Protection Motivation Theory:
Understanding the Determinants of Individual Security Behavior

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Abstract

Individuals are considered the weakest link when it comes to securing a personal computer system. All the technological solutions can be in place, but if individuals do not make appropriate security protection decisions they introduce holes that technological solutions cannot protect. This study investigates what personal characteristics influence differences in individual security behaviors, defined as behaviors to protect against security threats, by adapting Protection Motivation Theory into an information security context.

This study developed and validated an instrument to measure individual security behaviors. It then tested the differences in these behaviors using the security research model, which built from Protection Motivation Theory, and consisted of perceived security vulnerability, perceived security threat, security self-efficacy, response efficacy, and protection cost. Participants, representing a sample population of home computer users with ages ranging from 20 to 83, provided 279 valid responses to surveys. The behaviors studied include using anti-virus software, utilizing access controls, backing up data, changing passwords frequently, securing access to personal computers, running software updates, securing wireless networks, using care when storing credit card information, educating others in one's house about security behaviors, using caution when following links in emails, running spyware software, updating a computer's operating system, using firewalls, and using pop-up blocking software. Testing the security research model found different characteristics had different impacts depending on the behavior studied. Implications for information security researchers and practitioners are provided, along with ideas for future research.

Dedication

This dissertation is dedicated to my loving wife, Crystal, and my two wonderful boys, David and Aidan, who encouraged me and supported me through the arduous task of pursuing my Ph.D. Crystal, your unconditional love, patience, and understanding as I have enjoyed the highs of success and lows of failure have provided a balance that has enabled me to persevere through this process. David and Aidan, your infectious laughter and desire to roughhouse and play with Daddy regardless of my state of mind and are a continuous reminder that there are more important things in life than the work that is forever in front of me. I love all of you very much and look forward to the journey, wherever life may take us.

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Chapter One: Introduction

Prior to the emergence of the Internet, computers had no direct access to other computers. In such an environment, there was little concern for the security of information. As computers began to plug into the Internet, which connected computers from all over the world, a door was opened that allowed for vast sharing of information. With information easily flowing over this network and the lack of a security conscious design, the Internet allowed some people to use this resource to steal and destroy for opportunistic gain or for fun. As security of information became a concern, mechanisms were added on top of the existing Internet to provide for protection of information. This piece-meal approach to providing security on the Internet has created an environment where information security professionals must continually work to keep information safe (Whitman et al. 2009).

Businesses lose a significant amount of money each year due to security attacks. One survey of United States companies, conducted by the Computer Security Institute (CSI) with the support of the Federal Bureau of Investigation (FBI), found that companies lost an average of $345,000 due to security breaches and computer crime during 2006 (Richardson 2007). However, it is likely that such losses are even greater as it is often difficult to quantify security losses (Richardson 2007) and many companies do not have a way to measure the cost of security breaches beyond direct revenue losses (Deloitte 2006). To address the losses from security breaches, 98% of companies worldwide continue to significantly increase their security budgets (Deloitte 2007). Increased funding is often included as part of the overall IT budget, indicating companies view information security as an IT function, which is contrary to the fact that information security is as much a people problem as it is a technological problem (Deloitte 2005; Deloitte 2006; Deloitte 2007).

One approach used to address the security issues posed by people within an organization is to increase the awareness and training of employees. When utilizing training and awareness programs, it is important to train people on the security mechanisms they can use to protect information as well as to make them aware of potential threats to computer systems (Whitman 2003). However, corporations do very little to provide training to their employees. One author noted that "while the industry talks a good game about teaching users how to be good stewards of company network resources, they don't put real dollars behind the proposition" (Richardson 2007). Other studies support this claim by Richardson, finding that companies view training and awareness as important aspects of their security plan, but do not have adequate funding or programs to properly educate and train their employees (Deloitte 2005; 2006; 2007).

The issue of security takes on a new level of concern when extending the performance of individuals beyond the corporate setting into a home environment. In a corporate setting, there are employees available to perform part of the security task, but in a home environment, it is completely up to the individual to take all of the steps to secure their home computers and network. Failing to secure home computers and networks properly can result in financial losses and time loss for individuals, dealing with such things as identity theft, lost or corrupted files, and stolen laptops. Improperly secured home computers can result in additional issues for corporations when the stolen access to an individual's computer is used to mount attacks against the corporation, which can lead to a number of issues such as financial losses and increased down time on network machines due to denial of service attacks (Whitman et al. 2009).

One of the more costly issues that individuals face online is identity theft, which has become a serious problem facing many people. A recent study (http://www.privacyrights.org/ar/idtheftsurveys.htm) by the Javelin Strategy and Research group, a research group focusing on consumer security and privacy, found that 8.4 million Americans were victims of identity theft during 2007, decreasing from 9.3 million in 2005. Such decreases are encouraging, but a large number of identity thefts still occur. The victims of identity theft in 2007 lost $49.3 billion for an average loss per victim of over $5,000. These losses go beyond a financial impact to consumers; it also creates a cost for businesses that have to return money they made on products sold due to stolen credit cards and other forms of stolen information. In order to fight the vast number of thefts due to identity theft, it is necessary to educate consumers on the steps they need to take.

