion of validity occurs because of the unjustified confidence that results from the fit between the output and input of the process. This illusion persists even if the decision maker is aware of other factors that may affect the process (Tversky and Kahneman 1974).

6. Misconception of Regression

Regression toward the mean was first discussed by Galton more than 150 years ago. In this phenomenon, the scores of a group of people will usually deviate around the mean. For example, a large group of students may take two versions of an aptitude test if 10 students have scored high in the first test, then it is highly probable they will score less in the second test. Conversely, if 10 students score poor in the second test, they are more likely to score high in the second test. This phenomenon of regression toward the mean may not be understood well by people. So, parents may punish their child if he scores poor in a test and they may see improvement in his score next text. Moreover, they may praise his performance for high score and observe a decline in his score in the next test. So, they may conclude that punishment may improve performance while praising may deteriorate it. This way of thinking could be attributed to the phenomenon of misperception of regression toward the mean (Tversky and Kahneman 1974).

Debiasing Strategies

It has been mentioned that cognitive biases are an inherent part of the human mind. Although it is difficult to eliminate all cognitive biases all the time, the negative impact of these biases could be reduced. Literature has suggested different strategies to mitigate these biases and consequently increase the rationality of decision-making. Kaufmann, Michel and Carter (2009) developed a framework to counter the impact of such cognitive biases. They defined debiasing strategies as "the approaches and sets of actions aimed at reducing the detrimental influence of decision biases and as such to enhance the rationality and effectiveness of decisions". They proposed 3 debiasing strategies. These strategies are (1) expanding the rational boundary of

decision makers, (2) minimizing the decision-making environmental dynamics and (3) minimizing the decision-making environmental complexity.

The first strategy deals directly with the mind of decision maker. By providing some training and awareness of the possible cognitive biases, the quality of decisions may improve. The second and third strategies deal with the environment in which a decision is taken. By minimizing the dynamics and complexity of the decision environment, the decision maker will be less exposed to decision biases. In this study, the strategy of expanding the rationality of decision maker will be adopted. The reason is that humans may have shared mental characteristics. They may show similar cognitive biases in different environments. Therefore, if the strategy of reducing the bias proves to be effective, it could be modified to fit specific business environments. The second and third strategies will not be adopted in this study because it is usually difficult for decision makers to change the environmental parameters in which they work in (Graf et al. 2012). For example, making the environment less dynamics is preferred but it may not easily under the control of the decision maker. However, it is an open area for future research to see how these two strategies may help decision makers make more rational decision.

1. Expanding the rational boundary of decision makers

Under this strategy, literature has identified methods that help decision makers to expand their rational boundary. These methods are (a) Making decision makers aware of their biases that could impact the quality of their decisions, (b) Decomposing a decision task and (c) Allowing the decision maker to look at the problem from a different perspective

a) Awareness of cognitive biases

The primary source of decision biases is the decision maker and not the task under consideration. Literature shows that providing a decision maker with an awareness of the existence of cognitive biases seems to be an effective strategy to reduce the biases. Awareness could be given through even a simple training of the threats of biases and how to counteract their negative impact in the business environment (Graf et al. 2012). A proposed awareness training should include (1) clarifying the types of biases that may face a decision maker, (2) explaining the causes and sources of such biases and (3) assuring that cognitive biases should not harm the self-esteem of the decision maker (Kaufmann, Michel and Carter 2009). Since operations management professionals usually improve the quality of their decisions with experience, the objective of such training is to make an effective decisions more effective.

Training could take different forms. For example, Dunbar et al, (2014) have used serious games as a tool to reduce two cognitive biases: confirmation bias and fundamental attribution error. These two cognitive biases are not studied in this dissertation. However, using games as a training tool seems to be useful to mitigate the negative effect of cognitive biases.

b) Decomposing a decision task

The second method to increase the rational boundary is to deal with fewer variables in uncertain environment. This is usually done by splitting the complete problem into a set of small problems. Each small problem can be dealt with more efficiently. By solving

separate small problems, the big problem can be solved with fewer biases compared with a one complex problem.

One example of decomposing a complex problem is the use of software to aid the decision maker performs the required computation. When a manager is faced with a problem that needs a decision, she may face two parts of complexity. The first part is the nature of the problem with all variables affecting it. The second part is the computation of the gains and losses of different alternatives of the problem. By using a software, the decision maker may reduce the complexity by allowing the software to perform the computations. The decision maker then will put more energy and effort to explore the various aspects of the problem (Kaufmann, Michel and Carter 2009).

c) *Looking at the problem from a different perspective*

A decision maker who looks at the problem from one perspective may commit a bias. However, if she looks at the problem from a different perspective, she may take a more rational decision with fewer biases. One method for looking at the problem from different perspectives is to compare the solution of the given problem with a decision made to a previous problem. The decision maker may evaluate the similarities and differences between the current problem and the old problems and therefore she may not take a biased decision.

Another method is to increase the accountability of the decision. If the manager is set accountable for his decision, he will pay more attention to the problem and will think more thoroughly. This accountability may induce the manager to be suspicious of his intuition in making a decision.

Based on this discussion, the following hypotheses are developed:

H1: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "Insensitivity to Prior Probability" bias.

H2: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "Insensitivity to Sample Size" bias.

H3: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "Misconception of Chance" bias.

H4: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "Insensitivity to Predictability" bias.

H5: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "The Illusion of Validity" bias.

H6: Given a scenario that elicits the representativeness heuristic, providing training will decrease the likelihood that the people are prone to the "Misconception of Regression" bias.

Cognitive Reflection

When an individual face a problem and tries to solve it, her mind may operate under two systems: system 1 and system 2. System 1 is described to be intuitive, tacit, contextualized and

rapid. On the other hand, system 2 is described to be reflective and analytical. The division of human mind into two systems is referred to in the literature as dual process theory of decision making (Stanovich and West 2000). So, when making a decision, system 1 will suggest an initial intuitive answer. Although this intuitive answer is usually correct in many instances, it could be subjected to some cognitive biases. System 2 may interfere with the intuitive answer suggested by system 1. Since system 2 requires much energy and deliberate thinking, it could accept or reject the intuitive answer given by system 1. When system 2 is used, the cognitive biases associated with the intuitive thinking characterizing system 1 decisions are usually reduced. The tendency of system 2 to accept or reject the intuitive responses from system 1 is called cognitive reflection. (Kahneman 2011) observes that cognitive reflection is affected by several factors including individual differences, task environment and experience.

Studies in cognitive psychology show that high level of cognitive reflection is correlated with making les biased decisions (Moritz, Hill and Donohue 2012). Specifically, Cesarini et al. (2012) concluded that those people with high score in cognitive reflection are reluctant to the cognitive biases of illusion of control, insensitivity to sample size and representativeness. Since this dissertation will study cognitive biases resulting from representativeness heuristic, the following six hypotheses are developed:

H7: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "Insensitivity to Prior Probability" bias

H8: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "Insensitivity to Sample Size" bias

H9: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "Misconception of Chance" bias

H10: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "Insensitivity to Predictability" bias

H11: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "The Illusion of Validity" bias

H12: Given a scenario that elicits the representativeness heuristic, people with high score of CRT are less prone to the "Misconception of Regression" bias

The 12 hypotheses tested in this study are depicted in figure 6.

Summary

This chapter discusses previous studies concerning six cognitive biases which are insensitivity to prior probability, insensitivity to sample size, misconception of chance, insensitivity to predictability, the illusion of validity and misconception of regression. Moreover, the chapter reviews the literature on debiasing strategies. One effective strategy is to provide training in terms of awareness to the decision maker. By providing awareness, the decision maker is expected to take less biased decisions. Finally, this chapter discusses the cognitive reflection as a

construct that predicts the committing of such cognitive biases. People with high cognitive reflection tend to take less biased decisions.

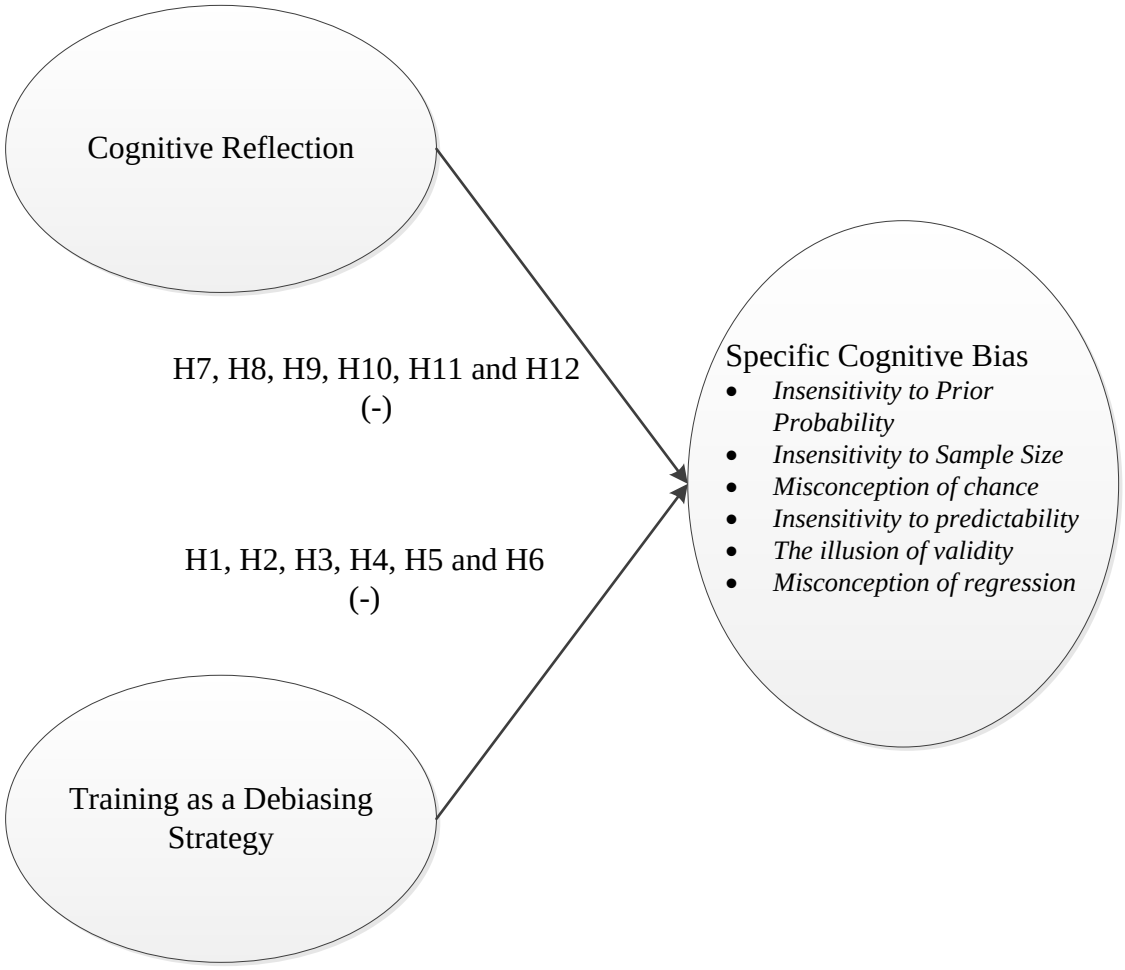

Figure 6. Conceptual Framework (Elaborated)

CHAPTER 3

METHODS

Research Design

The objective of this study is to examine the impact of cognitive reflection of the individual and the awareness of the existence of cognitive biases on taking biased decisions in operations management context. In order to achieve this objective, the study will use experimental design as the main research tool. The reasons for using experimental work is discussed below.

Why is Experiment Used?

Experimental work is an appropriate tool to study the individual behavior in decision making for 3 reasons. First, experiments allow us to investigate how behavioral factors affect empirical findings by controlling operational parameters. For example, in the gas station scenario, which will be discussed later in this chapter, many operational parameters are assumed to be fixed. An example of such parameter is the specific location of the gas station. The location is an important factor that determines the consumption of gasoline and diesel. Some locations which are close to the downtown may have higher demand for gasoline because big trucks usually do not go there frequently. In the scenario, it was mentioned that the ratio of gasoline and diesel is almost 50-50 in the region. However, this ratio may not be the same for every gas station. Nonetheless, by fixing the ratio of gasoline to diesel for all gas stations, the impact of the location of gas station is eliminated. Another factor that may impact the demand is the easy access of cars and trucks to the gas station. In some gas stations, it may not be easy for big trucks to access the gas station especially if the road is narrow and crowded. Again, as mentioned

above, by fixing the operational parameters, their impact on decisions are eliminated. So, by controlling experiments, we could see the impact of variables investigated, namely the impact of cognitive reflection of the individual and the impact of awareness of the existence of cognitive biases in decision making. (Croson and Donohue, 2002).

Second, experiments allow us to estimate the relative impact of different factors on cognitive biases. In this study, since the only main factors considered are cognitive reflection and awareness of cognitive biases, the relative strength of these two factors on cognitive biases could be estimated. Moreover, experiments can be designed to estimate the relative strength of both operational and cognitive factors on cognitive biases (Croson and Donohue, 2002).

Finally, experiments can be used to estimate the effect of changing operational parameters in the presence of behavioral factors. For example, in the gas station scenario, the ratio of gasoline and diesel is assumed to be 50-50. In experiments, we may vary this ratio to be 40:60 or 30:70 and see how the change of such operational parameters may impact the cognitive biases. This important factor has not been studied in this dissertation but it could be investigated in future studies. So, experiments play a complementary role to the theoretical work (Croson and Donohue, 2002).

Pilot Studies

Since this dissertation is experimental in nature, pilot studies are needed to develop and test the scenarios used. 2 pilot studies and a final one have been performed throughout the dissertation. The first pilot study examined the first two cognitive biases through two scenarios. A scenario called water bottle was developed to study the insensitivity to prior probability bias and another scenario called gas station was developed to study insensitivity to sample size. The

analysis of this pilot shows that the gas station scenario was effective and therefore it was retained for the subsequent pilot study. The water bottle scenario was not successful. A close look at the scenario revealed that the scenario put the participant under emotional stress to save the life of people mentioned in the scenario. The emotional part of people seemed to overcome the cognitive part and therefore it was decided that the scenario should be replaced by another one.

The second pilot study included 4 scenarios. The insensitivity to prior probability bias was investigated by a new scenario called restaurant. The gas station scenario retained from the 1st pilot study was used again to study the insensitivity to sample size bias. The misconception of chance bias was explored using two versions of a scenario called truck. In this pilot, the restaurant, gas station and one version of the truck scenarios were successful and therefore these 3 scenarios were retained for the final study.

In the final study, 3 more new scenarios were developed. The insensitivity to predictability was studied through sport scenario. Copy center scenario was used to examine the illusion of validity bias. Finally, forecast scenario was used to study the misconception of regression. Table 3 summarizes the scenarios used in each one of these studies.

Table 3: Scenarios Used to Study the Cognitive Biases in the 2 Pilot and Final Studies

No	Cognitive Bias	Pilot 1	Pilot 2	Final
1	Insensitivity to Prior Probability	Water Bottle	Restaurant	Restaurant
2	Insensitivity to Sample Size	Gas Station	Gas Station	Gas Station
3	Misconception of Chance		Truck (V1 &2)	Truck
4	Insensitivity to Predictability			Sport
5	The Illusion of Validity			Copy Center
6	Misconception of Regression			Forecast

Scenarios Used in the Final Study

The final list of scenarios used in this dissertation is shown in table 4. Six scenarios in OM context have been developed. Each scenario is intended to study one cognitive bias.

Table 4: Scenarios Used to Study the Cognitive Biases Associated with the Representativeness Heuristic

No	Cognitive Bias	Scenario	# of Words	Count of Numbers
1	Insensitivity to Prior Probability	Restaurant	326	9
2	Insensitivity to Sample Size	Gas Station	165	5
3	Misconception of Chance	Truck	138	8
4	Insensitivity to Predictability	Sport	147	2
5	The Illusion of Validity	Copy Center	208	46
6	Misconception of Regression	Forecast	83	22

For each scenario, a question is asked to the participant. If the participant chooses the right answer, then there is no cognitive bias. Otherwise, the participant selects the wrong choice and therefore shows the cognitive bias in that scenario. The six scenarios used in the dissertation as well as the right answers and justification are presented below:

1. Insensitivity to Prior Probability (Restaurant Scenario)

This scenario was developed by Dr. Nick Evangelopoulos, after interviewing a store manager from a restaurant chain in California in the early 2000s. The scenario used is shown below:

"ABC is a chain of buffet-style restaurants. Assume you are the new assistant store manager. Part of your duties is to maintain food safety procedures. The restaurant offers a soup bar. To control bacteria growth in your soups, it is important to keep their temperatures either cold enough, or hot enough. Keeping soups at a safe temperature can be challenging, since they

need to be heated when they are cooked, chilled when they are stored, and reheated when they are about to be consumed by the customers. One morning, as you review the previous day's soup temperature log, you are puzzled —and concerned— by a few temperature entries that were around 120 ^{0}F, which is not hot enough, making the soups unsafe. When this type of problem occurs, the most likely cause is human error related to the handling of the refrigerator (e.g. the refrigeration temperature setting is too cold) or the stove (e.g. the heating temperature setting is not hot enough).

While refrigerator problems generally occur six times more frequently than stove problems, you can recall many recent instances when the soup temperature was around 120 ^{0}F toward the end of the day and the cause was the stove. When this type of problem can be traced to the refrigerator, about two-thirds of the time the problem occurs toward the beginning of the day, and only about one third of the times the problem occurs toward the end of the day. When the stove causes the problem, the problem tends to occur almost exclusively toward the end of the day. In fact, your records verify that, among the 12 occurrences of a temperature problem caused by the stove in the past six months, all 12 (100%) occurred toward the end of the day. Looking at the temperature log, you see that the problem this time occurred toward the end of the day. You now need to establish the most likely cause and take specific action.

Q. Given that the problem occurred toward the end of the day, what is the most likely cause of the low temperature in soups?

1. The refrigerator 2. The stove 3. About the same"

In order to solve this problem correctly, one has to think about 2 pieces of information. The first one is the probability distribution of the cause of the problem both at the beginning and end of the day which is shown in table 5.

Table 5: Probability Distribution of the Cause of the Problem

	Refrigerator	Stove
Beginning of the Day	2/3	0
End of the Day	1/3	1

The second piece of information is the prior probability or base rate of outcomes. In this scenario, the prior probability is mentioned in the following statement "refrigerator problems generally occur six times more frequently than stove problems". This prior probability can be described as in table 6.

Table 6: Prior Probability or Base Rate

	Refrigerator	Stove
Prior probability	6/7	1/7

Combining these two pieces of information, it can be shown that toward the end of the day, the refrigerator generally causes the problem two times more frequently than stove. This is shown in table 7. However, since many people ignore the prior probability, they may wrongly choose the stove as the most probable cause of the problem.

Table 7: The Final Probability Distribution on which Decision should be Based

	Refrigerator	Stove
Beginning of the Day	4/7	0
End of the Day	2/7	1/7

2. Insensitivity to Sample Size (Gas Station Scenario)

This scenario was developed for this dissertation. The scenario used is shown below:

"Gas Station Company ABC is operating in Texas. It has opened stores in different cities such as Dallas and Denton. The company is competing with other gas station chains such as QT and Chevron.

ABC gas stations offer both gasoline and diesel for cars and trucks. Historical data in your area shows that consumptions of gasoline and diesel are about equal. Therefore, about 50 percent of total fuel consumption is gasoline and about 50 percent is diesel. However, the exact percentage varies from week to week. Sometimes it may be higher that 50 percent, sometimes lower.