It is surprising that little education or training takes place, considering that corporations view education as an important step in their efforts to fight security attacks. It is also surprising that there are few, if any studies, trying to understand the human component of a secure information system as end users are an integral component in securing information systems. It has also been noted that there is a dearth of research on the socio-organizational perspective of security within the IS research community (Dhillon et al. 2000; 2001). An understanding of factors that influence people to perform behaviors to protect against security threats seems a necessary precursor to a successful training program. However, very little empirical research exists upon which to make such assessments (Cannoy et al. 2006). This raises the following question: What differences in individuals influence their effectiveness at performing security behaviors?

The goal of this dissertation is to begin to address this question by 1) proposing a research model to explain what motivates people to perform individual security behaviors and 2) developing a way to measure individual security behaviors. This research builds upon an existing theory to propose a new theory, which suggests that, an individual's perceptions of threat severity and vulnerability, along with their ability to respond to threats, explains their performance of security behaviors. As part of the research process, a validated instrument to measure individual security behaviors is developed following the recommendations of Straub (1989).

Purpose of the Study

An awareness and understanding of the threats posed by security attacks is a necessary precursor to making a decision to implement a countermeasure to protect against those threats. One approach taken by businesses to deal with threats is to conduct a risk assessment. This is done by quantifying the cost of a threat occurring, the probability that it will occur, and the cost of performing the countermeasure to protect against the threat. These numbers are used to determine whether a proposed expenditure is a cost effective approach to preventing the threat. The process of deciding whether to implement a threat prevention measure is performed by assigning each threat a monetary value along with an expected likelihood of the event occurring. These two values are multiplied together to calculate an expected cost for the threat. Then, the cost of invoking a countermeasure, or coping mechanism, to prevent that threat is determined. By subtracting the cost of responding to the threat from the cost of the threat occurring a determination is made as to whether it is financially worth it to invoke the countermeasure (Panko 2004). A graphical illustration of this decision making process is presented in Table 1.1.

Table 1.1 - Security Risk Analysis Matrix (Panko 2004)

Step	Threat	A	B	C	D
1	Cost if attack succeeds	$800,000	$20,000	$150,000	$5,000
2	Probability of occurrence	80%	20%	5%	70%
3	Threat severity	$640,000	$4,000	$7,500	$3,500
4	Countermeasure cost	$300,000	$5,000	$5,000	$10,000
5	Value of protection	$340,000	($1,000)	$2,500	($7,500)
6	Apply countermeasure?	Yes	No	Yes	No
7	Priority	1	NA	2	NA

An underlying assumption of the risk analysis presented in Table 1.1 is that the threat is known, which allows for an assessment can be made. A similar argument can be made for users of computer systems. Once the threats are known they mentally perform some sort of an assessment about whether they should perform a countermeasure to protect against the threat, and they need to believe that the countermeasure will be an effective tool to fight against the threat and that they have the capabilities to perform the countermeasure.

Research Question

Moving from the way that corporations assess and make decisions about security risk to understanding the way individuals assess and make decisions about security risks is a sizable jump, filled with many unknowns and assumptions. However, understanding the process that individuals go through in making decisions about performing security countermeasures is important due to the increasing cost of dealing with a successful security attack. This leads to the purpose of this study, which is to address the following research question:

RQ: What determines the security behaviors of individuals?

This research proceeds to answer this question in four stages. First, a framework to build a new behavioral research model upon is built by relying on existing IS security literature. Second, an instrument for measuring the security behaviors of individuals is created. Then, the newly proposed behavioral security research model is tested, utilizing the newly designed instrument, which serves as the dependent variable in the model. Finally, the results and implications for future research are considered.

Research Framework

One theory generally been relied upon to explain IS misuse within an organization is General Deterrence Theory (GDT), which was adapted from the criminal justice field and has been used within IS research to show that security countermeasures can act as a deterrent by increasing the perceptions of the severity and certainty of punishment for misusing information systems (Straub 1990). GDT uses three variables to explain IS misuse within an organization; severity of punishment, certainty of punishment, and rival explanations, which has been operationalized in many different ways including IS specific codes of ethics (Harrington 1996), preventative measures (Kankanhalli et al. 2003), and ethics training (Workman et al. 2007), to name a few. One limitation to GDT is that it only applies within a corporate setting. When expanding the explanation of preventing IS misuse through punishment to a home environment, the theory no longer holds, as there is no one to punish individual users. However, if the definition of GDT is adapted from punishment to threats then the theory provides a framework, upon which a new theory can emerge. This adaptation is possible because a punishment is a threat to the individual that the company will implement an undesired action, similar to a threat in the home environment where an unknown attacker will impose an undesired action.