Assume you work as the regional manager in Denton. Among the gas stations under your management, you have a small gas station (station A) equipped with 4 pumps and a large gas station (station B) equipped with 12 pumps. You are responsible for placing orders. The week-to-week fluctuation in consumption is important, because it is related to possible stockouts. Each week, the consumptions of gasoline and diesel are recorded.

Q. Which gas station has a higher probability to record a mix of fuel sold as 65% or more gasoline and, therefore, 35% or less diesel?

1. Small gas station (station A) 2. Large gas station (station B) 3. About the same"

The right answer to this problem is small gas station. In statistical theory, small sample size usually has higher probability to deviate from the mean. In this problem, on average, half of the fuel consumption is gasoline and half is diesel. The small gas station has more probability to deviate from this mean. However, some participants may not consider this fact and therefore ignore the impact of sample size. So, they may choose the large gas station because the question asks about a mix of 65% or more gasoline and, therefore, 35% or less diesel. Since 65% is greater than 35%, then large gas station will have more probability to deviate from the mean. Alternatively, they may choose the third option, about the same, because the problem states that half of the fuel consumption is gasoline and half is diesel. Therefore, they may choose the third option that both small and large stations have equal probability to deviate from the mean.

3. Misconception of Chance (Truck Scenario)

This scenario was developed for this dissertation. The scenario used is shown below:

"Company ABC operates a regional distribution center for meat products. Assume you are the new assistant operations manager. Part of your job is to keep track of the arrival times of the delivery trucks.

Based on observations from the last one year, 99% of deliveries arrived independently of each other within 15 minutes from the target arrival time. Half of them arrived within 15 minutes early (ahead of time) and half of them arrived within 15 minutes late. Being early vs. late has

different consequences depending on the day of the week. It is part of your job to plan for such consequences and have contingencies in place.

During the last 6 days, you recorded the status (E = early, L = late) of a certain truck driver as follows.

Day	*Mon*	*Tue*	*Wed*	*Thu*	*Fri*	*Sat*
Status	*E*	*L*	*E*	*E*	*E*	*E*

Q. What do you think will happen on the 7th day (which is a Monday, since Sunday is the driver's day off)?

1. An early (E) status will most likely be observed on the 7th day

2. A late (L) status will most likely be observed on the 7th day

3. Early (E) or late (L) are equally likely to be observed on the 7th day"

The right answer to this problem is option 3 "Early (E) or late (L) are equally likely to be observed on the 7th day". It is mentioned in the scenario that the arrivals of the trucks are independent of each other and half of them are early and half of them are late. So, on the 7th day, early or late arrival should have equal probability. However, the pattern of the arrival of the past 6 days shows that in 5 days the arrival is early and in one day it is late. Therefore, some people may choose early arrival option thinking that because early arrival happens 5 times in the past, then it has more probability to continue in the 7th day. On the other hand, some people may choose late arrival thinking that the process has to fix itself. Since early arrival occurred 5 times, it is the time for late arrival to occur and therefore the proportion of late arrival increases to be close to the proportion of early arrivals.

4. Insensitivity to Predictability (Sport Scenario)

This scenario is adopted from a book titled "Practical Operations Management" by Simpson, N and Hancock, P (2013, P 279). The original scenario is intended to cover purchasing and supply chain partnering. There are six food suppliers. Moreover, the case study provides 3 pieces of information: bid on contract, food quality score and delivery risk score. The scenario is modified to include only 2 food suppliers. Moreover, only food quality is used as the criteria to measure this cognitive bias. The scenario used is shown below:

"ABC Sports Camp runs training sessions for young athletes. The training sessions are held at the ABC Sports Complex, which includes athletic facilities, classroom space, dormitories and a picnic area. Currently, a commercial kitchen is absent from the complex. ABC Sports Camp has identified 2 candidate companies to provide food to the athletes. These two candidates are Salem Food Service (SFS) and Dragon Meals (DM). SFS is a multinational company that uses a network of local suppliers to deliver food locally. Last year, SFS launched a civic engagement initiative and built children's playgrounds in a number of local communities around the country. DM is a small and new company that is trying to develop a local market share. It has its own underutilized fleet of vehicles. Last August, DM was expected to open three new restaurants in town, but the entire project got delayed by six months.

Q. ABC Sports Camp needs to select one of the two companies. One important dimension of the selection decision is the quality of food provided. Which company do you expect to have higher food quality?

1. Salem Food Service (SFS) *2. Dragon Meals (DM)* *3. About the same "*

The right answer to this question is option 3 (about the same). The question was about selecting a company based on the quality of the food provided. The scenario provides positive description about Salem Food Service (SFC) and less favorable description about Dragon Meals (DM). In the descriptions of the two companies, there is no clue at all to the quality of food provided by these companies. So, ideally the two companies should be rated equally in terms of food quality. However, since some people will be insensitive to their ability to predict the outcomes, they may base their prediction on the favorableness of the description of the outcome. In this case, SFC has better description than DM and therefore may be expected to have better quality food.

5. The Illusion of Validity (Copy Center Scenario)

This scenario is adopted from the same book titled "Practical Operations Management" by Simpson, N and Hancock, P (2013, P 121). The original scenario is intended to cover forecasting and specifically regression. There are 8 courses. To simplify the case study, the modified scenario includes only 2 courses. The scenario used is shown below:

"ABC Copying Center (ABCCC) is a small business located near a large university complex. ABCCC provides a variety of services to its customers including copies of course materials, sold in packs to students enrolled in the university courses.

ABCCC has a mission to have high reputation for customer service. Therefore, when a student comes to buy a pack from ABCCC, the pack should be available in inventory. If it is not available, ABCCC would print a copy, which usually takes 15-20 minutes. The waiting student

may become dissatisfied with the service. On the other hand, if ABCCC builds excessive inventories of packs, then the unsold packs would represent monetary loss to ABCCC. So, the goal of ABCCC is to satisfy its customers at the lowest possible cost.

As part of their inventory management efforts, ABCCC hires you to carefully look at the data from last year. The data consists of the actual sales of 10 courses. 5 courses are in Banking (BA) and 5 are in Economics (EC). The actual sales are thought to be related to 3 factors: the major, the number of enrolled students, and whether the course is optional or required. The data is shown in the following table:

Course	***Actual Sales***	***Major***	***Enrollment***	***Optional***
BA201	*101*	*BA*	*130*	*No*
BA220	*102*	*BA*	*115*	*No*
BA222	*105*	*BA*	*118*	*No*
BA250	*109*	*BA*	*215*	*Yes*
BA275	*185*	*BA*	*200*	*No*
EC101	*84*	*EC*	*165*	*Yes*
EC201	*95*	*EC*	*215*	*Yes*
EC220	*96*	*EC*	*105*	*No*
EC250	*85*	*EC*	*175*	*Yes*
EC260	*95*	*EC*	*118*	*No*

Q1. In the long run, which of the two majors do you expect to produce higher sales?

1. The BA Major *2. The EC major* *3. About the same*

Q2. How confident are you in the answer you provided above?

1. High level of confidence *2. Low level of confidence"*

The correct answer to question 1 is the third option (About the same). At first glance of the table, it seems that the sales of BA are higher than the sales of EC since all BA courses have actual sales greater than 100 and all EC courses have actual sales less than 100. A closer look reveals that only BA275 has sales of 185 which is very far from 100. The remaining other courses are slightly higher than 100. Moreover, 2 courses in EC have sales in 80s and the other 3 courses have sales slightly less than 100. So, it seems that the course type is not strong predictor of the sales. The two strong predictors are the number of enrollment in the course and whether the course is required or optional. If the course is required, then most of the students would purchase the pack. Conversely, if the course is optional, almost half of the students would buy the pack. Table 8 shows the regression analysis of this problem. The dependent variable is the actual sales and the 3 independent variables are major, enrolment and optional.

Table 8: Regression Analysis of CC Problem

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
ReportedEnrollment	1	4250.57	4250.57	27.17	0.002
Optional	1	3676.66	3676.66	23.50	0.003
Major	1	1.80	1.80	0.01	0.918
Error	6	938.55	156.42		
Total	9	7558.10			

The major is not a significant factor with a P value of 0.918. However, both enrolment and optional are significant factors with very low p values.

The previous discussion is about determining the right answer to the first question of the CC scenario. Question 2 actually measures the essence of the illusion of validity bias. Ideally, people who choose the right answer should be more confident on their choice. On the other hand,

people who choose the wrong answer should have low confidence. According to the literature, this is not the case. People tend to overestimate their confidence in their decisions even if the answer is not true. So, in the analysis part, the second question will be used as an indicator for this bias.

6. Misconception of Regression (Forecast Scenario)

This scenario is adopted from a book titled "Thinking Fast and Slow" by Kahneman, D (2013, P 184). The original scenario is intended to cover this same cognitive bias "misconception of regression. The scenario is almost the same except for very minor words' changes. Moreover, forecast 2 was developed to reflect the principle that Kahneman thinks is the right way. The scenario used is shown below:

"*You are the sales forecaster of a department store chain ABC. All stores are similar in size and merchandise selection, but their sales differ because of competition, and random factors. You are given the results for 2014 and asked to forecast sales for 2015. You have been instructed to accept the forecast of economists that sales will increase overall by 10%. The following table shows the actual sales for the 4 stores in 2014 as well as 2 forecasts for 2015.*

Store	*2014*	*2015 (Forecast 1)*	*2015 (Forecast 2)*
1	*$11,000,000*	*$12,100,000*	*$14,600,000*
2	*$23,000,000*	*$25,300,000*	*$23,600,000*
3	*$18,000,000*	*$19,800,000*	*$21,800,000*
4	*$29,000,000*	*$31,900,000*	*$29,100,000*
Total	***$81,000,000***	***$89,100,000***	***$89,100,000***

Q. Which forecast do you think is more probable?

1. Forecast 1 *2. Forecast 2* *3. About the same"*

Forecast 2 is the right answer. The key phrase in this problem is "All stores are similar in size and merchandise selection, but their sales differ because of competition, and random factors". Because these 4 stores are similar, their sales should also be similar. Since the sales in 2014 were disperse, they should statistically regress toward the mean sales in 2015. This can be achieved by increasing the sales of low-sale stores by more than 10% and increasing the sales of high-sale stores by less than 10% which is achieved in forecast 2. Some people may not capture the idea of regression toward the mean and simply think that high-sale stores will continue their performance forever and low-sale stores will continue selling less. Another possible explanation for not choosing forecast 2 is that students studying business are taught that firms should develop their own business advantage. The firm should keep this advantage for long time. Therefore, these students may choose forecast 1 which simply add 10% to the actual sales in 2014 and consider the results as the forecast for 2015.

Measurement Scales

This study includes 3 main constructs. Two constructs which are the cognitive reflection and training about cognitive biases represent the independent variables. The third construct is the cognitive bias which represents the dependent variables. The operationalization of these 3 constructs is discussed below:

Cognitive Reflection

Fredrick (2005) developed a set of 3 questions to measure the cognitive reflection of the individual. This set of 3 questions is called cognitive reflection test CRT. The test is shown in table 9.

Table 9: The Cognitive Reflection Test (CRT)

No	Question
1	A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?
2	If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?
3	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?

The intuitive answer to question 1 is 10 cents. However, a more careful thinking will show the right answer to be 5 cents. If the ball is 5 cents, the bat will be $ 1.05 and their sum is $ 1.10. In case of the intuitive answer 10 cents, the bat will be $ 1.10 and the total is $ 1.20 which is inconsistent with the information in the question.

For the second question, the intuitive answer is 100 minutes. This comes from the fast and intuitive observation that 5 machines will produce 5 widgets in 5 minutes. So, 100 machines will produce 100 widgets in 100 minutes. However, the right answer is 5 minutes because each machine produces 1 widget in 5 minutes. So, 100 machines will produce 100 widgets in 5 minutes.

The intuitive answer to question 3 is 24 days. Since the lake will be full in 48 days, simply dividing 48 by 2 will produce the intuitive answer 24 days. However, since the problem states that the water in the lake doubles every day, the right answer is 47 days.

Fredrick (2005) defined the score of CRT to be the sum of the right answers to those 3 questions. So, the possible scores for CRT are 0, 1, 2 and 3. If no answer is correct, CRT will be 0. If all answers are right, the CRT will be 3.

Training about Cognitive Biases

In order to investigate the impact of providing training on making biased decisions, the participants has been divided into two groups. The first group was given the scenarios without training. The other group was given the 6 scenarios with training in the form of simple warning. The warning consists of a brief description of the cognitive bias followed by a simple example to clarify it. For example, the warning given to truck scenario is shown below:

"As you consider your choice between early and late, please note that such choices are sensitive to a well-known cognitive bias, called "gambler's fallacy". In this bias, the decision maker expects that a sequence of events generated by a random process will correct itself to match the long-run probabilities, even when the sequence is short.

After observing a long run of red on the roulette wheel, for example, most people erroneously believe that black is now due, presumably because the occurrence of black will result in a more representative sequence than the occurrence of an additional red. This is not true. Although, in the long run, observed frequencies tend to match the corresponding probabilities, in the short run, processes do not "correct themselves". Thus, observing red or

black will be equally likely at each occurrence, regardless of what has been observed in the immediately preceding occurrences."

The warning for all 6 scenarios are shown in the survey in Appendix B at the end of the dissertation. In order to code this construct, a dummy variable for each scenario is developed. If the participant received the warning, the value of the dummy variable is 1. On the other hand, if the participant did not receive the warning, the variable's value is 0.

Cognitive Bias

The cognitive bias construct is operationalized as a dummy variable. If the participant chooses the wrong answer, the dummy variable is given the value of 1. If the answer is right, the dummy variable is 0. Since there are 6 scenarios, 6 dummy variable are used. Table 10 shows the values of the dummy variables with the selected choices.

Table 10: Operationalizing the Dependent Variable of Cognitive Bias for the 6 Scenarios

No	Scenario	The Value of the Dependent Variable is	
		0 if the answer is	1 if the answer is
1	Restaurant	The refrigerator	Otherwise
2	Gas Station	Small gas station (station A)	Otherwise
3	Truck	Early (E) or late (L) are equally likely to be observed on the 7th day	Otherwise
4	Sport	About the same	Otherwise
5	Copy Center	Low level of confidence	Otherwise
6	Forecast	Forecast 2	Otherwise

Covariates

In addition to the two main independent variables, the dissertation has considered then impact of other covariates. The following is a list of covariates that have been included in this study:

Delay gratification

Previous studies have shown a relationship between cognitive abilities and patience. People with high cognitive abilities tend to be more patient and delay their immediate gratification (Fredrick 2005). In this study, delay gratification is assumed to be one covariate and the instrument to measure it is taken from Fredrick (2005). The instrument consists of 9 statements related to receiving or losing financial rewards. For each statement, the participant expresses his or her preference for an immediate low return or delayed high return. The preference is measured using 7 points Likert scale. The statements are shown in the survey in Appendix B. Factor analysis will be used to combine these questions into factors that can be used in the analysis.

Risk-Taking

For a long time, scientists have debated whether risk-taking is a personality trait or not. Those who believe that risk-taking is a personality trait assume that the person's attitude toward risk is fixed over all situations. So, if a person is risk-seeking, then he will show this attitude in all his decisions. Unfortunately, this is not supported by research investigating how the managers deals about their own money or the company money. This suggests that risk taking is not solely a personal trait. Therefore, scientists start to think about the impact of both personal as well as the

situational factors (Blais & Weber 2006). Since a decision maker may face diverse situations in life, his or her risk attitude or perception should be evaluated in these situations. Based on this, Blais and Weber (2006) have developed a scale called "A Domain-Specific Risk-Taking (DOSPERT) scale". This scale measures the risk attitude in 5 different domains which are ethical, financial, health/safety, recreational and social. Each domain is measured using 6 questions. The total number of the questions in this scale is 30. 7-point Likert scale is used to estimate the participant's risk-perception. Factor analysis will be used to combine these questions and therefore be used in the analysis. The 30 questions are shown in the survey in Appendix B.

Age group

The question to classify respondents based on their age is:

Q What is your age group?

[18-20] *[21-25]* *[26-35]* *[36-50]* *[51 or more]*

People who are 36 or more are considered old and given the value of 1. Conversely, people who are less than 36 are considered young and given the value of 0

Gender

Gender is operationalized using a dummy variable. Males are coded 1 and females are coded 0.

Academic Status

The question measuring the academic status is:

Q. What is your academic status?

1. *Freshman*
2. *Sophomore*
3. *Junior*
4. *Senior*
5. *Post-graduate*

Students who are post graduate are coded 1 and undergraduate students are coded 0.

Operations Management Work Experience

To measure the work experience in the field of operations management, the following question has been used:

Q. Rate your work experience in the field of operations management?

1. *None*
2. *Less than six months*
3. *Between six months and a year*
4. *Between a year and three years*
5. *Over three years*

People who has experience of more than 1 year are considered to have high experience in operations management and given the value of 1. On the other hand, people who have less than 1 year experience in operations management are given the value of 0.

General Work Experience

To measure the work experience in any field, the following question has been used:

Q. Rate your work experience in any field?

1. *None*
2. *Less than six months*
3. *Between six months and a year*
4. *Between a year and three years*
5. *Over three years*

People who has experience of more than 1 year are considered to have high work experience and given the value of 1. On the other hand, people who have less than 1 year experience are given the value of 0.

Target Population and Study Samples

This study will be conducted by distributing a survey to students in the College of Business at UNT. The students will be a mixed of bachelor, master and doctorate students. This population was selected because it is expected that the majority will work in business after their graduation. Since they study at College of Business, they should have some statistical knowledge which is a major tool to avoid the biased decisions.

Survey Instrument

A paper-based survey is the main data collection tool used to run this research. The survey consists of 5 major parts. Part 1 asks the 3 questions of cognitive reflection test (CRT). Part 2 presents the 6 scenarios discussed above. Part 3 is about the delayed gratification (DG)

attitude of the participant. Part 4 asks 30 questions to measure participant's perception of risk taking (RT). Finally, part 5 requests some demographic information about the participants. Two points have been considered in the design of the survey. The first point is concerned with the learning effect of the six scenarios in part 2. If all students received the survey in the same order, it is possible that the students may miss the correct answer of the first scenarios and gradually learn throughout the survey and therefore answer the last scenarios correctly. In order to counteract the learning effect, the order of the scenarios has been set up according to the Balanced Latin Square (MacKenzie 2002). Since there are 6 scenarios, then 6*6 design has been implemented. The second point is that since this is an experimental study investigating the effect of training on cognitive bias, the participants should be grouped into 2 categories. The control group receives the 6 scenarios without training. The other group receives the 6 scenarios with training. Based on these two points, 12 versions of the survey have been prepared and distributed to students at UNT. The order of the scenarios and the presence of training in these 12 versions are shown in table 11.

Summary

This chapter discusses why experiment is used to conduct this research. Moreover, the 6 scenarios are presented with justification to select the right answer for each scenario. CRT is also presented with both the intuitive wrong answers and the deep right answers. Measurement scales for dependent, independent and covariates is discussed. Finally, the targeted population and the survey instrument are explained.