By changing GDT and substituting threats of security attacks rather than punishment for IS misuse, a framework emerges that propounds the view that severity and vulnerability to threats along with rival explanations determines the security behavior of individuals. This framework provides a theoretical approach that is no longer specific just to organizations where punishment is possible, but to any person who is dealing with security threats. Additionally, it provides a foundation for drawing upon theories from outside disciplines in order to deal with explaining IS security behavior, which was suggested as an approach to understanding the complexities of security by a panel on IS security at the 2007 Americas Conference on Information Systems (AMCIS) (Choobineh et al. 2007).

Detailed Research Model

Building on the framework adapted from GDT, this study relies on an adaptation of the Protection Motivation Theory (PMT), which models behavioral intentions to change health behaviors (Floyd et al. 2000; Rogers 1975). PMT incorporates threat appraisals, the perceived effectiveness of a response, an individual's ability to perform that response, and cost analyses into its design. PMT was created to determine what stimuli variables raise fear in a person and the cognitive process necessary to adopt a behavior that will protect him from the outcome of the fear (Rogers 1975). PMT has been applied successfully to health related issues, injury prevention, political issues, environmental concerns, protecting others, online privacy, and home wireless security (Floyd et al. 2000; Woon et al. 2005; Youn 2005). This suggests that the theory would apply to a broad range of threats that an individual can effectively respond to by performing a given response. Over the course of the last two decades, PMT has proven to be a reliable theory. A meta-analysis of the research conducted using PMT, consisting of 65 studies with approximately 30,000 subjects, representing over 20 health issues, showed that all variables of the theory exerted at least moderate effects in determining adoption of adaptive behaviors (Floyd et al. 2000). As information security is as much about technical solutions as it is about getting people to respond to threats with a given action (Panko 2004), and computer security is often referred to as computer health (Kearns 2006; Lacy et al. 2006), it should be expected that this theory will display similar effects when applied to the information security setting.

The premise of PMT is that individuals go through a coping assessment process to determine whether they should perform some behavior that will influence their health. Sources of information from personal experience or an outside source influences this coping assessment. The individual then performs a threat appraisal, where he determines how severe a given threat is and how vulnerable he thinks he is to that threat. This threat appraisal combines with the individual's coping appraisal, where he determines how well he thinks he can perform the coping mechanism and how effective he thinks the coping mechanism is at providing protection from the threat. By adapting this approach from threats to a person's health to threats to a person's computer system the result is individual security behavior as a dependent variable of interest.

Individual Security Behaviors

Prior to testing a research model that explains the security behaviors of individuals, it is important to understand what composes individual security behaviors and how to measure this construct. A number of IS studies note that there is a lack of research about individual behaviors towards security (Cannoy et al. 2006; Dhillon et al. 2000; 2001). The majority of studies that exist utilize a dichotomous variable to measure security behaviors; none utilizes a validated measure. However, the use of consistent validated measures will ensure the instrument possesses reliability and longitudinal validity (Straub 1989). Using validated measures also allows future researchers to build upon one another's work in an effort to provide a greater understanding of the studied phenomenon. To ensure the dependent variable in this study is reliable and valid and that future researchers can build on findings from this study, this research follows the process that Straub describes to construct a validated measure for individual security behaviors. This process consists of reviewing existing literature to create a foundation of existing suggested security behaviors, followed by a series of interviews with information security experts to provide further insight into appropriate behaviors. The developed instrument is validated on a sample population to ensure that it possesses acceptable levels of reliability and validity.

Independent Variables

Factors that influence individual security behaviors are tested by adapting constructs from PMT. The particular adaptations of the PMT variables to the behavioral security research model are based on how the variables were used in PMT research and how they fit within the security context. This section briefly describes the threat appraisal measures (perceived security vulnerability and perceived threat appraisal) and the coping appraisal measures (security self-efficacy, response efficacy, and prevention cost). Chapter Two provides a more detailed explanation of these measures.

Perceived Security Vulnerability

Protection Motivation Theory research regularly employs a measure called threat vulnerability; defined as the probability that a person believes he or she will experience health related consequences due to performing an unhealthy behavior (Maddux et al. 1983; Rogers 1975). In the context of protecting against security threats, perceived security vulnerability is the probability that a person will experience a computer attack due to a failure to perform a security countermeasure. Perceived security vulnerability, as illustrated in Table 1.1, is one of the processes that businesses utilize to assess the perceived risk of a security threat. Additionally, IS research has investigated the effect that perceived risk has on individual behavior. Perceived risk is conceptualized as uncertainty and consequences (Conchar et al. 2004; Dowling et al. 1994; Jia et al. 1999; Nicolaou et al. 2006; Pavlou et al. 2004). One view of a person's vulnerability to a threat is the certainty with which they perceive that the threatening event will occur. Adapting this PMT measure to explain IS research is fitting, therefore, as it aligns with existing measures used in previous research.