Table 11: Order of the 6 Scenarios and Presence of Training in the 12 Versions of the Survey

Version	Order						Training
	1	2	3	4	5	6	
1	Restaurant	Gas Station	Forecast	Truck	Copy Center	Sport	No
2	Gas Station	Truck	Restaurant	Sport	Forecast	Copy Center	No
3	Truck	Sport	Gas Station	Copy Center	Restaurant	Forecast	No
4	Sport	Copy Center	Truck	Forecast	Gas Station	Restaurant	No
5	Copy Center	Forecast	Sport	Restaurant	Truck	Gas Station	No
6	Forecast	Restaurant	Copy Center	Gas Station	Sport	Truck	No
7	Restaurant	Gas Station	Forecast	Truck	Copy Center	Sport	Yes
8	Gas Station	Truck	Restaurant	Sport	Forecast	Copy Center	Yes
9	Truck	Sport	Gas Station	Copy Center	Restaurant	Forecast	Yes
10	Sport	Copy Center	Truck	Forecast	Gas Station	Restaurant	Yes
11	Copy Center	Forecast	Sport	Restaurant	Truck	Gas Station	Yes
12	Forecast	Restaurant	Copy Center	Gas Station	Sport	Truck	Yes

CHAPTER 4

DATA ANALYSIS

Introduction

The survey data collected in this research was analyzed using a variety of statistical techniques such as factor analysis, logistic regression and descriptive statistics. The analysis starts with cleaning the data and using only valid responses. Then among these valid responses, missing data observations were removed. Next, two simple relationships are illustrated. The first one is between CRT and biased decisions. The second one is between warning/no-warning groups and their percentages of biased decisions. Then, a factor analysis provided an interpretation of the items used in the delayed gratification and risk-taking instruments. Finally, logistic regression analyses were used to examine the relationship between the dependent variable, cognitive biases for a particular operations management scenario, and CRT, training and other covariates as independent variables.

Data Collection and Cleanup

The survey, shown in Appendix B, was distributed to students in the College of Business at the University of North Texas (UNT). A total of 315 responses were collected. Of these, 13 responses were invalid for one of the following reasons:

1. There is no answer to the questions of one or more scenarios. (7 responses)
2. There is no entry for delayed gratification questions or risk-taking questions. (4 responses)
3. The response answers to the delayed gratification and risk-taking items were all equal to 4. (2 responses)

Since the scenarios represent the core of the study, any respondent who did not answer one of the scenarios was removed and their responses were considered invalid. Seven responses were removed from the analysis. Moreover, four students completely missed either the delayed gratification or the risk-taking questions. Therefore, they are eliminated. Yet, some of the remaining valid responses missed one or two questions in the delayed gratification or the risk-taking items. In this case, missing responses were replaced by the average response for that item. Finally, two responses were removed because the response four was provided for all delayed gratification and risk-taking items. These responses indicated that the respondent may not have read the survey thoroughly and their response was eliminated. So, a total of 302 valid responses were used in the analysis.

Demographic Statistics

The demographic characteristics of the 302 participants in this study are shown in tables 12 through 16 and figures 7 through 11. The following demographic characteristics were included: gender (table 12 and figure 7), age (table 13 and figure 8), academic status (table 14 and figure 9), experience in operations management (OM) field (table 15 and figure 10) and experience in any field (table 16 and figure 11). A few participants did not provide some of their demographic information. Therefore, these response were treated as missing data.

Table 12: Gender Demographic Frequency Data

	Frequency	Percent	Cumulative Percent
Male	150	50%	50%
Females	136	45%	95%
Missing	16	5%	100%
Total	302	100%	

Table 13: Age Demographic Frequency Data

	Frequency	Percent	Cumulative Percent
18-20	97	32%	32%
21-25	121	40%	72%
26-35	48	16%	88%
36-50	16	5%	93%
51 or older	2	1%	94%
Missing	18	6%	100%
Total	302	100%	

Table 14: Academic Status Demographic Frequency Data

	Frequency	Percent	Cumulative Percent
Freshman	3	1%	1%
Sophomore	57	19%	20%
Junior	104	34%	54%
Senior	78	26%	80%
Pot-Graduate	59	20%	100%
Not a Student	0	0%	100%
Missing	1	0%	100%
Total	302	100%	

Table 15: OM Experience Demographic Frequency Data

	Frequency	Percent	Cumulative Percent
None	221	73%	73%
0 - 6 months	32	11%	84%
6 months - 1 year	13	4%	88%
1 year - 3 years	20	7%	95%
3 years or more	15	5%	100%
Missing	1	0%	100%
Total	302	100%	

Table 16: General Experience Demographic Frequency Data

	Frequency	Percent	Cumulative Percent
None	39	13%	13%
0 - 6 months	33	11%	24%
6 months - 1 year	38	13%	36%
1 year - 3 years	77	25%	62%
3 years or more	114	38%	100%
Missing	1	0%	100%
Total	302	100%	

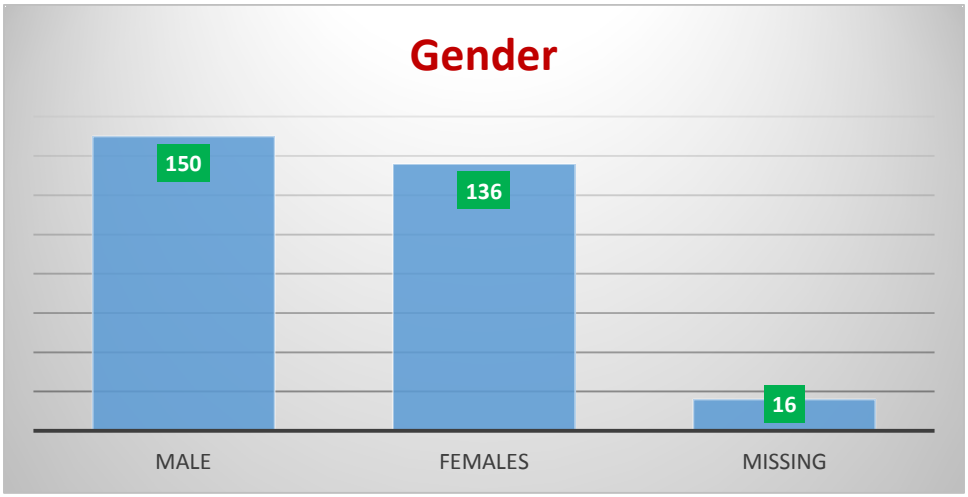

Figure 7. Gender Demographic

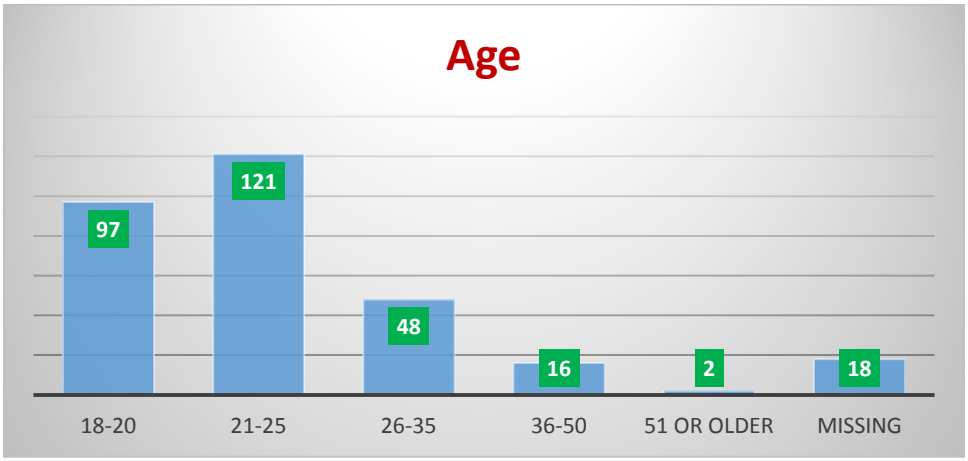

Figure 8. Age Demographic

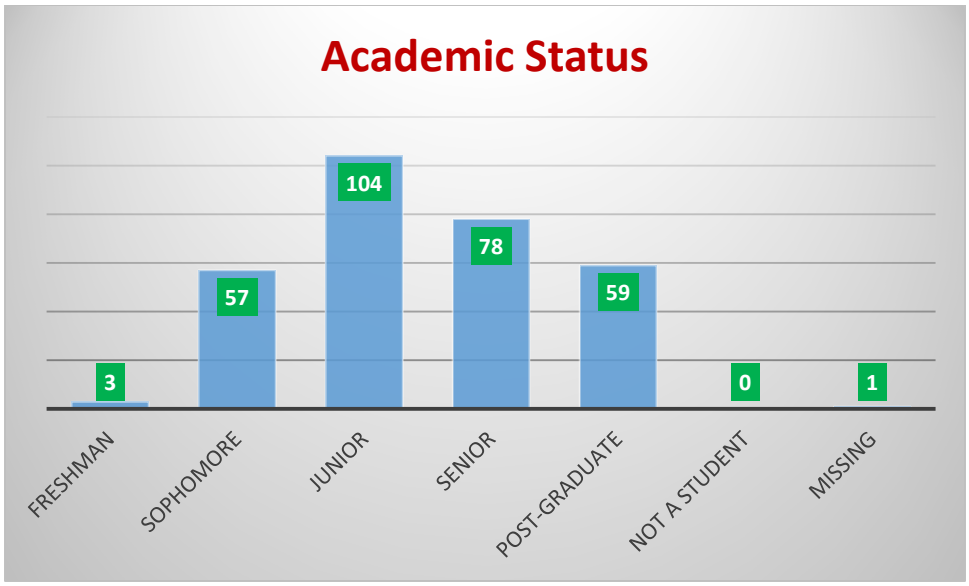

Figure 9. Academic Status Demographic

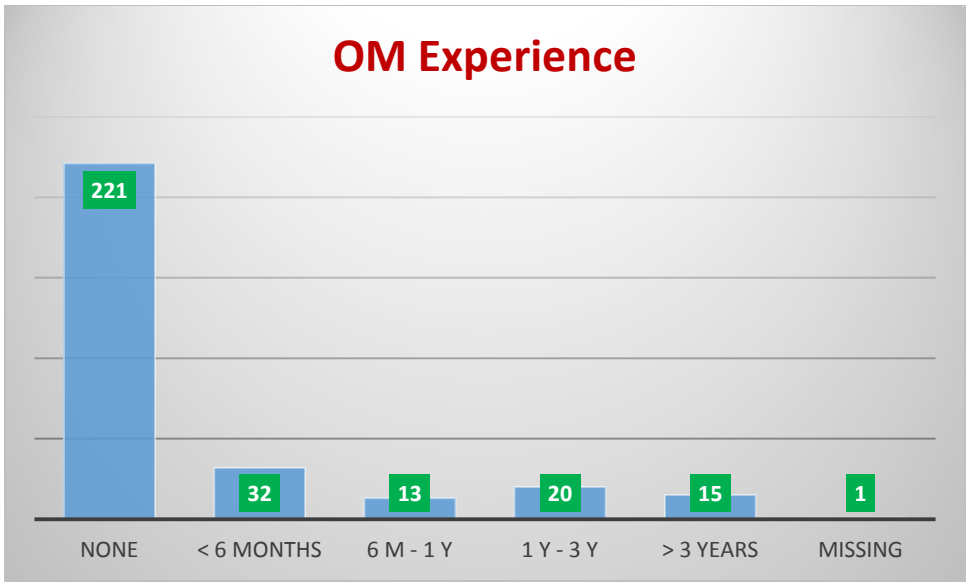

Figure 10. OM Experience Demographic

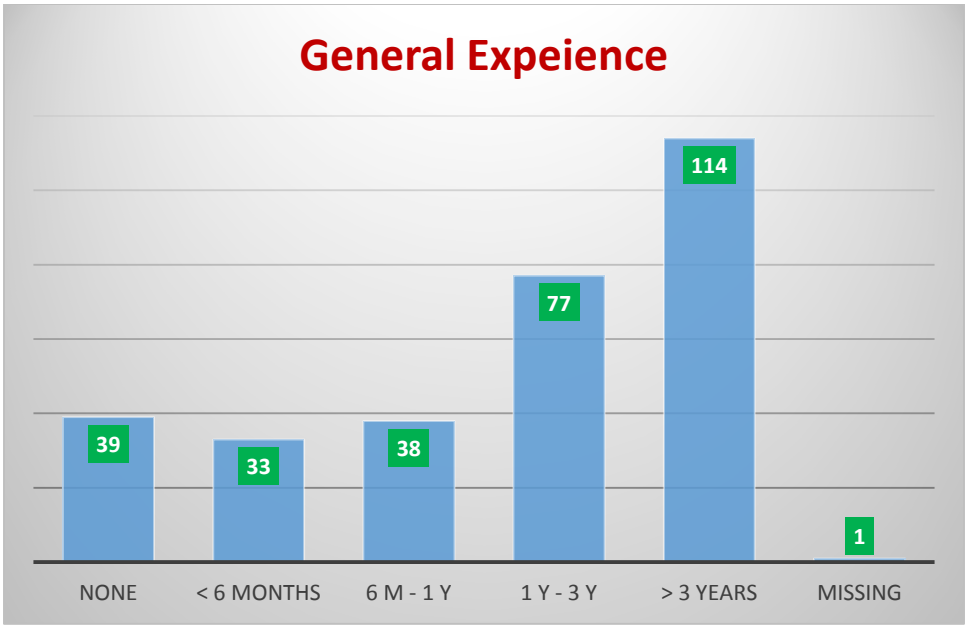

Figure 11. General Experience Demographic

Cognitive Reflection Test (CRT)

As previously mentioned, the score of CRT is calculated as the sum of correct answers to the 3 questions. So, if the individual answers all questions incorrectly, then the score of CRT is 0. If only one answer is right, then the score is 1. If the participant answers all 3 questions correctly, then the score of CRT is 3. Table 17 shows the distribution of CRT for the second pilot and the final studies. The results are consistent across the 2 studies. The majority of students scored a 0 in this test and only few scored a 3. Table 18 displays the results of the CRT for the final study both in numbers and percentages. Table 19 compares the results obtained in the study with the results reported by Fredrick (2005). The mean CRT score for UNT students in this study is 1.06 which is slightly higher than that for students in Bowling Green University.

Table 17: Comparing CRT Score Distribution among the Pilot Study and the Final Study

CRT		
	Pilot	**Final Study**
0	50%	43%
1	18%	23%
2	17%	19%
3	15%	15%
# Participants	211	302

Table 18: CRT Score Distribution for the Final Study

CRT		
	#	%
0	131	43%
1	68	23%
2	58	19%
3	45	15%
Total	302	100%

Table 19: CRT Scores, by Location (Fredrick 2005)

		Percentages coring 0, 1, 2 or 3				
Locations at which data were collected	*Mean CRT score*	*Low 0*	*1*	*2*	*High 3*	*N =*
Massachusetts Institute of Technology	2.18	7%	16%	30%	48%	61
Princeton University	1.63	18%	27%	28%	26%	121
Boston fireworks display	1.53	24%	24%	26%	26%	195
Carnegie Mellon University	1.51	25%	25%	25%	25%	746
Harvard University	1.43	20%	37%	24%	20%	51
University of Michigan: Ann Arbor	1.18	31%	33%	23%	14%	1267
Web-based studies	1.1	39%	25%	22%	13%	525
University of North Texas (UNT)	**1.06**	**43%**	**23%**	**19%**	**15%**	**302**
Bowling Green University	0.87	50%	25%	13%	12%	52
University of Michigan: Dearborn	0.83	51%	22%	21%	6%	154
Michigan State University	0.79	49%	29%	16%	6%	118
University of Toledo	0.57	64%	21%	10%	5%	138
Overall	**1.24**	**33%**	**28%**	**23%**	**17%**	**3428**

Tables 20 and 21 display frequencies and percentages to display the relationship between the CRT scores and biased (incorrect) decisions for each of the six scenarios. The following points should be noted from observing these tables:

- 43% of the respondents scored a 0 in CRT. This percentage decreased gradually as the score of CRT increased and reached 15% for people who score 3.
- Cognitive biases (incorrect decisions) in an OM context are demonstrated to be occurring. In all scenarios, more than 50% of respondents' decisions are biased.

The inverse relationship between CRT and making a biased decisions appear to be somewhat consistent in 4 scenarios, namely, restaurant, gas station, truck and sport. The scenarios for copy center and forecast do not clearly show this relationship.

Table 20: Relationship between CRT and Biased Decisions (Numbers)

CRT			Incorrect Answer					
	#	%	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
0	131	43%	103	82	74	93	77	99
1	68	23%	52	42	36	45	52	53
2	58	19%	41	26	27	42	47	46
3	45	15%	33	21	20	28	32	30
Total	302	100%	229	171	157	208	208	228

Table 21: Relationship between CRT and Biased Decisions (Percentages)

CRT			Incorrect Answer					
	#	%	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
0	131	43%	79%	63%	56%	71%	59%	76%
1	68	23%	76%	62%	53%	66%	76%	78%
2	58	19%	71%	45%	47%	72%	81%	79%
3	45	15%	73%	47%	44%	62%	71%	67%
Total	302	100%	76%	57%	52%	69%	69%	75%

Training

One primary objective of this dissertation is to study the effect of providing training on reducing cognitive biases. To achieve this, one group of the students were given the survey without training and the other group were given it with training. Table 22 shows that exactly half of the respondents received training and while the other half received no training. The relationship between providing training about cognitive biases and making a biased decision is shown in tables 23 and 24. The main observation in these two table is that providing training to respondents helps them to make more objective decisions. However, the training is not equally effective for all scenarios. The training is more effective in the first 4 scenarios compared with the last two scenarios.

Table 22: Training Distribution

Training		
	#	%
0 No Training	151	50%
1 Training	151	50%
Total	302	

Table 23: Relationship between Training and Biased Decisions (Numbers)

Training			Incorrect Answers					
	#	%	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
0 No Training	151	50%	121	89	85	121	107	116
1 Training	151	50%	108	82	72	87	101	112
Total	302		229	171	157	208	208	228

Table 24: Relationship between Training and Biased Decisions (Percentages)

Training			Incorrect Answers					
	#	%	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
0 No Training	151	50%	80%	59%	56%	80%	71%	77%
1 Training	151	50%	72%	54%	48%	58%	67%	74%
Total	302		76%	57%	52%	69%	69%	75%

Delayed Gratification (DG)

Factor analysis was used to group the 9 questions measuring the delayed gratification construct. Principal component analysis with a VARIMAX rotation is a popular procedure in factor analysis. The results of the factor analysis are shown in table 25. The table only shows loadings that are greater than 0.60. The 9 questions load onto 3 factors. Factor 1 includes items 6, 7 and 8. Factor 2 includes items 3, 4 and 5. Finally factor 3 includes items 1 and 9. Item 2 does not load in any factor. To check for the internal reliability, Cronbach's alpha was calculated for these 3 factors. The results are shown in table 26. Factors 1 and 2 have Cronbach's alphas greater than 0.70 which indicates acceptable internal consistency. On the other hand, factor 3 has a very low reliability and therefore was not be included in the analysis.

Table 25: Factor Analysis of DG

	Factor		
	1	2	3
Q1			0.72
Q2			
Q3		0.79	
Q4		0.81	
Q5		0.74	
Q6	0.78		
Q7	0.82		
Q8	0.83		
Q9			0.73

Table 26: Cronbach's Alpha for DG Factors

Factor	Questions	Cronbach's Alpha
1	Q6	0.772
	Q7	
	Q8	
2	Q3	0.727
	Q4	
	Q5	
3	Q1	0.172
	Q9	

Risk-Taking (RT)

The risk-taking opinions of the participants were divided into 5 aspects: ethical (E), financial (F), health/safety (H/S), recreational (R) and social (S). Each aspect was measured using 6 items. So, there are 30 items measuring a participant's risk perception. As with delayed gratification, the items for risk taking were grouped based on factor analysis using principal component analysis with VARIMAX rotation. The results of factor analysis are shown in table 27. The table shows that the 30 items loaded on 9 factors. Factors 1, 5, 6 and 9 have one items loading on them. Therefore, these factors are dropped from the analysis. Each of factors 2 and 7 have 3 financial items. Similarly, factors 3 and 8 each consist of two social questions. Finally, factor 4 has two recreational questions.