Perceived Security Threat

Another measure used as part of PMT research is threat severity; defined as *the severity of health related consequences that a person believes occur due to performing an unhealthy behavior* (Maddux et al. 1983; Rogers 1975). Adapting this to the context of dealing with security threats means that perceived security threat is *how severe a person believes the consequences are when a security threat manifests itself into a successful attack*. Similar to the Perceived Security Vulnerability discussion above, this is part of the process businesses use in assessing the risk of a security threat. This is also similar to the consequences aspect of perceived risk, as discussed above. The decisions people make when it comes to taking security countermeasures is in direct relation to how severe they believe the consequences are should the threat materialize. Similar to the applicability of adapting threat vulnerability to the IS research field, adapting threat severity is fitting as it also aligns with existing measures used in previous research.

Security Self-Efficacy

PMT also utilizes a measure for self-efficacy or *a person's confidence in his ability to perform some sort of coping mechanism to change an unhealthy behavior* (Maddux et al. 1983). Adapting this to the context of dealing with security threats means that it is the confidence that a person has that he can perform a security countermeasure to prevent a threat from manifesting into a successful attack. For the purpose of this study, this construct is referred to as security self-efficacy. IS research regularly relies on self-efficacy to explain individuals' performance at using computers (Burkhardt et al. 1990; Carlson et al. 1992; Compeau et al. 1999; Compeau et al. 1995a; Delcourt et al. 1993; Fagan et al. 2003; Fenech 1998; Gist et al. 1989; Johnson et al. 2000; Lee et al. 2003; Stephens 2005). One particular approach proposed the concept of computer self-efficacy and validated an instrument to measure the confidence that a person has in using a computer application (Compeau et al. 1995b). Another study provided an analysis of the research using computer self-efficacy and found that it was appropriate and necessary to adapt the computer self-efficacy construct to be context specific (Marakas et al. 2007). Thus, adapting the self-efficacy construct from PMT research to the security self-efficacy construct used in this study is also appropriate and necessary.

Response Efficacy

Response efficacy is another measure that is a part of PMT. PMT research defines this measure as *the perceived effectiveness of a coping mechanism at changing an unhealthy behavior* (Maddux et al. 1983; Rogers 1975). Adapting this to the context of dealing with security threats means that it is the confidence that a person has that performing a security countermeasure will prevent a threatening security event from manifesting itself into a successful attack. This definition is essentially the same as the outcome expectations, which is "*a person's estimate that a given behavior will lead to certain outcomes"* (Bandura 1977). Outcome expectations is a measure that has regularly been used in IS research to explain user performance or acceptance of technology (Chung et al. 2002; Compeau et al. 1999; Compeau et al. 1995b; Lam et al. 2006; Venkatesh et al. 2003). Given that in this study response efficacy is being used to explain a person's performance at performing security behaviors, it is appropriate to apply it in an IS research study.

Prevention Cost

Protection Motivation Theory research utilizes a response cost measure to capture the cost that individuals perceive in performing a different health behavior (Floyd et al. 2000; Rogers 1975). In PMT research, this could have consisted of a reward for continuing unhealthy behavior or a cost for performing a new behavior. However, in a computer security setting, only the cost for performing a new behavior conceptually makes sense. Response cost influencing the performance of a new behavior is consistent with IS research, which has found that cost influences the use or adoption of new technology (Ghorab 1997; Reardon et al. 2007; Wu et al. 2005). However, response cost could be inferred to mean the cost of responding to an attack, therefore this measure is referred to as prevention cost in the study, which reflects the cost of preventing a threat from manifesting into a successful attack.

Research Model

A recent panel on IS security at the 2007 Americas Conference on Information Systems (AMCIS) suggested that, in order to deal with the increased challenges of IS security, new theories from reference disciplines needed to be examined (Choobineh et al. 2007). Such a suggestion is consistent with a study that reviewed security research in the top IS journals over a ten-year period and found very little theoretically founded, empirical research in the realm of IS security (Cannoy et al. 2006). A more expansive review of the literature, as presented in Chapter Two of this dissertation, found results consistent with the study by Cannoy and her colleagues. Following the suggestions of Choobineh and his colleagues, a theory from a reference discipline was referred to in order to help explain the security behaviors of individuals. The present study utilizes a framework provided by existing IS literature to justify the adaptation of a theory from a reference discipline. Drawing from existing IS literature to borrow a theory from another discipline ensures that findings from previous IS research can readily be combined with findings from this study, which is necessary in order to enable future research to expand upon the findings of this study. Figure 1.1 presents the research model developed and tested as part of this study and is described more in depth in Chapter Two.

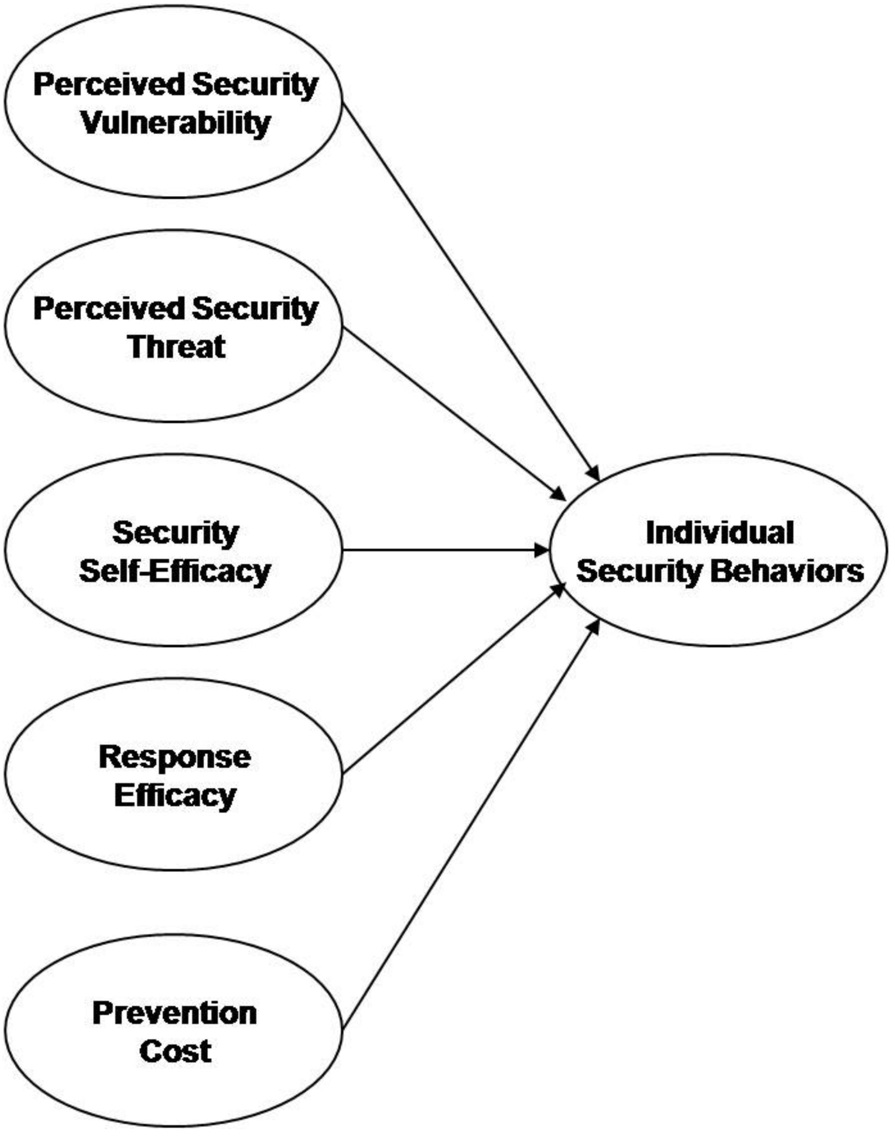
Perceived Security Vulnerability
Perceived Security Threat
Security Self-Efficacy
Response Efficacy
Prevention Cost
Individual Security Behaviors

Figure 1.1 - Research Model

Expected Contributions

This research contributes to IS research by 1) creating and validating an instrument to measure individual security behaviors and 2) proposing and testing a new theory in the IS domain to provide a better understanding of the factors that influence individual security behaviors. The results of this research provide both academics and practitioners a tool to measure the security behaviors of individuals, as well as a theoretical understanding of what influences those behaviors. For academics, such a tool provides a common instrument to measure individual security behaviors consistently. By using a common, validated method of measuring individual security behavior, future studies can build upon one another using this measure as a constant base. For practitioners, such a tool will be useful for assessing how thorough a person is at protecting his or her computer from security attacks. It also allows for a follow-up measure to be performed, determining how successful different training and education endeavors are. The theoretical understanding of what influences security behaviors also provides useful insights for academics and practitioners alike. For academics, it provides one more piece of the puzzle to build upon and combine with other theories to provide further understanding of what determines an individual's security behaviors. For practitioners, it provides insight into improving training and education programs to better influence the outcome they are after – improved individual security behaviors.

Overview of the Dissertation

The remainder of this dissertation is organized as follows: Chapter Two contains a review of the literature with main sections on outcome oriented IS security research, behavioral IS security research, protection motivation theory, and the behavioral security research model; Chapter Three describes the research design and methodology; Chapter Four provides a detailed analysis of the data collected; Chapter Five discusses the research results and implications; and Chapter Six provides a conclusion, which includes contributions, limitations of the study, and recommendations for future research.