Table 27: Factor Analysis of RT

	Factor								
	1	2	3	4	5	6	7	8	9
S1									
R2					0.61				
F3		0.79							
F4							0.67		
H_S5									
E6									0.66
S7									
F8		0.85							
E9									
E10						0.75			
R11									
F12							0.65		
R13									
F14		0.83							
H_S15									
E16									
H_S17	0.72								
F18							0.76		
R19				0.74					
H_S20									
S21								0.78	
S22								0.71	
H_S23									
R24				0.66					
R25									
H_S26									
S27			0.72						
S28			0.71						
E29									
E30									

The Cronbach's alphas for these 5 factors are shown in table 28. The Cronbach's alpha for the first factor is 0.806 which is very high. The Cronbach's alpha for the remaining 4 factors are moderate. Yet, because they are greater than 0.50, they will be used in the analysis.

Table 28: Cronbach's Alpha for RT Factors

Factor	Questions	Cronbach's Alpha
1	F3	0.806
	F8	
	F14	
2	S27	0.672
	S28	
3	R19	0.616
	R24	
4	F4	0.565
	F12	
	F18	
5	S21	0.565
	S22	

Logistic Regression

Logistic regression has been used to analyze the six scenarios. The "Backward Selection" option in SPSS was used to determine the significant variables. For each scenario, the dependent variable is a binary one. If the answer is incorrect, then there is a cognitive bias and the value of the variable is 1. On the other hand, if the answer is correct, there is no bias and the value is 0. The two main independent variables are the CRT and training. Moreover, there are 20 other independent variables. The full list of the independent variables is shown in table 29.

Table 29: Dependent and Independent Variables

No	Type	Name	Values	Note
1	Dependent	Cognitive Bias	0 or 1	1 if there is a bias; 0 otherwise
1	Independent	CRT	0, 1, 2 or 3	
2		CRT^2	0, 1, 4 or 9	
3		Training	0 or 1	1 if training is given to the participant; 0 otherwise
4		Grad Education	0 or 1	1 if participant is graduate; 0 otherwise
5		Male	0 or 1	1 if male; 0 if female
6		Work Experience Any	0 or 1	1 if participant has experience of more than 1 year in any field; 0 otherwise
7		Work Experience OM	0 or 1	1 if participant has experience of more than 1 year in OM field; 0 otherwise
8		DG 1	Continuous from 1 to 7	These are the 2 factors resulting from factor analysis of delayed gratification
9		DG 2	Continuous from 1 to 7	
10		RT Financial 1	Continuous from 1 to 7	These are the 5 factors resulting from factor analysis of Risk Taking
11		RT Financial 2	Continuous from 1 to 7	
12		RT Social 1	Continuous from 1 to 7	
13		RT Social 2	Continuous from 1 to 7	
14		RT Recreational	Continuous from 1 to 7	
15		Male*Training	0 or 1	Interaction Terms
16		Male*Work Experience Any	0 or 1	
17		Male*Work Experience OM	0 or 1	
18		CRT*Training	0, 1, 2 or 3	
19		CRT*DG Factor 1	Continuous from 0 to 21	
20		CRT*DG Factor 2	Continuous from 0 to 21	
21		Training*DG Factor 1	Continuous from 1 to 7	
22		Training*DG Factor 2	Continuous from 1 to 7	

For each scenario, there will be 4 tables reported. The first table shows the results of including the main factors excluding the interaction terms. This means 14 independent variables will be presented. The second table shows only significant variables using the backward selection. The third table includes both the main factors as well as the interactions terms. This means including all 22 independent variables. The last table shows only the significant factors among these 22 variables. Significant variables are classified using the following criterion

1. If p-value is ≤ 0.01, the variable is significant at 0.01 level and symbolized as ***
2. If $0.01 <$ p-value ≤ 0.05, the variable is significant at 0.05 level and symbolized **
3. If $0.05 <$ p-value ≤ 0.10, the variable is significant at 0.10 level and symbolized as *
4. Otherwise, it is insignificant.

1. *Restaurant*

Both models result in the same significant factors. Training is a significant factor at 10% level with negative sign as expected. The two risk-taking financial factors are significant but they have opposite signs. Gender is a significant factor with negative sign. It means that males tend to take less biased decisions compared with females. Finally, general work experience is significant factor with negative sign. So, people with higher work experience tend to take less biased decisions.

Table 30: Logistic Regression for Restaurant Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.49	0.46	1.13	1.00	0.29	0.61
CRT_Sq	0.12	0.16	0.59	1.00	0.44	1.13
Training	-0.77	0.32	5.99	1.00	0.01	0.46
DG_Factor1	-0.07	0.09	0.71	1.00	0.40	0.93
DG_Factor2	0.05	0.08	0.42	1.00	0.52	1.05
RT_Financial1	0.17	0.11	2.22	1.00	0.14	1.18
RT_Financial2	-0.45	0.16	8.28	1.00	0.00	0.64
RT_Social1	-0.21	0.11	3.41	1.00	0.06	0.81
RT_Social2	-0.02	0.12	0.04	1.00	0.83	0.98
RT_Recreational	0.14	0.10	2.03	1.00	0.15	1.15
Gender_male	-0.76	0.33	5.35	1.00	0.02	0.47
Grad_Edu	-0.17	0.39	0.19	1.00	0.66	0.84
Work_Exp_OM	0.07	0.49	0.02	1.00	0.88	1.08
Work_Exp_Any	-0.84	0.34	5.91	1.00	0.02	0.43
Constant	4.20	1.31	10.21	1.00	0.00	66.55

Table 31: Logistic Regression for Restaurant Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
Training	-0.56	0.29	3.69	1.00	0.055	0.57	*
RT_Financial1	0.21	0.11	3.91	1.00	0.048	1.23	**
RT_Financial2	-0.41	0.15	7.59	1.00	0.006	0.67	***
Gender_male	-0.87	0.31	8.18	1.00	0.004	0.42	***
Work_Exp_Any	-0.75	0.33	5.32	1.00	0.021	0.47	**
Constant	3.10	0.93	11.22	1.00	0.001	22.19	***

Table 32: Logistic Regression for Restaurant Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-1.06	0.75	2.01	1.00	0.16	0.35
CRT_Sq	0.17	0.17	1.00	1.00	0.32	1.18
Training	-2.18	1.18	3.44	1.00	0.06	0.11
DG_Factor1	-0.08	0.18	0.18	1.00	0.67	0.93
DG_Factor2	-0.13	0.17	0.58	1.00	0.45	0.88
RT_Financial1	0.16	0.11	2.03	1.00	0.15	1.18
RT_Financial2	-0.46	0.16	8.49	1.00	0.00	0.63
RT_Social1	-0.23	0.12	3.97	1.00	0.05	0.79
RT_Social2	-0.03	0.12	0.07	1.00	0.80	0.97
RT_Recreational	0.14	0.10	1.82	1.00	0.18	1.14
Gender_male	-1.56	0.76	4.24	1.00	0.04	0.21
Grad_Edu	-0.17	0.41	0.17	1.00	0.68	0.85
Work_Exp_OM	-0.36	0.89	0.16	1.00	0.69	0.70
Work_Exp_Any	-1.32	0.57	5.43	1.00	0.02	0.27
Male_by_Training	0.49	0.69	0.51	1.00	0.48	1.63
Male_by_Work_Exp_OM	0.58	1.05	0.31	1.00	0.58	1.79
Male_by_Work_Exp_Any	0.67	0.71	0.89	1.00	0.35	1.95
CRT_by_Training	0.30	0.32	0.89	1.00	0.35	1.35
CRT_by_DG_Factor1	-0.01	0.08	0.01	1.00	0.94	0.99
CRT_by_DG_Factor2	0.08	0.08	1.05	1.00	0.31	1.08
Training_by_DG_Factor1	0.03	0.18	0.02	1.00	0.88	1.03
Training_by_DG_Factor2	0.14	0.17	0.65	1.00	0.42	1.15
Constant	6.00	1.76	11.69	1.00	0.00	403.99

Table 33: Logistic Regression for Restaurant Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
Training	-0.56	0.29	3.69	1.00	0.055	0.57	*
RT_Financial1	0.21	0.11	3.91	1.00	0.048	1.23	**
RT_Financial2	-0.41	0.15	7.59	1.00	0.006	0.67	***
Gender_male	-0.87	0.31	8.18	1.00	0.004	0.42	***
Work_Exp_Any	-0.75	0.33	5.32	1.00	0.021	0.47	**
Constant	3.10	0.93	11.22	1.00	0.001	22.19	***

2. Gas Station

The two models result in slightly different outcomes. In the model without interaction terms, only CRT and RT-financial 2 factors are significant. CRT has a negative sign as expected. RT-financial 2 has a positive sign. This means that people who are riskier tend to make more biases decisions, The second model include the interaction terms. CRT and RT-financial 2 are still significant factors. Additionally, Training is significant factor but its sign is positive. The positive sign could be because the interaction between training and DG factor 1. DG factor 1 itself is not significant. However, it is retained because its interaction with training is significant.

Table 34: Logistic Regression for Gas Station Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.18	0.39	0.22	1.00	0.64	0.83
CRT_Sq	-0.03	0.13	0.04	1.00	0.83	0.97
Training	-0.24	0.26	0.84	1.00	0.36	0.79
DG_Factor1	-0.08	0.07	1.17	1.00	0.28	0.92
DG_Factor2	0.03	0.07	0.17	1.00	0.68	1.03
RT_Financial1	-0.02	0.10	0.06	1.00	0.80	0.98
RT_Financial2	0.19	0.13	2.37	1.00	0.12	1.21
RT_Social1	0.01	0.09	0.02	1.00	0.89	1.01
RT_Social2	0.12	0.10	1.47	1.00	0.22	1.12
RT_Recreational	0.09	0.08	1.12	1.00	0.29	1.09
Gender_male	0.28	0.27	1.13	1.00	0.29	1.33
Grad_Edu	-0.20	0.33	0.36	1.00	0.55	0.82
Work_Exp_OM	-0.61	0.41	2.18	1.00	0.14	0.55
Work_Exp_Any	0.14	0.27	0.25	1.00	0.62	1.15
Constant	-0.81	1.03	0.61	1.00	0.43	0.44

Table 35: Logistic Regression for Gas Station Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
CRT	-0.21	0.11	3.90	1.00	0.048	0.81	**
RT_Financial2	0.25	0.11	4.85	1.00	0.028	1.29	**
Constant	-0.59	0.54	1.19	1.00	0.274	0.56	

Table 36: Logistic Regression for Gas Station Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.09	0.58	0.03	1.00	0.87	0.91
CRT_Sq	-0.01	0.14	0.01	1.00	0.92	0.99
Training	1.11	0.87	1.62	1.00	0.20	3.03
DG_Factor1	0.27	0.15	3.17	1.00	0.08	1.31
DG_Factor2	-0.14	0.13	1.19	1.00	0.28	0.87
RT_Financial1	-0.04	0.10	0.19	1.00	0.66	0.96
RT_Financial2	0.22	0.13	2.80	1.00	0.09	1.25
RT_Social1	0.01	0.10	0.01	1.00	0.92	1.01
RT_Social2	0.11	0.10	1.16	1.00	0.28	1.11
RT_Recreational	0.10	0.09	1.26	1.00	0.26	1.10
Gender_male	0.16	0.53	0.09	1.00	0.76	1.17
Grad_Edu	-0.34	0.34	1.02	1.00	0.31	0.71
Work_Exp_OM	0.09	0.69	0.02	1.00	0.89	1.10
Work_Exp_Any	0.06	0.40	0.03	1.00	0.87	1.07
Male_by_Training	0.11	0.55	0.04	1.00	0.85	1.11
Male_by_Work_Exp_OM	-1.16	0.87	1.81	1.00	0.18	0.31
Male_by_Work_Exp_Any	0.23	0.55	0.17	1.00	0.68	1.26
CRT_by_Training	-0.11	0.26	0.17	1.00	0.68	0.90
CRT_by_DG_Factor1	-0.11	0.07	2.52	1.00	0.11	0.89
CRT_by_DG_Factor2	0.09	0.06	2.12	1.00	0.15	1.10
Training_by_DG_Factor1	-0.47	0.16	8.55	1.00	0.00	0.62
Training_by_DG_Factor2	0.14	0.14	1.02	1.00	0.31	1.16
Constant	-1.51	1.26	1.45	1.00	0.23	0.22

Table 37: Logistic Regression for Gas Station Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
CRT	-0.30	0.12	6.78	1.00	0.009	0.74	***
Training	1.17	0.61	3.70	1.00	0.055	3.22	**
DG_Factor1	0.09	0.09	0.90	1.00	0.342	1.09	
RT_Financial2	0.23	0.12	3.88	1.00	0.049	1.26	**
Training_by_DG	-0.36	0.14	7.27	1.00	0.007	0.69	***
Constant	-0.62	0.74	0.72	1.00	0.397	0.54	

3. Truck

In the truck scenario, both CRT and training are significant factors with negative signs, as expected. This is true for both models. Surprisingly, all the other covariates considered in this research are not significant in this scenario.

Table 38: Logistic Regression for Truck Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.39	0.38	1.03	1.00	0.31	0.68
CRT_Sq	0.05	0.13	0.15	1.00	0.70	1.05
Training	-0.57	0.26	4.94	1.00	0.03	0.56
DG_Factor1	-0.06	0.07	0.78	1.00	0.38	0.94
DG_Factor2	0.08	0.07	1.51	1.00	0.22	1.09
RT_Financial1	-0.07	0.10	0.54	1.00	0.46	0.93
RT_Financial2	0.00	0.12	0.00	1.00	0.98	1.00
RT_Social1	0.05	0.09	0.28	1.00	0.59	1.05
RT_Social2	-0.08	0.09	0.67	1.00	0.41	0.93
RT_Recreational	0.04	0.08	0.21	1.00	0.64	1.04
Gender_male	0.06	0.26	0.05	1.00	0.81	1.06
Grad_Edu	-0.54	0.32	2.80	1.00	0.09	0.58
Work_Exp_OM	0.21	0.41	0.28	1.00	0.60	1.24
Work_Exp_Any	0.18	0.27	0.44	1.00	0.51	1.20
Constant	0.92	1.02	0.81	1.00	0.37	2.52

Table 39: Logistic Regression for Truck Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
CRT	-0.21	0.11	3.79	1.00	0.051	0.81	*
Training	-0.43	0.24	3.32	1.00	0.068	0.65	*
Constant	0.52	0.22	5.81	1.00	0.016	1.68	**

Table 40: Logistic Regression for Truck Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.67	0.57	1.39	1.00	0.24	0.51
CRT_Sq	0.07	0.14	0.29	1.00	0.59	1.08
Training	-0.17	0.85	0.04	1.00	0.84	0.85
DG_Factor1	-0.09	0.14	0.42	1.00	0.52	0.91
DG_Factor2	0.14	0.12	1.24	1.00	0.27	1.15
RT_Financial1	-0.06	0.10	0.42	1.00	0.52	0.94
RT_Financial2	0.02	0.13	0.01	1.00	0.91	1.02
RT_Social1	0.05	0.10	0.24	1.00	0.62	1.05
RT_Social2	-0.09	0.10	0.91	1.00	0.34	0.91
RT_Recreational	0.03	0.08	0.16	1.00	0.69	1.03
Gender_male	0.81	0.52	2.48	1.00	0.12	2.26
Grad_Edu	-0.64	0.34	3.58	1.00	0.06	0.53
Work_Exp_OM	0.51	0.71	0.52	1.00	0.47	1.66
Work_Exp_Any	0.66	0.39	2.88	1.00	0.09	1.93
Male_by_Training	-0.25	0.53	0.22	1.00	0.64	0.78
Male_by_Work_Exp_OM	-0.21	0.87	0.06	1.00	0.81	0.81
Male_by_Work_Exp_Any	-0.99	0.54	3.33	1.00	0.07	0.37
CRT_by_Training	0.27	0.25	1.17	1.00	0.28	1.31
CRT_by_DG_Factor1	0.01	0.07	0.01	1.00	0.93	1.01
CRT_by_DG_Factor2	0.02	0.06	0.14	1.00	0.71	1.02
Training_by_DG_Factor1	0.02	0.15	0.02	1.00	0.89	1.02
Training_by_DG_Factor2	-0.15	0.14	1.25	1.00	0.26	0.86
Constant	0.61	1.24	0.24	1.00	0.62	1.84

Table 41: Logistic Regression for Truck Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
CRT	-0.21	0.11	3.79	1.00	0.051	0.81	*
Training	-0.43	0.24	3.32	1.00	0.068	0.65	*
Constant	0.52	0.22	5.81	1.00	0.016	1.68	**

4. Sport

Training is a significant factor in the sport scenario with a negative sign. Risk-taking financial 2 is a significant factor with a positive sign as in the gas station scenario. Finally, risk-taking social 1 is also a significant factor with a positive sign.

Table 42: Logistic Regression for Sport Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.09	0.43	0.05	1.00	0.83	0.91
CRT_Sq	-0.01	0.15	0.00	1.00	0.95	0.99
Training	-1.19	0.29	16.44	1.00	0.00	0.30
DG_Factor1	0.07	0.08	0.74	1.00	0.39	1.07
DG_Factor2	-0.08	0.08	1.07	1.00	0.30	0.93
RT_Financial1	0.08	0.11	0.64	1.00	0.42	1.09
RT_Financial2	0.33	0.14	5.38	1.00	0.02	1.39
RT_Social1	0.20	0.11	3.43	1.00	0.06	1.22
RT_Social2	-0.14	0.11	1.76	1.00	0.18	0.87
RT_Recreational	-0.02	0.09	0.04	1.00	0.83	0.98
Gender_male	0.13	0.29	0.21	1.00	0.65	1.14
Grad_Edu	-0.08	0.36	0.05	1.00	0.83	0.93
Work_Exp_OM	0.26	0.45	0.34	1.00	0.56	1.30
Work_Exp_Any	-0.17	0.30	0.33	1.00	0.57	0.84
Constant	-0.25	1.12	0.05	1.00	0.82	0.78

Table 43: Logistic Regression for Sport Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
Training	-1.08	0.27	16.18	1.00	0.00	0.34	***
RT_Financial2	0.30	0.13	5.50	1.00	0.02	1.34	**
RT_Social1	0.17	0.10	3.05	1.00	0.08	1.18	*
Constant	-0.40	0.60	0.45	1.00	0.50	0.67	

Table 44: Logistic Regression for Sport Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	-0.74	0.67	1.21	1.00	0.27	0.48
CRT_Sq	0.03	0.16	0.04	1.00	0.85	1.03
Training	-1.83	1.03	3.14	1.00	0.08	0.16
DG_Factor1	-0.12	0.19	0.43	1.00	0.51	0.89
DG_Factor2	0.02	0.16	0.02	1.00	0.88	1.02
RT_Financial1	0.09	0.11	0.75	1.00	0.39	1.10
RT_Financial2	0.36	0.15	5.91	1.00	0.02	1.43
RT_Social1	0.19	0.11	3.13	1.00	0.08	1.21
RT_Social2	-0.16	0.11	2.01	1.00	0.16	0.85
RT_Recreational	-0.02	0.09	0.04	1.00	0.84	0.98
Gender_male	0.33	0.63	0.27	1.00	0.60	1.39
Grad_Edu	-0.11	0.38	0.09	1.00	0.77	0.89
Work_Exp_OM	1.12	0.89	1.56	1.00	0.21	3.05
Work_Exp_Any	-0.04	0.44	0.01	1.00	0.92	0.96
Male_by_Training	0.32	0.61	0.28	1.00	0.60	1.38
Male_by_Work_Exp_OM	-0.97	1.04	0.88	1.00	0.35	0.38
Male_by_Work_Exp_Any	-0.43	0.62	0.48	1.00	0.49	0.65
CRT_by_Training	0.43	0.29	2.16	1.00	0.14	1.53
CRT_by_DG_Factor1	0.07	0.08	0.76	1.00	0.38	1.07
CRT_by_DG_Factor2	0.02	0.07	0.06	1.00	0.80	1.02
Training_by_DG_Factor1	0.22	0.19	1.39	1.00	0.24	1.24
Training_by_DG_Factor2	-0.22	0.16	1.85	1.00	0.17	0.80
Constant	0.30	1.48	0.04	1.00	0.84	1.35

Table 45: Logistic Regression for Sport Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
Training	-1.08	0.27	16.18	1.00	0.00	0.34	***
RT_Financial2	0.30	0.13	5.50	1.00	0.02	1.34	**
RT_Social1	0.17	0.10	3.05	1.00	0.08	1.18	*
Constant	-0.40	0.60	0.45	1.00	0.50	0.67	

5. *Copy Center*

In the first model without interaction, both CRT and CRT^2 are significant factors. However, the direction of CRT is revered. So, people with higher cognitive reflection tend to make more biased decisions which is counter to theory. Although the sign of CRT^2 is negative, its coefficient is small which is not enough to offset the positive effect of CRT. Moreover, DG factor 1 is significant with positive sign. So, people who are patient tend to make more biased decisions. This is counter to intuition.