Chapter Two: Background

This research uses a multi-phased and multi-theoretical perspective, extending an existing information systems theory, General Deterrence Theory, by adapting a theory from the field of social psychology, Protection Motivation Theory. In addition, this research builds a newly validated instrument for measuring the security behaviors of individuals. This approach is used to address the research question presented in Chapter One; what determines the security behaviors of individuals? This chapter is organized as follows: first, a discussion of outcome oriented research in IS security is presented; then behavioral IS security research is discussed; this is followed by a presentation of a guiding framework for advancing behavioral research in IS security; the final section adapts a theory from the field of social psychology by building upon existing IS research.

Outcome Oriented IS Security Research

Much of the existing work in security research revolves around investigation of the ends as opposed to the mean, meaning that research has been focusing more on developing better technological solutions to providing security as opposed to understanding the individuals who utilize the technology (Dhillon et al. 2001). Some of the technological solutions that have been researched deal with risk analysis, improved approaches to implementing better security, as well as specific tools for increasing the security capabilities of computers.

Risk

Risk is one component regularly studied in IS security research. One approach looks at cultural differences to understand the differences in people's risk perceptions based on their worldview, which provides management with a better way to manage risk given different cultural settings (Tsohou et al. 2006). Another approach to risk deals with a cost/benefit analysis prior to implementing given security countermeasures. The cost/benefit analysis considers the cost of a risk occurring versus the cost of investing in a countermeasure to deal with the risk. If the cost of investing in the countermeasure is less than the cost of the risk occurring, then there is enough benefit to justify the expenditure. Such an approach uses mathematical formulas to provide a subjective way of determining which security countermeasures should be invested in (Karabacak et al. 2005). Further research illustrates the risk that management faces in the new era of Internet based computing and provides methods that management can take to mitigate these risks (Farahmand et al. 2005). Risk is an important component to understand when considering the security of systems in a number of other contexts including accounting information systems (Abu-Musa 2006), justifying information systems (Baskerville 1991), justifying the economics of information security (Cavusoglu et al. 2004), setting security goals (Koskosas et al. 2003), developing information systems (Maguire 2002), making management decisions (Straub et al. 1998), and analyzing threats to information security (Whitman 2003).

Improved Approaches to Security

Several authors have suggested ways in which improved approaches to security can decrease the number or severity of attacks. One such paper introduces the Process-Oriented Security Model (POSeM), which relies on business process descriptions to create necessary security safeguards (Rohrig et al. 2004). An evaluation of POSeM is provided in an e-commerce setting. Another paper provides a framework for applying multiple high-level security models to meet the diverse set of requirements in an e-commerce environment (Essmayr et al. 2004). The Information Governance Security Framework is proposed to provide a holistic perspective to governing security, which, the authors claim, will minimize risk and cultivate a greater level of information security culture (Veiga et al. 2007). Another study provides a framework that suggests that sharing security information along with investments in security technology work as complements to one another in ensuring a secure computing environment (Gal-Or et al. 2005). Many other models and frameworks have been proposed to increase the security of a system including policy (Rees et al. 2003; Siponen et al. 2006b) and standards setting (Backhouse et al. 2006; Ma et al. 2005; Myler et al. 2006; Siponen 2002), information assurance (Ezingeard et al. 2005), cyberterrorism protection (Foltz 2004), outsourcing (Karyda et al. 2006), security goal setting (Koskosas et al. 2003), risk assessment (Misra et al. 2007; Sun et al. 2006; Willison et al. 2006), access control (Miller et al. 1996; Pan et al. 2006; Zhang et al. 2003), design frameworks (Siponen 2005; Siponen et al. 2006a; Tak et al. 2004), and information systems security management (Trcek 2003; Zuccato 2007).

In addition to the proposed models and frameworks for increasing the security of systems, other studies provide discussions on how better approaches to security can be implemented, either to comply with legal regulations and security best practices or to deal with the changing complexity of information technology. One study proposed a new way of encoding personal micro-data in such a way that no individual person's information would be at risk, but that would allow for the sharing of information between people that legally have the right to access that information (Garfinkel et al. 2007). Encoding personal micro-data this way helps to ensure that medical institutions are following the law and provide an extra layer of privacy protection to individuals. A number of other studies explore better approaches to security in such areas as risk management and assessment (Anderson 2007; Bernard 2007; Magklaras et al. 2002; Theoharidou et al. 2005; Tsoumas et al. 2004; Yeh et al. 2007), complying with health regulations (Dantu et al. 2007; Thomas et al. 2007), deployment of information systems and technologies (Doherty et al. 2006), recommendations for tighter security systems (Issac et al.

2007), ethical and legal impacts of spyware (Sipior et al. 2005), managing user relationships (Vroblefski et al. 2007), and user authentications (Warkentin et al. 2004).