In the second model, the 3 significant variables in model 1 are also significant here. Moreover, training is a significant factor with negative sign. Delayed gratification factor 2 is also significant. Finally, the interaction term between training and delayed gratification factor 2 is significant with positive sign.

Table 46: Logistic Regression for Copy Center Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	1.14	0.43	7.11	1.00	0.01	3.12
CRT_Sq	-0.33	0.15	5.10	1.00	0.02	0.72
Training	-0.02	0.28	0.01	1.00	0.94	0.98
DG_Factor1	0.14	0.08	3.16	1.00	0.08	1.15
DG_Factor2	-0.01	0.07	0.02	1.00	0.88	0.99
RT_Financial1	-0.01	0.11	0.00	1.00	0.95	0.99
RT_Financial2	0.04	0.13	0.09	1.00	0.76	1.04
RT_Social1	-0.04	0.10	0.15	1.00	0.70	0.96
RT_Social2	-0.13	0.10	1.53	1.00	0.22	0.88
RT_Recreational	0.12	0.09	1.76	1.00	0.18	1.13
Gender_male	0.36	0.28	1.63	1.00	0.20	1.43
Grad_Edu	0.20	0.36	0.29	1.00	0.59	1.22
Work_Exp_OM	0.34	0.48	0.51	1.00	0.47	1.41
Work_Exp_Any	0.11	0.29	0.14	1.00	0.71	1.11
Constant	-0.52	1.09	0.23	1.00	0.63	0.59

Table 47: Logistic Regression for Copy Center Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
CRT	1.23	0.40	9.31	1.00	0.002	3.43	***
CRT_Sq	-0.35	0.14	5.94	1.00	0.015	0.71	**
DG_Factor1	0.12	0.07	2.82	1.00	0.093	1.13	*
Constant	-0.15	0.35	0.18	1.00	0.672	0.86	

Table 48: Logistic Regression for Copy Center Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	1.00	0.62	2.63	1.00	0.10	2.72
CRT_Sq	-0.28	0.16	3.34	1.00	0.07	0.75
Training	-1.24	0.91	1.85	1.00	0.17	0.29
DG_Factor1	0.21	0.15	1.94	1.00	0.16	1.23
DG_Factor2	-0.22	0.13	2.88	1.00	0.09	0.80
RT_Financial1	-0.03	0.11	0.05	1.00	0.82	0.97
RT_Financial2	0.05	0.14	0.14	1.00	0.71	1.05
RT_Social1	-0.05	0.10	0.23	1.00	0.63	0.95
RT_Social2	-0.13	0.11	1.63	1.00	0.20	0.87
RT_Recreational	0.11	0.09	1.36	1.00	0.24	1.11
Gender_male	0.34	0.54	0.40	1.00	0.52	1.41
Grad_Edu	0.13	0.39	0.11	1.00	0.74	1.14
Work_Exp_OM	0.41	0.76	0.30	1.00	0.58	1.51
Work_Exp_Any	-0.08	0.41	0.04	1.00	0.85	0.93
Male_by_Training	-0.56	0.58	0.93	1.00	0.34	0.57
Male_by_Work_Exp_OM	-0.25	0.99	0.06	1.00	0.80	0.78
Male_by_Work_Exp_Any	0.56	0.58	0.93	1.00	0.33	1.76
CRT_by_Training	0.09	0.27	0.11	1.00	0.74	1.09
CRT_by_DG_Factor1	-0.05	0.07	0.41	1.00	0.52	0.95
CRT_by_DG_Factor2	0.04	0.07	0.29	1.00	0.59	1.04
Training_by_DG_Factor1	-0.03	0.16	0.04	1.00	0.84	0.97
Training_by_DG_Factor2	0.37	0.15	6.10	1.00	0.01	1.45
Constant	0.31	1.29	0.06	1.00	0.81	1.36

Table 49: Logistic Regression for Copy Center Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
Training	-1.42	0.58	5.94	1.00	0.015	0.24	**
CRT	1.16	0.42	7.73	1.00	0.005	3.17	***
CRT_Sq	-0.32	0.15	4.79	1.00	0.029	0.73	**
DG_Factor1	0.13	0.08	2.96	1.00	0.086	1.14	*
DG_Factor2	-0.20	0.10	4.34	1.00	0.037	0.82	**
Training_by_DG	0.35	0.13	7.28	1.00	0.007	1.42	***
Constant	0.65	0.52	1.54	1.00	0.215	1.91	

6. Forecast

There is no single significant factor in the forecasting scenario in both models. It seems that this scenario is very difficult one for student to solve. Table 54 summarizes the significant variables using the first model that excludes the interaction terms. This summary is for all 6 scenarios. Moreover, the sign of the coefficient for each significant factor is shown between parentheses. Moreover, table 55 summarizes the significant factors in the second model in which both the main variables and the interaction terms are included.

Table 50: Logistic Regression for Forecast Scenario (all 14 Independent Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	0.57	0.46	1.57	1.00	0.21	1.77
CRT_Sq	-0.25	0.15	2.58	1.00	0.11	0.78
Training	-0.22	0.30	0.55	1.00	0.46	0.80
DG_Factor1	0.00	0.09	0.00	1.00	0.96	1.00
DG_Factor2	-0.06	0.08	0.57	1.00	0.45	0.94
RT_Financial1	0.10	0.11	0.84	1.00	0.36	1.11
RT_Financial2	-0.06	0.14	0.15	1.00	0.70	0.95
RT_Social1	-0.06	0.11	0.31	1.00	0.58	0.94
RT_Social2	-0.01	0.11	0.01	1.00	0.91	0.99
RT_Recreational	-0.05	0.10	0.25	1.00	0.61	0.95
Gender_male	-0.10	0.30	0.11	1.00	0.74	0.90
Grad_Edu	-0.35	0.36	0.92	1.00	0.34	0.70
Work_Exp_OM	-0.50	0.45	1.24	1.00	0.27	0.60
Work_Exp_Any	0.34	0.31	1.15	1.00	0.28	1.40
Constant	1.68	1.18	2.01	1.00	0.16	5.35

Table 51: Logistic Regression for Forecast Scenario (only Significant Variables Excluding Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
No Significant Factors							

Table 52: Logistic Regression for Forecast Scenario (all 22 Independent Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)
CRT	0.96	0.66	2.10	1.00	0.15	2.61
CRT_Sq	-0.25	0.16	2.37	1.00	0.12	0.78
Training	-1.10	1.00	1.21	1.00	0.27	0.33
DG_Factor1	0.01	0.16	0.00	1.00	0.97	1.01
DG_Factor2	-0.11	0.14	0.61	1.00	0.44	0.90
RT_Financial1	0.11	0.11	0.98	1.00	0.32	1.12
RT_Financial2	-0.05	0.15	0.11	1.00	0.74	0.95
RT_Social1	-0.06	0.11	0.31	1.00	0.58	0.94
RT_Social2	-0.01	0.11	0.00	1.00	0.96	0.99
RT_Recreational	-0.06	0.10	0.33	1.00	0.57	0.95
Gender_male	-0.07	0.59	0.01	1.00	0.91	0.93
Grad_Edu	-0.33	0.38	0.72	1.00	0.40	0.72
Work_Exp_OM	-0.51	0.77	0.44	1.00	0.51	0.60
Work_Exp_Any	0.33	0.46	0.54	1.00	0.46	1.40
Male_by_Training	-0.10	0.62	0.03	1.00	0.87	0.90
Male_by_Work_Exp_OM	-0.17	0.95	0.03	1.00	0.85	0.84
Male_by_Work_Exp_Any	0.10	0.63	0.02	1.00	0.87	1.11
CRT_by_Training	-0.17	0.28	0.34	1.00	0.56	0.85
CRT_by_DG_Factor1	-0.05	0.08	0.49	1.00	0.48	0.95
CRT_by_DG_Factor2	-0.02	0.07	0.12	1.00	0.72	0.98
Training_by_DG_Factor1	0.10	0.18	0.34	1.00	0.56	1.11
Training_by_DG_Factor2	0.17	0.16	1.13	1.00	0.29	1.18
Constant	1.63	1.45	1.27	1.00	0.26	5.13

Table 53: Logistic Regression for Forecast Scenario (only Significant Variables Including Interaction)

	B	S.E.	Wald	df	Sig.	Exp(B)	Significant
No Significant Factors							

Table 54: Summary of Significant Factors Excluding Interaction

	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
CRT		** (-)	* (-)		*** (+)	
CRT_Sq					** (-)	
Training	* (-)		* (-)	*** (-)		
DG_Factor1					* (+)	
DG_Factor2						
RT_Financial1	** (+)					
RT_Financial2	*** (-)	** (+)		** (+)		
RT_Social1				* (+)		
RT_Social2						
RT_Recreational						
Gender_male	*** (-)					
Grad_Edu						
Work_Exp_OM						
Work_Exp_Any	** (-)					
Constant	*** (+)					

Table 55: Summary of Significant Factors Including Interaction

	Restaurant	Gas Station	Truck	Sport	Copy Center	Forecast
CRT		*** (-)	* (-)		*** (+)	
CRT_Sq					** (-)	
Training	* (-)	*** (+)	* (-)	*** (-)	** (-)	
DG_Factor1					* (+)	
DG_Factor2					** (-)	
RT_Financial1	** (+)					
RT_Financial2	*** (-)	** (+)		** (+)		
RT_Social1				* (+)		
RT_Social2						
RT_Recreational						
Gender_male	*** (-)					
Grad_Edu						
Work_Exp_OM						
Work_Exp_Any	** (-)					
Male_by_Training						
Male_by_Work_Exp_OM						
Male_by_Work_Exp_Any						
CRT_by_Training						
CRT_by_DG_Factor1						
CRT_by_DG_Factor2						
Training_by_DG_Factor1		*** (-)				
Training_by_DG_Factor2					*** (+)	
Constant	*** (+)		** (+)			

Summary

This chapter presents detailed analyses of the survey. It starts with the process of cleaning the data. Then, demographic information has been provided about the sample used. Then, analysis of CRT and its relationship with the cognitive biases in the 6 scenarios have been presented. Similar analysis has been performed to show the relationship between training and the 6 cognitive biases. Factor analysis using VARIMAX and reliability analysis using Cronbach's alpha have been performed on both delayed gratification and risk taking. Finally, logistic regression has been used to analyze the relationship between the CRT and training as the major independent variables as well as the remaining covariates and the cognitive bias as the dependent variable for all 6 scenarios.

CHAPTER 5

DISCUSSION, CONTRIBUTION AND FUTURE RESEARCH

Discussion

The research objectives of this dissertation has been successfully demonstrated. Cognitive biases are inherent in the mind of people. Although Tversky and Kahneman (1974) did their research on cognitive biases in economic and financial contexts, the same cognitive biases can be observed using operations management contexts. In each of the 6 scenarios tested in the dissertation, more than 50% of the participants chose the biased decision. Some cognitive biases are harder to select than others. Specifically, the copy center and the forecast scenarios seem to be very difficult for the participants. With the copy center scenario, a person has to think deeply to determine that enrollment and whether the course is optional. Enrollment and the optional nature of the course are the two important variables that need to be considered in solving the problem correctly. For the forecast scenario, Kahneman (2013) stated that the concept of regression toward the mean is very difficult and it took Sir Francis Galton a long time to discover this concept. So, it seems that simple training is not enough to help people understand and realize this concept. More advanced training may be required to counteract this cognitive bias. For the other 4 scenarios which are moderately difficult, cognitive biases can be predicted partially using the CRT score. People with high cognitive reflection capabilities tend to make more rational decisions. Moreover, the adverse impact of cognitive biases can be counteracted using training.

Cognitive Reflection Test (CRT) is a reliable test that shows consistent results in the pilot and final studies conducted in this dissertation. The highest percentage of participants score 0 on the test and the lowest percentage scores 3. This is in agreement with the literature that people

have a limited amount of cognitive energy. Therefore, they tend to spend little energy using heuristics and intuition to solve their problems. The CRT is a reasonable predictor of the cognitive biases. It is a significant variable in the gas station and truck. Although CRT is significant in the copy center scenario, its direction is reversed. On the other hand, CRT^2 is only a significant factor in the copy center scenario. Therefore, the square term for CRT may not be useful in predicting cognitive biases.

Training also is a good predictor for cognitive biases. Providing simple training in terms of warning statements helps to reduce the cognitive biases in 3 scenarios: restaurant, truck and sport. For the copy center scenario, it is significant only in the model with interaction terms. Providing training in more sophisticated ways may further improve participants' awareness of cognitive biases and therefore assist them make more rational decisions. An example of such training could be providing a one-week course in which the nature of the cognitive biases are described. Then, trainees may participate in the course by recalling practical examples from their experience. Sharing these practical examples may expand the knowledge of the people and help them to think more deeply and take more rational decisions.

Delayed gratification is represented by two factors in this study. The two factors are significant only in the copy center scenario. However, the sign of their coefficients are opposite to each other. Therefore, in this study DG may not be used as an effective factor in predicting cognitive biases.

Although risk-taking is measured using questions from 5 domains, only three categories show reliable results: financial, social and recreational. Moreover, the financial factor has been also divided into 2 sub factors. The first one is concerned with betting perception and the second one is concerned with investment behavior. The betting factor was significant only in the

restaurant scenario with positive sign. It means that people who perceive betting to be risky tend to make more biased decisions. For the investment factor, there were two situations. In the restaurant scenario, people who perceive investing in high uncertainity situations tend to make less biased decisions. However, these same people tend to make more biased decisions in the gas station and the sport scenarios. Based on the results of these two sub factors, it seems that people with high risk tend to make more biased decisions. Similar conclusion can be inferred based on the social factor. Social factor 1 is significant factor in the sport scenario with positive sign. Again, people who perceive high risk in social situations tend to make more biased decisions.

It can be observed that delayed gratification is measured using questions about financial rewards. Therefore, there could be an overlap between delayed gratification and the financial category of risk taking. Tables 56 shows the regression analysis in which delayed gratification factor 1 is the dependent variable and the 5 factors in risk taking are the independent variables. Similarly, table 57 shows the regression analysis in which the delayed gratification factor 2 is the dependent variable. The only significant factor is risk taking financial 2 in table 56. This overlap could be the reason why delayed gratification is not a significant predictor of the cognitive biases.

Table 56: Regression Analysis in which DG Factor 1 is the Dependent Variable

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.95	0.65		7.62	0.00
RT_Financial1	0.06	0.08	0.04	0.76	0.45
RT_Financial2	-0.18	0.10	-0.11	-1.73	0.08
RT_Social1	0.03	0.08	0.02	0.34	0.74
RT_Social2	-0.03	0.08	-0.02	-0.37	0.72
RT_Recreational	-0.08	0.07	-0.07	-1.07	0.29

Table 57: Regression Analysis in which DG Factor 2 is the Dependent Variable

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.70	0.72		5.16	0.00
RT_Financial1	0.07	0.09	0.05	0.82	0.42
RT_Financial2	-0.08	0.11	-0.04	-0.72	0.47
RT_Social1	0.09	0.09	0.07	1.09	0.28
RT_Social2	0.03	0.09	0.02	0.34	0.73
RT_Recreational	-0.04	0.08	-0.03	-0.54	0.59

Gender is significant only in the restaurant scenario. In this scenario, males tend to make less biased decisions. This is consistent with the literature that males tends to be more rational but the difference is not huge. Instead, it is a subtle difference. Among the 6 scenarios presented in this dissertation, only one scenario shows a gender difference in taking biased decisions.

Work experience in any field is significant in only the restaurant scenario. People with more experience show less cognitive biases. This is an expected results. As people get more experience, they tend to make more rational decisions. It could be because they encounter many situations and they learn from them the right action. However, experience should not be taken as a strong predictor for cognitive biases. In this study, only one scenario shows the effectiveness of experience whereas the other 5 scenarios do not show such result. Moreover, experience in a specific area of OM was not significant predictor in any scenario. One possibility is that the population of this study consists primarily from students. Many of these students have not worked in specialized jobs in OM. Actually, around 73% of the participants reported they have 0 experience in OM field.

The study has 8 interaction terms. Only one interaction term is significant and that is the interaction between training and delayed gratification factor 1 in the gas station scenario and between training and delayed gratification factor 2 in the copy center scenario. The signs of these interaction terms are opposites in the two scenarios. We may conclude that the interaction terms may not be useful in predicting the cognitive biases made by people.

Summary of Hypotheses Tests

This study tests 12 hypotheses. Six hypotheses are related to the training construct and the other six are related to CRT construct. Since two models have been used in the analysis, the results of hypotheses testing are shown in two tables. Table 58 shows the hypotheses testing summary for model 1 in which only the main variables are included. Table 59 shows the summary of using model 2 in which the main variables as well as the interaction terms are included in the analysis.

In both models, 2 hypotheses related to CRT are supported. These two hypotheses are in the gas station and truck scenarios. Similarly, 3 hypotheses related to training are supported in both models. These 3 hypotheses are in the restaurant, truck and sport scenarios. Hypothesis 5 for the copy center scenario is supported only in model 2 including the interaction term

Table 58: Summary of Hypotheses Testing in this Study Using Model 1 (Interaction Terms are Excluded)

Hypothesis	Scenario	Construct	Supported or Not?
H1	Restaurant	Training	Supported
H2	Gas station		Not Supported
H3	Truck		Supported
H4	Sport		Supported
H5	Copy center		Not Supported
H6	Forecast		Not Supported
H7	Restaurant	CRT	Not Supported
H8	Gas station		Supported
H9	Truck		Supported
H10	Sport		Not Supported
H11	Copy center		Not Supported
H12	Forecast		Not Supported

Table 59: Summary of Hypotheses Testing in this Study Using Model 1 (Interaction Terms are Included)

Hypothesis	Scenario	Construct	Supported or Not?
H1	Restaurant	Training	Supported
H2	Gas station		Not Supported
H3	Truck		Supported
H4	Sport		Supported
H5	Copy center		Supported
H6	Forecast		Not Supported
H7	Restaurant	CRT	Not Supported
H8	Gas station		Supported
H9	Truck		Supported
H10	Sport		Not Supported
H11	Copy center		Not Supported
H12	Forecast		Not Supported

Contribution

This dissertation contributes to the decision-making literature in three main areas. The first one is that cognitive biases is a relatively new area of research in operations management literature. Schweitzer & Cachon (2000) started investigating cognitive bias as a specific area of operations management with inventory control though the newsvendor problem. Much subsequent research in cognitive biases focused its attention on the newsvendor problem from different angles. This research presents six scenarios addressing six different cognitive biases in different areas of operations management. The restaurant scenario represents a quality control area. The gas station, copy center and forecast scenarios are related to different aspects of the forecasting domain. The truck scenario characterizes the transportation field. The sport scenario represents purchasing and supply chain partnering. The wide range of OM contexts in which cognitive biases can be observed signifies the importance of this topic and how its adverse effects can be counteracted.

The second contribution is that cognitive biases can be studied in different ways such as simple survey, experiment, case study or meta-analysis. An experimental study is considered costly and time-consuming but the results obtained can be interpreted in terms of cause and effect. In this study, students have been divided into two groups in which the control group received no training and the experimental group received training. The experimental nature of this dissertation helps us to know that although the cognitive biases are inherent in people' mind, its averse effect can be reduced by providing training to these people. So in managerial settings, people who work in OM jobs should be provided training about these biases to help them make more rational decisions.

Finally, organizations could use the CRT test as a way to measure the cognitive reflection of people working in OM areas. However, the CRT should be used with caution. It should not be used as the only tool to measure people's cognition. It should be used as a tool among other tools and criteria to assess the suitability of the person to the OM position concerning making more rational decisions.

Limitations

There are two main limitations in this dissertation. The first one is that the population of the study consists of students enrolled in the business college at UNT. This population is selected because these students are expected to graduate and hold both technical and managerial positions in the work place. When encountered with decisions requiring the use of heuristics, these decisions may be biased. So, this population could be regarded as representative of the people working in service and industry but it is difficult to easily make generalizations. So, external validity may need to be considered in this study. A follow up study could be performed among managers and professionals in OM to verify the results obtained in this study

The second limitation is that this study provides participants with six scenarios. These scenarios represent situations in which participants need to think deeply about difficult tasks in short period of time. Many students complained that although the survey was interesting and thought-provoking, it required a lot of effort. Thinking this deeply is usually beyond the capability of most people. It seems that providing students with four scenarios as done in the second pilot was reasonable, but the effort needed by most people to understand these tasks would need to be further verified in subsequent research.

Future Research

A natural extension of this research is to use the same model and apply it to other 7 cognitive biases proposed by Tversky and Kahneman (1974). In that paper, the representativeness is linked to 6 cognitive biases which have been studied in this dissertation. There are also four cognitive biases related to the availability heuristics and 3 cognitive biases related to the anchoring and adjustment heuristic. By conducting such research, it can be verified that these proposed 13 cognitive biases are applicable in the OM context. Consequently, the literature in this area can be expanded.

The second area of research was to investigate if there is are individual trait differences between people in committing this bias. In this dissertation, cognitive reflection, delayed gratification and risk-taking were used as personal traits that can be used to predict cognitive biases. Other possible personal traits could be an innate tendency to work-hard and neuroticism. These personal traits and others should be explored to predict cognitive biases.

A third possible research area is the creation of additional OM scenarios to test cognitive biases. For example, the restaurant scenario was intended to study the insensitivity to prior probability bias. Two or 3 scenarios could be developed to ensure that this bias occurs in diverse contexts of OM.

Summary

This chapter concludes the dissertation. It discusses the results obtained in chapter 4. Moreover, it summarizes the hypotheses tested in this research. It also presents the contribution and limitations of this dissertation. Finally, it suggests some areas of research as continuation of this dissertation for future investigation.

APPENDIX A

INSTITUTIONAL REVIEW BOARD

APPLICATION NO. 15-260

UNT

A green light to greatness.

THE OFFICE OF RESEARCH INTEGRITY AND COMPLIANCE

June 24, 2015

Supervising Investigator: Dr. Nicholas Evangelopoulos
Student Investigator: Mohammed Alkhars
Department of Information Technology and Decision Sciences
University of North Texas

RE: Human Subjects Application No. 15-260

Dear Dr. Evangelopoulos:

In accordance with 45 CFR Part 46 Section 46.101, your study titled "Decision Making in Operations Management, Part 2" has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

Enclosed is the consent document with stamped IRB approval. Please copy and **use this form only** for your study subjects.

No changes may be made to your study's procedures or forms without prior written approval from the UNT IRB. Please contact Shelia Bourns, Research Compliance Analyst, ext. 4643, if you wish to make any such changes. Any changes to your procedures or forms after three years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Chad Trulson, Ph.D.
Professor
Department of Criminal Justice
Chair, Institutional Review Board

CT:sb

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UNT

A green light to greatness.

THE OFFICE OF RESEARCH INTEGRITY AND COMPLIANCE

October 20, 2015

Supervising Investigator: Dr. Nicholas Evangelopoulos
Student Investigator: Mohammed Alkhars
Department of Information Technology and Decision Sciences
University of North Texas

Institutional Review Board for the Protection of Human Subjects in Research (IRB)
RE: Human Subject Application #15-260

Dear Dr. Evangelopoulos,

The UNT IRB has received your request to modify the study titled "Decision Making in Operations Management, Part 4." As required by federal law and regulations governing the use of human subjects in research projects, the UNT IRB has examined the request to revise the title to Part 4, use 6 scenarios on the survey instrument rather than 4, and revise the time needed for participation in the consent forms. The modifications to this study are hereby approved for the use of human subjects.

The IRB must review this project prior to any other modifications.

Please contact Shelia Bourns, Research Compliance Analyst, at (940) 565-4643 if you wish to make changes or need additional information.

Sincerely,

Chad Trulson, Ph.D.
Professor
Department of Criminal Justice
Chair, Institutional Review Board

CT/sb

For IRB Use Only	
File Number:	
Approval	

Minimal Review Application

University of North Texas Institutional Review Board
OHRP Federalwide Assurance: FWA00007479

Section I: Filling Out and Saving the Form

Save this file as a Word document on your computer, answer all questions completely within Word, and submit it along with all supplemental documents to the IRB Office as described in the Electronic Submission Checklist on page 6.

For Mac Users: To select your response for each check box, click on the appropriate check box and then hit the space bar to place an "X" in the box to indicate your answer.

Section II: Does this Form Apply?

Please click the box indicating your answer to **each** of the following questions.

1. Will your research study involve any vulnerable populations such as children, prisoners, pregnant women or mentally disabled persons?	☐	Yes
	☒	No
2. Could public disclosure of any identifiable data you collect place the participants at risk of criminal or civil liability or be damaging to the participants' financial standing, employability or reputation?	☐	Yes
	☒	No
3. Will your study involve data collection procedures other than surveys, educational tests, interviews, or observation of public behavior?	☐	Yes
	☒	No
4. Will your study involve any sensitive subject matters such as: abortion, criminal activity, sexual activity, sexually transmitted diseases, prior diagnosis for mental health disorders, or victims of violence?	☐	Yes
	☒	No
5. Will your study involve audio-recording or video-recording the participants?	☐	Yes
	☒	No
6. Will your study involve obtaining individually identifiable information from health care plans, health care clearinghouses, or health care providers?	☐	Yes
	☒	No

If you answered YES to any of the above questions, your study will not meet the criteria for Minimal Review. Please fill out the Expedited or Full Board Application for your study.

Section III: General Information

Type only in the blue fields, and closely follow all stated length limits. Handwritten forms will not be accepted.

1. Title of Study

Must be identical to the title of any related internal or external grant proposal.

Decision Making in Operations Management, Round 4

2. Investigator (or Supervising Investigator for Student Studies)

Must be a full-time UNT faculty member or a full-time staff employee whose job responsibilities include conducting human subjects research. A faculty **Supervising Investigator** is required for all student studies which require IRB review, including some theses and dissertations. Student Investigator information is entered in Section 4.

First Name	Last Name	Title
Nicholas	Evangelopoulos	Associate Professor

Form designed and maintained by UNT ORIC, 940. 565.4643. Last updated on August 2013

UNT Department	Email Address	Office Phone Number
Info Tech & Decision Sciences	Nick.Evangelopoulos@unt.edu	9405653056

3. Co-Investigator (if applicable)

First Name	Last Name	E-mail Address

UNT Department or University	Title

4. Student Investigator (if applicable, for student studies such as theses and dissertations)

First Name	Last Name	E-mail Address
Mohammed	AlKhars	Mohammed.alkhars@unt.edu

UNT Department	Degree Program
Info Tech & Decision Sciences	PhD in Business

5. Key Personnel

List the name of all other Key Personnel (including students) who are responsible for the design, conduct, or reporting of the study (including recruitment or data collection).

NIH or CITI IRB Training

Have you, any Co-Investigator, any Student Investigator, and all Key Personnel completed the NIH IRB training course ("Protecting Human Research Participants") or the CITI IRB training course ("Human Subjects Research") and electronically submitted a copy of the completion certificate to untirb@unt.edu?

☒ Yes

☐ No

If you answered "No," this training is required for all Key Personnel before your study can be approved. The NIH IRB course may be accessed by visiting: http://phrp.nihtraining.com. The CITI IRB course may be accessed by visiting: https://www.citiprogram.org/.

6. Funding Information (if applicable)

Has **external or internal funding** been proposed or awarded for this project?

☐ Yes

☒ No

If yes, please submit the statement of work or a project summary and provide the proposal number or project ID number for any external funding or the account number for any internal funding for this project.

Proposal Number or Project ID Number _____
Statement of work or project summary attached?

☐ Yes
☐ No

7. Financial Conflict of Interest Disclosure (if applicable)
Has **external funding** been proposed or awarded for this project?

☐ Yes
☒ No

If yes, the UNT Conflict of Interest Policy for Sponsored Projects requires the Principal Investigator, any Co-Investigator, any project director, and any other person with responsibility for designing, conducting, or reporting of externally funded research to complete an online Financial Conflict of Interest disclosure each fiscal year. Have all investigators and other key personnel for this proposed project completed an online Financial Conflict of Interest disclosure for the current fiscal year? (The online process for submitting a Financial Conflict of Interest Disclosure is available at: https://research.unt.edu/faculty-resources/research-integrity-and-compliance/financial-conflict-interest.)

☐ Yes
☐ No

8. Purpose of Study

In no more than a paragraph, briefly state the purpose of your study in **lay language**, including the research question(s) you intend to answer. A brief summary of what you write here should be included in the informed consent form.

The purpose of this study is to investigate how operations managers make decisions under uncertainty by adapting findings from the behavioral economics and cognitive psychology literature
The research questions are:

1. What cognitive biases can occur in an operations management context?
2. What interventions can reduce such cognitive biases, and how effective are they?

9. Recruitment of Participants

Describe the projected number of subjects.

The study will involve approximately 400 subjects recruited from courses taught in the College of Business

Describe the population from which subjects will be recruited (including gender, racial/ethnic composition, and age range).

The population from which the subjects will be recruited has demographics that generally mirror those of the UNT campus. Subjects will be recruited from undergraduate and graduate courses taught at UNT. The composition of these classes is mixed gender with slightly more male than female, mixed ethnic composition but predominantly Caucasian, and from 19 to approximately 60 years in age.

Describe how you will recruit subjects (face-to-face, e-mail, flyer, classroom announcement, etc.).

Participation will be voluntary. The subjects will be recruited using class announcements posted on Blackboard Learn, invitation e-mails, and face-to-face class announcements.

Have you attached a copy of all recruitment materials such as flyers, e-mails, and scripts for classroom announcements?

☒ Yes

☐ No

10. Location of Study

Identify all locations where the study will be conducted.

The study will only be conducted at UNT in Denton, Texas.

For data collection sites other than UNT, have you attached a signed and dated letter on the cooperating institution's letterhead giving approval for data collection at that site?

☐ Yes

☐ No

11. Informed Consent

Describe the steps for obtaining the subjects' informed consent (by whom, where, when, etc.).

There will be two versions of the data collection survey: A paper version and an online version (Qualtrics).

In the paper-based survey, the first page will include the informed consent asking the student to voluntarily participate in the survey. Mr. Mohammed AlKhars will read the informed consent to the students and obtain appropriate signatures for participation in this study during a regularly scheduled class. This will begin as soon as the project obtains IRB approval.

For the Qualtrics survey, the first screen will ask students to read the informed consent notice and then it will remind them that, once they click to agree, they consent to the terms of participation explained in the informed consent notice. The survey will be posted as soon as the project obtains IRB approval.

12. Informed Consent Forms

Written informed consent forms to be signed by the subject after IRB approval are required for most research projects with human participants (exceptions include telephone surveys, internet surveys, and other circumstances where the subject is not present; an informed consent notice may be substituted). Templates for creating informed consent forms are located on the IRB website at http://research.unt.edu/faculty-resources/research-integrity-and-compliance/use-of-humans-in-research. **Final drafts of all informed consent documents you plan to use must be submitted before IRB review can begin.**

13. Foreign Languages

Will your study involve the use of any language other than English for informed consent forms, data collection instruments, or recruitment materials?

☐ Yes

☒ No

If "Yes," after the IRB has notified you of the approval of the English version of your forms, you must then submit the foreign language versions along with a back-translation for each. Specify all foreign languages below:

14. Data Collection

Which methods will you use to collect data?

☐ Interviews

☒ Surveys

☐ Focus Groups

☐ Other – Please list below.

☒ Internet Surveys

☐ Review of Existing Records

☐ Observation

If "Focus Groups" is checked above, please describe how you will record the data from the focus group.

If "Review of Existing Records" and/or "Observation" are checked above, please describe below the records you plan to review and/or the observations you plan to make for your study.

Have you attached a copy of all data collection instruments, interview scripts, and focus group topics to be used?

☒ Yes

☐ No

What is the estimated time for a subject's participation in each study activity (including time per session and total number of sessions)?

Each participant is expected to spend 30-40 minutes total. There is only one session for each participant.

15. Compensation

Describe any compensation subjects will receive for participating in the study. Include the timing for payment and any conditions for receipt of such compensation. If extra credit for a course is offered, an alternative non-research activity with equivalent time and effort must also be offered.

At the discretion of their instructor, student participants will receive extra academic credit as a compensation for their participation. If a student decides not to participate in this research, an alternative non-research assignment will be available to them. The alternative assignment will be complementary to their course material and will earn them the same extra academic credit.

16. Risks and Benefits

Describe any foreseeable risks to subjects presented by the proposed study and the precautions you will take to minimize such risks.

No foreseeable risks are involved in this study

Describe the anticipated benefits to subjects or others (including your field of study).

This study is not expected to be of any direct benefit to participants, but we hope to learn more about decision making in operations management. This study may help other researchers and practitioners understand how operations managers reach decisions when faced with similar situations.

17. Confidentiality

Describe the procedures you will use to maintain the confidentiality of any personally identifiable data.

The information collected at the exit online survey (equivalently, on the informed consent form for the paper-based survey), including student's name, course number, and instructor's name, will be stored separately and will be used only by the student's instructor for purposes of awarding the extra credit. The anonymous data collected by the main research survey will be stored in the HIPPA compliant Qualtrics secure database until it has been deleted by the student investigator. The data will be also downloaded to the student investigator's and supervising faculty investigator's computers in the form of Excel files. For the paper-based survey, the data will be entered into Excel manually, and then stored in the form of Excel files. These files will be password protected, stored on secure hard drives for 3 years as required by the Federal IRB regulations, and deleted after that period of time. The confidentiality of individual information will be maintained in any

publications or presentations regarding this study. Confidentiality will be maintained to the degree possible given the technology and practices used by the online survey company and UNT IT services. Participation in the online or paper-based survey involves risks to confidentiality similar to a person's everyday use of computers and the internet.

Please specify where your research records will be maintained, any coding or other steps you will take to separate participants' names/identities from research data, and how long you will retain personally identifiable data in your research records. Federal IRB regulations require that the investigator's research records be maintained for 3 years following the end of the study.

The names will be separated from the corresponding survey answers at an early stage. Subsequently, Mr. Mohammed AlKhars will code survey responses with the use of random re-ordering and system-generated response ID numbers, so that anonymity of research data is maintained. Research records will be maintained under lock and key for a period of three years in the researchers' offices and the College of Business computer systems.

18. Publication of Results

Please identify all methods in which you may publicly disseminate the results of your study.

- ☒ Academic Journal
- ☒ Academic Conference Paper or Public Poster Session
- ☐ Book or Chapter
- ☒ A Thesis or Dissertation for One of Your Students
- ☒ UNT Scholarly Works Repository
- ☐ Other – Please list below. (Website, blog, etc.)

Investigator or Supervising Investigator Certification

☒ By checking this box and e-mailing this application to the UNT IRB from my UNT e-mail account, I am certifying that the information in this application is complete and accurate. I agree that this study will be conducted in accordance with the UNT IRB Guidelines and the study procedures and forms approved by the UNT IRB.

Electronic Submission Checklist

1. Attach all supplementary documents, including:
   a. Copies of all NIH or CITI IRB Training completion certificates not previously submitted to the IRB Office;
   b. A copy of the statement of work or project summary for any internal or external funding for this study;
   c. A copy of all recruitment materials;
   d. A copy of the approval letter from each data collection site (other than UNT);
   e. A copy of all informed consent forms or notices; and
   f. A copy of all data collection instruments, interview scripts, focus group topics, and intervention protocols.
2. The application and all supplementary documents must be **e-mailed from the Investigator's or Supervising Investigator's UNT e-mail account to** untirb@unt.edu. Please insert "Minimal Review" in the subject line of your email.

Contact Jordan Harmon at Jordan.Harmon@unt.edu for any questions about completion of your application.

APPENDIX B

EXPERIMENT INSTRUMENT

Pilot 1 Survey Instrument

Informed Consent Notice

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: "Decision Making in Operations Management: Part 1"

Student Investigator: Mohammed AlKhars, University of North Texas (UNT), Department of Information Technology & Decision Sciences

Supervising Investigator: Nick Evangelopoulos, University of North Texas (UNT), Department of Information Technology & Decision Sciences

Purpose of the Study: The purpose of this study is to better understand how humans make decisions related to Operations Management problems.

Study Procedures: You will be asked a few general questions. Then you will be presented with 2 scenarios related to operations management. Your task is to make decisions as if you are appointed as the operations manager of the store and your objective is to maximize the store's profit. Finally you are asked to present some demographic information. It is estimated that participation in the study will take 20-30 minutes of your time. You have to be at least 18 years old to participate in this study.

Foreseeable Risks: No foreseeable risks are involved in this study.

Benefits to the Subjects or Others: This study may help researchers and practitioners understand how operations managers reach decisions when faced with similar situations.

Compensation for Participants: At the discretion of your instructor, you may receive extra academic credit as a compensation for your participation. Participation in this survey is optional. If you decide not to participate in this research, an alternative non-research assignment will be available to you. The alternative assignment will be complementary to your course material and will earn you the same extra academic credit.

Procedures for Maintaining Confidentiality of Research Records: The extra credit information, including your name, course number, and your instructor's name, will be stored separately and will be used only by your instructor for purposes of awarding you the extra credit. The data collected for the research survey will be stored in a secured lock until it has been deleted by the student investigator. The data will also be downloaded to the student investigator's and supervising faculty investigator's computers in the form of Excel files. These files will be stored on secure hard drives for 3 years as required by the Federal IRB regulations. The confidentiality of your individual information will be maintained in any publications or presentations regarding this study. Confidentiality will be maintained to the degree possible.