Another theme in security research is trust. One paper proposes a solution that will address trust issues in a wireless Internet setting, which should increase usage of wireless networks (Stewart et al. 2006). Other work has been done that proposes key components of a trust model that ensure a sense of security in a mobile computing environment (Misra et al. 2004). Following this approach, another paper proposes an expanded trust model for distributed systems that is rigorous enough to hold as technology changes (Hoffman et al. 2006). Furthermore, one author argues that biometrics increase people's trust over traditional security measures and online transactions should utilize this technology to effectively lower the cost and risk associated with online transactions (Kleist 2007). However, Kleist argues that the acceptance of biometrics for a solution such as this is constrained by a lack of standardization amongst biometric manufacturers and the use of proprietary algorithms, limiting the interconnectivity of this type of technology. Additionally, use of biometrics faces social challenges to get individuals to adopt the technology (Chandra et al. 2005). There exist several other papers detailing the importance of trust in ensuring a secure computer system (Eigeles 2005; Koskosas et al. 2003; Neumann 2006; Viega et al. 2001).

Contrary to the above findings that suggest trust impacts security, other papers suggest that how secure an individual thinks a system is influences their trust of the online-based system (Shalhoub 2006; Wakefield et al. 2006). Such a suggestion supports the argument that trust and security are related, but the nature of that relationship in an online environment is not fully understood. Based on these different findings of trust it may be argued that the relationship between security and trust is not a one-way relationship but a reciprocal relationship. As trust increases so does a person's perception of the security of a system, and likewise as a system has proven to be secure the trust a person places in that system increases.

Security has also been shown to be an issue when it comes to knowledge sharing. One set of papers argues that knowledge management models need security integrated into them (Jennex et al. 2007; Randeree 2006). Jennex and his colleague illustrate how two existing security models can be applied to the knowledge management context and provide two case studies illustrating how risk management can be applied to knowledge management governance. Similarly, another paper proposes a knowledge-sharing security model that combines preexisting models to create a way in which business partners can proactively monitor the shared knowledge assets within their shared value chain (Soper et al. 2007). Additionally, a couple of approaches to communicating knowledge within and across organizational boundaries via semantic mapping have been provided (Lee et al. 2005; Muthaiyah et al. 2007). The purpose of the semantic mapping is to provide a solution to the communication of security policies between organizations that arises due to the heterogeneous nature of policies across organizations. Another study relies on simulation to show that in order to properly secure knowledge, not only does the proper technology need to be relied upon, but the proper social environment for reporting issues needs to be in place (Sveen et al. 2007). Further discussions about the importance of security to knowledge management are also provided (Belsis et al. 2005; Gal-Or et al. 2005; Metaxiotis et al. 2003).

Technological Solutions

Technological solutions are an important aspect to securing information systems. One study proposes a better way to provide digital rights management (DRM) for protecting digital information (Abie et al. 2004), by proposing a set of criteria that a DRM solution should consist of and describe how they created an implementation that fits most of the criteria. Another study proposes a better way to watermark digital images, protecting the images from theft and defacement (Hsieh et al. 2004). Expanding the technological protection of security on networks even further, another paper provides a new way of performing detection intrusion on networked systems (Li et al. 2007), by addressing the weaknesses in current intrusion detection systems that prevent people from regularly relying on them to enhance their network's security. Further, it has been argued that the development of security tools has not taken advantage of the well-developed stream of research in human-computer interaction (HCI). By doing so it is suggested that the use of security tools can be significantly increased (Johnston et al. 2003). Many other technological solutions to security issues have been provided over the years including secure signatures (Backes et al. 2005; Clarke et al. 2007; Ding et al. 2006), audit services (Baldwin et al. 2005), firewalls (Byrne 2006), intrusion detection systems (Cavusoglu et al. 2005; Li et al. 2005; Williams et al. 2007; Ye et al. 2006), user authentication (Furnell et al. 2004; Itakura et al. 2005), cryptographic solutions (Galindo et al. 2005), countermeasures to security attacks (Gürgens et al. 2005), mobile phone security (Lee et al. 2006), usage control (Pretschner et al. 2006), network vulnerability assessment (Shahriari et al. 2007), and securing multi-agent systems (Viia et al. 2007).

Behavioral IS Security Research

As noted by Dhillon and Backhouse (2000; 2001), an understanding of the socio-organizational perspective is lacking in current IS security research. This observation is supported by another study in which several IS managers were interviewed about what they value in managing IS security, which suggested that, in order to maintain IS security, it was important to consider organizational principles and values instead of just technology (Dhillon et al. 2006). Similarly, in a review of security research in the top IS journals from 1996 to 2005, it was found that research in this area is very fragmented with very few papers testing research hypotheses and no framework emerging to explain security research (Cannoy et al. 2006). Cannoy and her colleagues also show that there has been no consistency in the variables used to explain security and that very few studies include major constructs and their relationships, but focus only on narrow topics or clarifying the details of a technical system. Along these same lines, as seen in Table 2.1, a review of security articles beyond the top IS journals, finds support for Cannoy and her colleagues' claim that no dependent variable has emerged as an agreed upon measure for this stream of research.