Questions about the Study: If you have any questions about the study, you may contact Mohammed AlKhars at mohammed.alkhars@unt.edu or Nick Evangelopoulos at 940-565-3056 by e-mail at Nick.Evangelopoulos@unt.edu

Research Participants' Rights:

Your participation in the survey confirms that you have read all of the above and that you agree to all of the following:

Mohammed AlKhars has explained the study to you and you have had an opportunity to contact him with any questions about the study. You have been informed of the possible benefits and the potential risks of the study.

You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.

Your decision whether to participate or to withdraw from the study will have no effect on your grade or standing in this course.

You understand why the study is being conducted and how it will be performed.

You understand your rights as a research participant and you voluntarily consent to participate in this study.

You understand you may print a copy of this form for your records.

You are at least 18 years old.

If you agree to participate in the survey, please continue to the next page.

Part 1

Q1.1. A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?

_____ Cents

Q1.2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

_____ Minutes

Q1.3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?

_____ Days

Part 2

Q2.1. Which of the following best describes the importance of Project Management in your career?

1. I have no interest in Project Management
2. I have some interest in Project Management, but hope to work in a different business discipline
3. I have an interest in Project Management and am trying to develop the necessary skills to be successful in this area.
4. I have a strong interest in Project Management and already understand many of the functions for which a Project Manager is responsible in this area
5. I have worked as a Project Manager and have performed many of the operations of a Project Manager

Part 3

ABC, a chain of convenience stores operating in Texas, has opened stores in different cities such as Dallas and Denton to compete with stores such as 7-Eleven and Speedway.

A destructive tornado has hit a region to the west of Denton and some residential areas have been devastated. Fortunately, nobody died from this event. However, thousands of people evacuated and need to spend 2-3 days away from home. These people are in need of critical supplies.

Because of falling trees and accidents by cars, a few of these people suffer from cuts, bruises, scrapes and other minor injuries. Generally, minor injuries should be treated to avoid infection.

Assume you are the supply chain manager for the ABC company and are in charge of optimizing the company's profits. One of your responsibilities is to forecast the aggregate demand of various products. Due to this event, a disturbance in the normal buying patterns has left you out of stock in a number of items including first aid kits and 1-gallon water bottles. You can place a rush order for only one of these two items.

Warning:

As you consider your choice between first aid kits and 1-gallon water bottles, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to prior probability of outcomes". In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing an underlying probability.

For example, suppose they give you a person's description as follows: "Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail". Then they ask you: is Steve more likely to be a farmer or a librarian? You will be tempted to select librarian, due to the resemblance of the description to a stereotypical librarian. However, there are many more farmers than there are librarians. Therefore, the description is actually more likely to correspond to a farmer, even though the percentage of people who fit the description is minority among farmers

Q3.1.Would you order water bottles or first aid kits?

1. Water bottles
2. First aid kits

Q3.2 How do you rate the clarity of this case?

Very Unclear				Very Clear
1	2	3	4	5

Q3.3 How do you rate the difficulty of this case?

Very Easy				Very Difficult
1	2	3	4	5

Part 4

Gas Station Company ABC is operating in Texas. It has opened stores in different cities such as Dallas and Denton. The company is competing with other gas station chains such as QT and Chevron.

The gas stations offer both gasoline and diesel for cars and trucks. Historical data in your area shows that consumptions of gasoline and diesel are about equal. Therefore, about 50 percent of total fuel consumption is gasoline and about 50 percent is diesel. However, the exact percentage varies from week to week. Sometimes it may be higher that 50 percent, sometimes lower.

Assume you have been selected to be the regional manager in Denton. Among the gas stations under your management, you have a small gas station (station A) equipped with 4 pumps and a large gas station (station B) equipped with 12 pumps. You are responsible for placing orders. The week-to-week fluctuation in consumption is important, because it is related to possible stockouts. Each week, the consumption of gasoline and diesel are recorded.

Warning:

As you consider your choice between small gas station and large gas station, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to sample size". In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing the effect of sample size

For example, suppose they give you a problem's description as follows: "A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower". Then they ask you: which hospital do you think recorded more days when more than 60 percent of the babies were boys? You will be tempted to select the option that the two hospitals are about the same, because these events are described by the same statistic and are therefore equally representative of the general

population. However, sampling theory entails that the expected number of days on which more than 60 percent of the babies are boys is much greater in the small hospital than in the large one, because a large sample is less likely to stray from 50 percent.

Q4.1 Which gas station has a higher probability to record a mix of sold fuel as 60% or more gasoline and, therefore, 40% or less diesel?

1/ Small gas station (station A) 2/ Large gas station (station B) 3/ About the same

Q4.2 How do you rate the clarity of this case?

Very Unclear				Very Clear
1	2	3	4	5

Q4.3 How do you rate the difficulty of this case?

Very Easy				Very Difficult
1	2	3	4	5

Part 5

Q5.1 How likely are you to agree with each of the following statements?

	Very Likely A		Equally likely A or B			Very Likely B	
1/ Receive (A) $3400 this month or (B)$3800 next month	[1]	[2]	[3]	[4]	[5]	[6]	[7]
2/ Receive (A) $100 now or (B) $140 next year	[1]	[2]	[3]	[4]	[5]	[6]	[7]
3/ Receive (A) $100 now or (B) $1100 in 10 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
4/ Receive (A) $9 now or (B) $100 in 10 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
5/ Receive (A) $40 immediately or (B) $1000 in 10 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
6/ Receive (A) $100 now or (B) $20 every year for 7 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
7/ Receive (A) $400 now or (B) $100 every year for 10 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
8/ Receive (A) $1000 now or (B) $100 every year for 25 years	[1]	[2]	[3]	[4]	[5]	[6]	[7]
9/ Receive (A) 30 min. massage in 2 weeks or (B) 45 min. massage in Nov	[1]	[2]	[3]	[4]	[5]	[6]	[7]
10/ Lose (A) $1000 this year or (B) $2000 next year	[1]	[2]	[3]	[4]	[5]	[6]	[7]
11/ (A) Have your tooth pulled today or (B) have your tooth pulled in a month	[1]	[2]	[3]	[4]	[5]	[6]	[7]
12/ Pay (A) $5 for overnight shipping or (B) $1 for shipping in one week.	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Q5.2 How likely are you to agree with each of the following statements?

	Very Unlikely			Neutral		Very Likely	
13/ I will procrastinate till homework assignments are due	[1]	[2]	[3]	[4]	[5]	[6]	[7]
14/ I think about the future in my decision making	[1]	[2]	[3]	[4]	[5]	[6]	[7]
15/ I think about inflation before deciding the amount to spend on a product	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Q 5.3 You are to receive $170 in two months. What is the smallest amount that you would be willing to receive today in stead of receiving the full $170 in two months.

$ _____

Part 6

Q6.1. What is your age group?

[18-20] [21-25] [26-35] [36-50] [51 or more]

Q6.2. What is your gender?

Male Female

Q6.3. What is your academic status?

6. Freshman
7. Sophomore
8. Junior
9. Senior
10. Post-graduate

Q6.4. Rate your work experience in the field of operations management?

6. None
7. Less than six months
8. Between six months and a year
9. Between a year and three years
10. Over three years

Q6.5. Rate your work experience in any field

1. None
2. Less than six months
3. Between six months and a year
4. Between a year and three years
5. Over three years

Q6.6 What is your major?

1. Accounting
2. Aviation Logistics
3. Business Integrated Studies
4. Decision Sciences
5. Economics
6. Entrepreneurship
7. Finance
8. Information Systems
9. Logistics and Supply Chain Management
10. Marketing
11. Operations and Supply Chain Management
12. Organizational Behavior and Human Resource Management
13. Real Estate
14. Risk, Insurance and Financial Services
15. Undeclared major

Any comments on the survey

_____

_____

_____

1C2C

Pilot 2 Survey Instrument

University of North Texas

Informed Consent Form

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: Decision Making in Operations Management, Part 3

Student Investigator: Mohammed AlKhars, University of North Texas (UNT), Department of Information Technology and Decision Sciences.

Supervising Investigator: Nicholas Evangelopoulos, PhD.

Purpose of the Study: The purpose of this study is to investigate how operations managers make decisions under uncertainty.

Study Procedures: You will be asked a few general questions. Then you will be presented with 4 scenarios related to operations management. Your task is to make decisions as if you are working as an operations manager and your objective is to make the right decision. Finally you are asked some demographic questions. It is estimated that participation in the study will take 20-30 minutes of your time. You have to be at least 19 years old to participate in this study.

Foreseeable Risks: No foreseeable risks are involved in this study with the possible exception of anxiety related to decision making. If anxiety becomes an issue for you, remember you can stop participation in this study at any time.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to participants, but we hope to learn more about decision making in operations management. This study may help other researchers and practitioners understand how operations managers reach decisions when faced with similar situations.

Compensation for Participants: At the discretion of your instructor, you will receive extra academic credit as a compensation for your participation. If you decide not to participate in this research, an alternative non-research assignment will be available to you. The alternative assignment will be complementary to your course material and will earn you the same extra academic credit.

Questions about the Study: If you have any questions about the study, you may contact Mohammed AlKhars at Mohammed.AlKhars @unt.edu or Nicholas Evangelopoulos at (940) 565-3056 or by e-mail at Nick.Evangelopoulos@unt.edu.

Research Participants' Rights:

This is a pilot study. Research study participant's rights are listed below for your reference

- Mohammed AlKhars (or Nicholas Evangelopoulos, where applicable) has explained the study to you and answered all of your questions. You have been told the possible benefits and the potential risks and/or discomforts of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- Your decision whether to participate or to withdraw from the study will have no effect on your grade or standing in this course.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You have been told you will receive a copy of this form.

_____

Printed Name of Participant

_____ _____

Signature of Participant Date

Title of Study: Decision Making in Operations Management, Part 3 (Pilot)

SURVEY INSTRUMENT

Survey Instructions

Please answer the questions below.

Part 1

Q1.1. A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?

_____ Cents

Q1.2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

_____ Minutes

Q1.3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?

_____ Days

Part 2

Q2.1. Which of the following best describes the importance of Operations Management in your career?

6. I have no interest in Operations Management
7. I have some interest in Operations Management, but hope to work in a different business discipline
8. I have an interest in Operations Management and am trying to develop the necessary skills to be successful in this area.
9. I have a strong interest in Operations Management and already understand many of the functions for which an Operations Manager is responsible in this area
10. I have worked as an Operations Manager and have performed many of the operations of an Operations Manager

Part 3

Gas Station Company ABC is operating in Texas. It has opened stores in different cities such as Dallas and Denton. The company is competing with other gas station chains such as QT and Chevron.

The gas stations offer both gasoline and diesel for cars and trucks. Historical data in your area shows that consumptions of gasoline and diesel are about equal. Therefore, about 50 percent of total fuel consumption is gasoline and about 50 percent is diesel. However, the exact percentage varies from week to week. Sometimes it may be higher that 50 percent, sometimes lower.

Assume you work as the regional manager in Denton. Among the gas stations under your management, you have a small gas station (station A) equipped with 4 pumps and a large gas station (station B) equipped with 12 pumps. You are responsible for placing orders. The week-to-week fluctuation in consumption is important, because it is related to possible stockouts. Each week, the consumptions of gasoline and diesel are recorded.

Warning:

As you consider your choice between small gas station and large gas station, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to sample size". In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing the effect of sample size.

For example, suppose they give you a problem's description as follows: "A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower". Then they ask you: which hospital do you think recorded more days when more than 60 percent of the babies were boys? You will be tempted to select the option that the two hospitals are about the same, because these events are described by the same statistic and are therefore equally representative of the general population. However, sampling theory entails that the expected number of days on which more than 60 percent of the babies are boys is much greater in the small hospital than in the large one, because a large sample is less likely to stray from 50 percent.

Q3.1. Which gas station has a higher probability to record a mix of fuel sold as 65% or more gasoline and, therefore, 35% or less diesel?

1/ Small gas station (station A) 2/ Large gas station (station B) 3/ About the same

Part 4

Company ABC operates a regional distribution center for meat products. Assume you are the new assistant operations manager. Part of your job is to keep track of the arrival times of the delivery trucks.

Based on observations from the last one year, 99% of deliveries arrived independently of each other within 15 minutes from the target arrival time. Half of them arrived within 15 minutes early (ahead of time) and half of them arrived within 15 minutes late. Being early vs. late has different consequences depending on the day of the week. It is part of your job to plan for such consequences and have contingencies in place.

During the last two weeks, you recorded the status (E = early, L = late) of a certain truck driver as follows.

Week 1 (Pattern 1):

Day	Mon	Tue	Wed	Thu	Fri	Sat
Status	E	L	E	L	L	E

Week 2 (Pattern 2):

Day	Mon	Tue	Wed	Thu	Fri	Sat
Status	E	L	E	E	E	E

Warning:

As you consider your choice between pattern 1 and pattern 2, please note that such choices are sensitive to a well-known cognitive bias, called "misconception of chance". In this bias, the decision maker expect that a sequence of events generated by a random process will represent the essential characteristics of that process even when the sequence is short.

For example, in considering tosses of a coin for heads or tails, people regard the sequence H-T-H-T-T-H to be more likely than the sequence H-H-H-H-T-H, which does not represent the fairness of the coin. This is not true, as both patterns are equally likely.

Q4.1. Which one of the two patterns is more likely to be observed in a specific future week?

1/ Pattern 1 is more likely to be observed in a specific future week
2/ Pattern 2 is more likely to be observed in a specific future week
3/ Both Patterns are equally likely to be observed in a specific future week

Part 5

Company ABC operates a regional distribution center for meat products. Assume you are the new assistant operations manager. Part of your job is to keep track of the arrival times of the delivery trucks.

Based on observations from the last one year, 99% of deliveries arrived independently of each other within 15 minutes from the target arrival time. Half of them arrived within 15 minutes early (ahead of time) and half of them arrived within 15 minutes late. Being early vs. late has different consequences depending on the day of the week. It is part of your job to plan for such consequences and have contingencies in place.

During the last 6 days, you recorded the status (E = early, L = late) of a certain truck driver as follows.

Day	Mon	Tue	Wed	Thu	Fri	Sat
Status	E	L	E	E	E	E

Warning:

As you consider your choice between early and late, please note that such choices are sensitive to a well-known cognitive bias, called "gambler's fallacy". In this bias, the decision maker expects that a sequence of events generated by a random process will correct itself to match the long-run probabilities, even when the sequence is short.

After observing a long run of red on the roulette wheel, for example, most people erroneously believe that black is now due, presumably because the occurrence of black will result in a more representative sequence than the occurrence of an additional red. This is not true. Although, in the long run, observed frequencies tend to match the corresponding probabilities, in the short run, processes do not "correct themselves". Thus, observing red or black will be equally likely at each occurrence, regardless of what has been observed in the immediately preceding occurrences.

Q5.1. What do you think will happen on the 7th day (which is a Monday, since Sunday is the driver's day off)?

1/ An early (E) status will most likely be observed on the 7th day
2/ A late (L) status will most likely be observed on the 7th day
3/ Early (E) or late (L) are equally likely to be observed on the 7th day

Part 6

ABC is a chain of buffet-style restaurants. Assume you are the new assistant store manager. Part of your duties is to maintain food safety procedures. The restaurant offers a soup bar, with six different types of soup available to the customers. You are aware that, according to the U.S. Department of Agriculture, thousands of deaths and millions of illnesses each year are directly linked to foodborne bacteria and other microorganisms. To control bacteria growth in your soups, it is important to keep their temperatures outside of the so-called *danger zone*, a range of temperatures from 40 to 140 ^{0}F (5 to 60 ^{0}C). Keeping soups at a safe temperature can be challenging, since they need to be heated when they are cooked, chilled when they are stored, and reheated when they are about to be consumed by the customers. Therefore, soups pass through the danger zone twice.

Throughout the day, soups are stored in the refrigerator inside plastic bags. Four times a day, cold plastic bags are opened and soup is quickly heated on a stove. When offered to the customers, the six types of soup are kept warm inside six metal containers (*bain-maries*). Soup temperature at ABC restaurants is monitored every half hour during the period 11:30am – 10pm, for a total of 22 measurements per day, which are entered into a soup temperature log.
One morning, as you review the previous day's soup temperature log, you are puzzled —and concerned— by a few temperature entries that were around 120 ^{0}F (49 ^{0}C). When this problem occurs, the most likely cause is human error related to the handling of the refrigerator (e.g. the refrigeration temperature setting is too cold) or the stove (e.g. the heating temperature setting is not hot enough).

While refrigerator problems generally occur six times more frequently than stove problems, you can recall many recent instances when the soup temperature was around 120 ^{0}F toward the end of the day and the cause was the stove. When this type of problem can be traced to the refrigerator, about two-thirds of the time the problem occurs toward the beginning of the day, and only about one third of the times the problem occurs toward the end of the day. When the stove causes the problem, the problem tends to occur almost exclusively toward the end of the day. In fact, your records verify that, among the 12 occurrences of a temperature problem caused by the stove in the past six months, all 12 (100%) occurred toward the end of the day. Looking at the temperature log, you see that the problem this time occurred toward the end of the day. You now need to establish the most likely cause and take specific action.

Warning:

As you consider your choice between the refrigerator and the stove, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to prior probability of outcomes." In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing an underlying probability.

For example, suppose they give you a person's description as follows: "Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail." Then they ask you: is Steve more likely to be a farmer or a librarian? You will be tempted to select librarian,

due to the resemblance of the description to a stereotypical librarian. However, there are many more farmers than there are librarians. Therefore, the description is actually more likely to correspond to a farmer, even though the percentage of people who fit the description is a minority among farmers.

Q6.1. Given that the problem occurred toward the end of the day, what is the most likely cause of the low temperature in soups?

1/ The refrigerator
2/ The stove

Part 7

Q7.1 How likely are you to agree with each of the following statements?

	Very Likely A			Equally likely A or B			Very Likely B	
1/ Receive (A) $3400 this month or (B)$3800 next month		[1]	[2]	[3]	[4]	[5]	[6]	[7]
2/ Receive (A) $100 now or (B) $140 next year		[1]	[2]	[3]	[4]	[5]	[6]	[7]
3/ Receive (A) $100 now or (B) $1100 in 10 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
4/ Receive (A) $9 now or (B) $100 in 10 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
5/ Receive (A) $40 immediately or (B) $1000 in 10 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
6/ Receive (A) $100 now or (B) $20 every year for 7 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
7/ Receive (A) $400 now or (B) $100 every year for 10 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
8/ Receive (A) $1000 now or (B) $100 every year for 25 years		[1]	[2]	[3]	[4]	[5]	[6]	[7]
9/ Lose (A) $1000 this year or (B) $2000 next year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	

Q 7.2 You are to receive $170 in two months. What is the smallest amount that you would be willing to receive today instead of receiving the full $170 in two months?

$ _____

Part 8

Q8.1. What is your age group?

[18-20] [21-25] [26-35] [36-50] [51 or more]

Q8.2. What is your gender?

Male Female

Q8.3. What is your academic status?

11. Freshman
12. Sophomore
13. Junior
14. Senior
15. Post-graduate (incl. graduate student)
16. Not a student

Q8.4. Rate your work experience in the field of operations management:

11. None
12. Less than six months
13. Between six months and a year
14. Between a year and three years
15. Over three years

Q8.5. Rate your work experience in any field:

6. None
7. Less than six months
8. Between six months and a year
9. Between a year and three years
10. Over three years

Q8.6 What is/was your major?

16. Accounting
17. Aviation Logistics
18. Business Integrated Studies
19. Decision Sciences
20. Economics
21. Entrepreneurship
22. Finance
23. Information Systems
24. Logistics and Supply Chain Management
25. Marketing
26. Operations and Supply Chain Management
27. Organizational Behavior and Human Resource Management
28. Real Estate
29. Risk, Insurance and Financial Services
30. Other major
31. Undeclared major/ No major

Q8.7. If you have any comments on this survey, please provide them below:

_____

_____

_____

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_____

_____

Final Study Survey Instrument

University of North Texas Institutional Review Board

Informed Consent Form

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: Decision Making in Operations Management, Part 4

Student Investigator: Mohammed AlKhars, University of North Texas (UNT), Department of Information Technology and Decision Sciences.

Supervising Investigator: Nicholas Evangelopoulos, PhD.

Purpose of the Study: The purpose of this study is to investigate how operations managers make decisions under uncertainty.

Study Procedures: You will be asked a few general questions. Then you will be presented with 6 scenarios related to operations management. Your task is to make decisions as if you are working as an operations manager and your objective is to make the right decision. Then, you will answer questions assessing your risk attitude. Finally you are asked some demographic questions. It is estimated that participation in the study will take 30-40 minutes of your time. You have to be at least 18 years old to participate in this study.

Foreseeable Risks: No foreseeable risks are involved in this study with the possible exception of anxiety related to decision making. If anxiety becomes an issue for you, remember you can stop participation in this study at any time.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to participants, but we hope to learn more about decision making in operations management. This study may help other researchers and practitioners understand how operations managers reach decisions when faced with similar situations.

Compensation for Participants: At the discretion of your instructor, you will receive extra academic credit as a compensation for your participation. If you decide not to participate in this research, an alternative non-research assignment will be available to you. The alternative assignment will be complementary to your course material and will earn you the same extra academic credit.

Procedures for Maintaining Confidentiality of Research Records: The information collected at the exit online survey (equivalently, on the informed consent form for the paper-based survey), including student's name, course number, and instructor's name, will be stored separately and will be used only by the student's instructor for purposes of awarding the extra credit. The anonymous data collected by the main research survey will be stored in the HIPPA compliant Qualtrics secure database until it has been deleted by the student investigator. The data will be also downloaded to the student investigator's and supervising faculty investigator's computers in the form of Excel files. For the paper-based survey, the data will be entered into Excel manually, and then stored in the form of Excel files. These files will be password protected, stored on secure hard drives for 3 years as required by the Federal IRB regulations,

and deleted after that period of time. The confidentiality of individual information will be maintained in any publications or presentations regarding this study. Confidentiality will be maintained to the degree possible given the technology and practices used by the online survey company and UNT IT services. Participation in the online or paper-based survey involves risks to confidentiality similar to a person's everyday use of computers and the internet.

Questions about the Study: If you have any questions about the study, you may contact Mohammed AlKhars at Mohammed.AlKhars @unt.edu or Dr. Nicholas Evangelopoulos at (940) 565-3056 or by e-mail at Nick.Evangelopoulos@unt.edu.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants' Rights:

Your signature below indicates that you have read or have had read to you all of the above and that you confirm all of the following:

- Mohammed AlKhars (or Nicholas Evangelopoulos, where applicable) has explained the study to you and answered all of your questions. You have been told the possible benefits and the potential risks and/or discomforts of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- Your decision whether to participate or to withdraw from the study will have no effect on your grade or standing in this course.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You have been told you will receive a copy of this form.

_____
Printed Name of Participant

_____ _____
Signature of Participant Date

For the Investigator or Designee:

I certify that I have reviewed the contents of this form with the subject signing above. I have explained the possible benefits and the potential risks and/or discomforts of the study. It is my opinion that the participant understood the explanation.

_____ _____
Signature of Investigator or Designee Date

Title of Study: Decision Making in Operations Management, Part 4

SURVEY INSTRUMENT

Survey Instructions

Please answer the questions below.

Section 1

Q1.1. A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?

_____ Cents

Q1.2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?

_____ Minutes

Q1.3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake?

_____ Days

Section 2

Q2.1. Which of the following best describes the importance of Operations Management in your career?

11. I have no interest in Operations Management
12. I have some interest in Operations Management, but hope to work in a different business discipline
13. I have an interest in Operations Management and am trying to develop the necessary skills to be successful in this area.
14. I have a strong interest in Operations Management and already understand many of the functions for which an Operations Manager is responsible in this area
15. I have worked as an Operations Manager and have performed many of the operations of an Operations Manager

Section 3

ABC is a chain of buffet-style restaurants. Assume you are the new assistant store manager. Part of your duties is to maintain food safety procedures. The restaurant offers a soup bar. To control bacteria growth in your soups, it is important to keep their temperatures either cold enough, or hot enough. Keeping soups at a safe temperature can be challenging, since they need to be heated when they are cooked, chilled when they are stored, and reheated when they are about to be consumed by the customers. One morning, as you review the previous day's soup temperature log, you are puzzled —and concerned— by a few temperature entries that were around 120 ^{0}F, which is not hot enough, making the soups unsafe. When this type of problem occurs, the most likely cause is human error related to the handling of the refrigerator (e.g. the refrigeration temperature setting is too cold) or the stove (e.g. the heating temperature setting is not hot enough).

While refrigerator problems generally occur six times more frequently than stove problems, you can recall many recent instances when the soup temperature was around 120 ^{0}F toward the end of the day and the cause was the stove. When this type of problem can be traced to the refrigerator, about two-thirds of the time the problem occurs toward the beginning of the day, and only about one third of the times the problem occurs toward the end of the day. When the stove causes the problem, the problem tends to occur almost exclusively toward the end of the day. In fact, your records verify that, among the 12 occurrences of a temperature problem caused by the stove in the past six months, all 12 (100%) occurred toward the end of the day. Looking at the temperature log, you see that the problem this time occurred toward the end of the day. You now need to establish the most likely cause and take specific action.

Q3.1. Given that the problem occurred toward the end of the day, what is the most likely cause of the low temperature in soups?

1/ The refrigerator
2/ The stove
3/ About the same

Warning:

As you consider your choice between the refrigerator and the stove, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to prior probability of outcomes." In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing an underlying probability.

For example, suppose they give you a person's description as follows: "Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail." Then they ask you: is Steve more likely to be a farmer or a librarian? You will be tempted to select librarian, due to the resemblance of the description to a stereotypical librarian. However, there are many more farmers than there are librarians. Therefore, the description is actually more likely to correspond to a farmer, even though the percentage of people who fit the description is a minority among farmers.

Section 4

Gas Station Company ABC is operating in Texas. It has opened stores in different cities such as Dallas and Denton. The company is competing with other gas station chains such as QT and Chevron.

ABC gas stations offer both gasoline and diesel for cars and trucks. Historical data in your area shows that consumptions of gasoline and diesel are about equal. Therefore, about 50 percent of total fuel consumption is gasoline and about 50 percent is diesel. However, the exact percentage varies from week to week. Sometimes it may be higher that 50 percent, sometimes lower.

Assume you work as the regional manager in Denton. Among the gas stations under your management, you have a small gas station (station A) equipped with 4 pumps and a large gas station (station B) equipped with 12 pumps. You are responsible for placing orders. The week-to-week fluctuation in consumption is important, because it is related to possible stockouts. Each week, the consumptions of gasoline and diesel are recorded.

Q4.1. Which gas station has a higher probability to record a mix of fuel sold as 65% or more gasoline and, therefore, 35% or less diesel?

1/ Small gas station (station A) 2/ Large gas station (station B) 3/ About the same

Warning:

As you consider your choice between small gas station and large gas station, please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to sample size". In this bias, the decision maker will jump to an intuitive choice after recognizing a familiar situation, without properly assessing the effect of sample size.

For example, suppose they give you a problem's description as follows: "A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower". Then they ask you: which hospital do you think recorded more days when more than 60 percent of the babies were boys? You will be tempted to select the option that the two hospitals are about the same, because these events are described by the same statistic and are therefore equally representative of the general population. However, sampling theory entails that the expected number of days on which more than 60 percent of the babies are boys is much greater in the small hospital than in the large one, because a large sample is less likely to stray from 50 percent.

Section 5

You are the sales forecaster of a department store chain ABC. All stores are similar in size and merchandise selection, but their sales differ because of competition, and random factors. You are given the results for 2014 and asked to forecast sales for 2015. You have been instructed to accept the forecast of economists that sales will increase overall by 10%. The following table shows the actual sales for the 4 stores in 2014 as well as 2 forecasts for 2015.

Store	2014	2015 (Forecast 1)	2015 (Forecast 2)
1	$11,000,000	$12,100,000	$14,600,000
2	$23,000,000	$25,300,000	$23,600,000
3	$18,000,000	$19,800,000	$21,800,000
4	$29,000,000	$31,900,000	$29,100,000
Total	**$81,000,000**	**$89,100,000**	**$89,100,000**

Q5.1. Which forecast do you think is more probable?

1/ Forecast 1 2/ Forecast 2 3/About the same

Warning:

As you consider your choice between Forecast 1 and Forecast 2, please note that such choices are sensitive to a well-known cognitive bias, called "Misconception of regression". In this bias, the decision maker will ignore the fact that extreme values, either above or below the average, are difficult to maintain. Therefore, there is a tendency for extreme values to regress toward the mean or average.

For example, suppose a large group of children has been examined on two equivalent versions of an aptitude test. If one selects ten children from among those who did best on one of the two versions, he will usually find their performance on the second version to be somewhat disappointing. Conversely, if one selects ten children from among those who did worst on one version, they will be found, on the average, to do somewhat better on the other version. Ultimately, the scores of the two groups would be close to the average value when they take the second test.

Section 6

Company ABC operates a regional distribution center for meat products. Assume you are the new assistant operations manager. Part of your job is to keep track of the arrival times of the delivery trucks.

Based on observations from the last one year, 99% of deliveries arrived independently of each other within 15 minutes from the target arrival time. Half of them arrived within 15 minutes early (ahead of time) and half of them arrived within 15 minutes late. Being early vs. late has different consequences depending on the day of the week. It is part of your job to plan for such consequences and have contingencies in place.

During the last 6 days, you recorded the status (E = early, L = late) of a certain truck driver as follows.

Day	Mon	Tue	Wed	Thu	Fri	Sat
Status	E	L	E	E	E	E

Q6.1. What do you think will happen on the 7th day (which is a Monday, since Sunday is the driver's day off)?

1/ An early (E) status will most likely be observed on the 7th day
2/ A late (L) status will most likely be observed on the 7th day
3/ Early (E) or late (L) are equally likely to be observed on the 7th day

Warning:

As you consider your choice between early and late, please note that such choices are sensitive to a well-known cognitive bias, called "gambler's fallacy". In this bias, the decision maker expects that a sequence of events generated by a random process will correct itself to match the long-run probabilities, even when the sequence is short.

After observing a long run of red on the roulette wheel, for example, most people erroneously believe that black is now due, presumably because the occurrence of black will result in a more representative sequence than the occurrence of an additional red. This is not true. Although, in the long run, observed frequencies tend to match the corresponding probabilities, in the short run, processes do not "correct themselves". Thus, observing red or black will be equally likely at each occurrence, regardless of what has been observed in the immediately preceding occurrences.

Section 7

ABC Copying Center (ABCCC) is a small business located near a large university complex. ABCCC provides a variety of services to its customers including copies of course materials, sold in packs to students enrolled in the university courses.

ABCCC has a mission to have high reputation for customer service. Therefore, when a student comes to buy a pack from ABCCC, the pack should be available in inventory. If it is not available, ABCCC would print a copy, which usually takes 15-20 minutes. The waiting student may become dissatisfied with the service. On the other hand, if ABCCC builds excessive inventories of packs, then the unsold packs would represent monetary loss to ABCCC. So, the goal of ABCCC is to satisfy its customers at the lowest possible cost.

As part of their inventory management efforts, ABCCC hires you to carefully look at the data from last year. The data consists of the actual sales of 10 courses. 5 courses are in Banking (BA) and 5 are in Economics (EC). The actual sales are thought to be related to 3 factors: the major, the number of enrolled students, and whether the course is optional or required. The data is shown in the following table:

Course	Actual Sales	Major	Enrollment	Optional
BA201	101	BA	130	No
BA220	102	BA	115	No
BA222	105	BA	118	No
BA250	109	BA	215	Yes
BA275	185	BA	200	No
EC101	84	EC	165	Yes
EC201	95	EC	215	Yes
EC220	96	EC	105	No
EC250	85	EC	175	Yes
EC260	95	EC	118	No

Q7.1. In the long run, which of the two majors do you expect to produce higher sales?

1/ The BA Major 2/ The EC major 3/ About the same

Q7.2. How confident are you in the answer you provided above?

1/ High level of confidence 2/ Low level of confidence

Warning:

As you consider your choice between BA Major and EC Major, please note that such choices are sensitive to a well-known cognitive bias, called "Illusion of validity". In this bias, the decision maker will use the internal consistency of a pattern of inputs as a major determinant of one's confidence in predictions based on these inputs. As a consequence, unwarranted confidence is produced by a good fit between the predicted outcome and the input information.

People tend to have great confidence in wrong predictions, which are based on redundant input variables. However, an elementary result in the statistics of correlation asserts that, given input variables of stated validity, a prediction based on several such inputs can achieve higher accuracy when they are independent of each other than when they are redundant or correlated. Thus, redundancy among inputs decreases accuracy even as it increases confidence.

In regression models, some predictor variables may be redundant, given the presence of other, strong predictors in the model.

People then tend to ignore the strong predictors and focus on the redundant ones, if the pattern of relationship between the redundant predictors and the response variable is easier to identify. The correct approach is to carefully assess the effect of all predictors, before deciding which ones are redundant, and then base the prediction on the strong, independent predictors.

Section 8

ABC Sports Camp runs training sessions for young athletes. The training sessions are held at the ABC Sports Complex, which includes athletic facilities, classroom space, dormitories and a picnic area. Currently, a commercial kitchen is absent from the complex. ABC Sports Camp has identified 2 candidate companies to provide food to the athletes. These two candidates are Salem Food Service (SFS) and Dragon Meals (DM). SFS is a multinational company that uses a network of local suppliers to deliver food locally. Last year, SFS launched a civic engagement initiative and built children's playgrounds in a number of local communities around the country. DM is a small and new company that is trying to develop a local market share. It has its own underutilized fleet of vehicles. Last August, DM was expected to open three new restaurants in town, but the entire project got delayed by six months.

Q8.1. ABC Sports Camp needs to select one of the two companies. One important dimension of the selection decision is the quality of food provided. Which company do you expect to have higher food quality?

1/ Salem Food Service (SFS)
2/ Dragon Meals (DM)
3/ About the same

Warning:

As you consider your choice between Salem Food Service (SFS) and Dragon Meals (DM), please note that such choices are sensitive to a well-known cognitive bias, called "Insensitivity to predictability". In this bias, the decision maker will depend on how favorable the description of the company is without considering the reliability of such description.

For example, suppose one is given a description of a company and is asked to predict its future profit. If the description of the company is very favorable, a very high profit will appear most representative of that description; if the description is mediocre, a mediocre performance will appear most representative. The degree to which the description is favorable is unaffected by the reliability of that description or by the degree to which it permits accurate prediction. Hence, if people predict solely in terms of the favorableness of the description, their predictions will be insensitive to the reliability of the evidence and to the expected accuracy of the prediction.

So, when predictability is nil, the same prediction should be made in all cases. For example, if the descriptions of companies provide no information relevant to profit, then the same value (such as average profit) should be predicted for all companies.

Section 9

Q9.1 Please provide a rating (in the parentheses next to each statement) from Extremely Unlikely A to Extremely Likely B, to indicate your preference of A vs. B, using the following scale:

1	2	3	4	5	6	7
Extremely Likely to Prefer A	Moderately Likely to Prefer A	Somewhat Likely to Prefer A	Equally Likely to Prefer A or B	Somewhat Likely to Prefer B	Moderately Likely to Prefer B	Extremely Likely to Prefer B

1/ Receive (A) $3400 this month or (B) $3800 next month ( )

2/ Receive (A) $100 now or (B) $140 next year ( )

3/ Receive (A) $100 now or (B) $1100 in 10 years ( )

4/ Receive (A) $9 now or (B) $100 in 10 years ( )

5/ Receive (A) $40 immediately or (B) $1000 in 10 years ( )

6/ Receive (A) $100 now or (B) $20 every year for 7 years ( )

7/ Receive (A) $400 now or (B) $100 every year for 10 years ( )

8/ Receive (A) $1000 now or (B) $100 every year for 25 years ( )

9/ Lose (A) $1000 this year or (B) $2000 next year ( )

Q 9.2 You are to receive $170 in two months. What is the smallest amount that you would be willing to receive today instead of receiving the full $170 in two months?

$ _____

Section 10

Q10.1 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.
For each of the following statements, please indicate **how risky you perceive** each situation. Please note that we are *not* asking you whether or not you have engaged in these behaviors, we are only asking you how risky you perceive them to be. Provide a rating from *Not at all Risky* to *Extremely Risky*, using the following scale:

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

1. Admitting that your tastes are different from those of a friend.	( )
2. Going camping in the wilderness.	( )
3. Betting a day's income at the horse races.	( )
4. Investing 10% of your annual income in a moderate growth mutual fund.	( )
5. Drinking heavily at a social function.	( )
6. Taking some questionable deductions on your income tax return.	( )
7. Disagreeing with an authority figure on a major issue.	( )
8. Betting a day's income at a high-stake poker game.	( )
9. Having an affair with a married man/woman.	( )
10. Passing off somebody else's work as your own.	( )
11. Going down a ski run that is beyond your ability.	( )
12. Investing 5% of your annual income in a very speculative stock.	( )
13. Going whitewater rafting at high water in the spring.	( )
14. Betting a day's income on the outcome of a sporting event	( )
15. Engaging in unprotected sex.	( )
16. Revealing a friend's secret to someone else.	( )
17. Driving a car without wearing a seat belt.	( )
18. Investing 10% of your annual income in a new business venture.	( )
19. Taking a skydiving class.	( )
20. Riding a motorcycle without a helmet.	( )
21. Choosing a career that you truly enjoy over a more secure one.	( )
22. Speaking your mind about an unpopular issue in a meeting at work.	( )
23. Sunbathing without sunscreen.	( )
24. Bungee jumping off a tall bridge.	( )
25. Piloting a small plane.	( )
26. Walking home alone at night in an unsafe area of town.	( )
27. Moving to a city far away from your extended family.	( )
28. Starting a new career in your mid-thirties.	( )
29. Leaving your young children alone at home while running an errand.	( )
30. Not returning a wallet you found that Contains $200.	( )

Section 11

Q11.1. What is your age group?

[18-20] [21-25] [26-35] [36-50] [51 or older]

Q11.2. What is your gender?

Male Female

Q11.3. What is your academic status?

17. Freshman
18. Sophomore
19. Junior
20. Senior
21. Post-graduate (incl. graduate student)
22. Not a student

Q11.4. Rate your work experience in the field of operations management:

16. None
17. Less than six months
18. Between six months and a year
19. Between a year and three years
20. Over three years

Q11.5. Rate your work experience in any field:

11. None
12. Less than six months
13. Between six months and a year
14. Between a year and three years
15. Over three years

Q11.6 What is/was your major?

32. Accounting
33. Aviation Logistics
34. Business Integrated Studies
35. Decision Sciences
36. Economics
37. Entrepreneurship
38. Finance
39. Information Systems
40. Logistics and Supply Chain Management
41. Marketing
42. Operations and Supply Chain Management
43. Organizational Behavior and Human Resource Management
44. Real Estate
45. Risk, Insurance and Financial Services
46. Other major
47. Undeclared major/ No major

Q11.7. If you have any comments on this survey, please provide them below:

_____

_____

_____

_____

_____

_____

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[Survey ABFCED 1]

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