One study found that an individual's concern about security was influenced by industry risk, the companies actions regarding security, and an individual's awareness of the potential for computer abuse (Goodhue et al. 1991). Additionally, it has been shown that individual training, awareness, monitoring, and motivation were associated with better password "hygiene" (Stanton et al. 2005). Another study, drawing on the theory of planned behavior, found that behavioral intention to use protective technologies was influenced by technology awareness, attitude, perceived behavioral control, perceived usefulness, perceived ease of use, and controllability (Dinev et al. 2007). One study measured end users' understanding of the security features built into often used operating systems and programs such as Windows XP, Microsoft Word, and Internet Explorer (Furnell et al. 2006). Another study investigated the use of tools installed on individuals' computers to protect their privacy (Furnell et al. 2007). It was also found that professional workers were not receiving security training and those that did receive training viewed it as something that they only need to do once. When these same individuals reviewed their security practices at home, weaknesses were found in almost all areas (Kim 2005). A number of additional studies exist that explore security behavior in a number of different facets including authentication (Zviran et al. 2006), vulnerability management (Al-Ayed et al. 2005) and wireless security settings (Woon et al. 2005).

Table 2.1 – Previous Empirical Behavioral Security Research

Source	**Theory**	**Dependent Variable**
(D' Arcy et al. In Press)	General Deterrence Theory	IS Misuse Intention
(Dinev et al. 2007)	Theory of Planned Behavior	Behavioral Intention
(Furnell et al. 2006)		Understanding of Security Features
(Furnell et al. 2007)		Use of Privacy Tools on Computer
(Goodhue et al. 1991)		Concern About Security
(Kankanhalli et al. 2003)	General Deterrence Theory	IS Security Effectiveness
(Kim 2005)		Security Practices at Home
(Straub 1990)	General Deterrence Theory	Computer Abuse
(Stanton et al. 2005)		Password "Hygiene"
(Woon et al. 2005)	Protection Motivation Theory	Wireless Security Enabled
(Workman et al. 2007)	General Deterrence Theory Theory of Planned Behavior	Threat of Software and Information Security

Individual Security Behavior

A review of the existing literature on empirical behavioral security research also revealed that no measure for individual security behavior has gone through an extensive validation process. This is problematic as without evidence of validity there is no assurance that the phenomenon of interest is actually being successfully measured (Straub 1989) and without a standardized dependent variable it is difficult for researchers to cumulate knowledge on information security behavior. With this in mind, one of the goals of this research is to design and validate a dependent variable to measure individual security behavior (ISB) that can be used in future information security research.

In order to measure and validate the ISB scale, it is first necessary to understand the behaviors that protect a computer from security threats. One study interviewed a number of security experts to uncover the threats that they faced most often as well as the mechanisms used to protect against these threats (Whitman 2004). As discussed above, research into the protection mechanisms used to secure a system regularly occurs in IS research. Additionally, a number of research groups seek to better understand the steps companies take to protect themselves from security threats (Deloitte 2007; Richardson 2007). Generally, this research is performed to provide a big picture understanding of what companies are doing and to provide opportunities for industry-wide improvement in securing computer systems.

Table 2.2 displays different mechanisms that individuals can implement to provide protection to threats against computer systems. Tasks generally performed by security or network administrators were not included in this list.

Table 2.2 – Protection Mechanisms for Computer Threats

Protection Mechanism	Source
Anti-Phishing Solutions	(Deloitte 2007; Hallam-Baker 2005)
Anti-Spam Software	(Deloitte 2007; Furnell et al. 2007; Highland 1996)
Anti-Spyware Software	(Deloitte 2007; Dinev et al. 2007; Furnell et al. 2007; Kim 2005; Richardson 2007)
Anti-Virus Software	(Cohen 1987; Deloitte 2007; Furnell et al. 2007; Furnell et al. 2006; Highland 1997; Kim 2005; Post et al. 2000; Richardson 2007; Whitman 2004)
Auto Account Logoff	(Whitman 2004)
Control of Workstations	(Deloitte 2007; Richardson 2007; Whitman 2004)
Data Encryption	(Boncella 2000; Jarvis 1999; Richardson 2007)
Firewall	(Boncella 2000; Deloitte 2007; Furnell et al. 2007; Furnell et al. 2006; Kim 2005; Richardson 2007; Wen et al. 1998; Whitman 2004)
Install Operating System Patches	(Furnell et al. 2007; Furnell et al. 2006; Kim 2005; Richardson 2007)
Install Software Patches	(Furnell et al. 2007; Kim 2005; Richardson 2007)
Media Backup	(Kim 2005; Post et al. 2000; Richardson 2007; Whitman 2004)
Use of Passwords	(Boncella 2000; Deloitte 2007; Furnell et al. 2006; Kim 2005; Richardson 2007; Stanton et al. 2005; Whitman 2004; Wood 1996; Zviran et al. 2006)
Web Content Filtering	(Deloitte 2007)
Wireless Security Settings	(Boncella 2002; Deloitte 2007; Richardson 2007; Woon et al. 2005)

Anti-phishing solutions protect people from falling prey to phishing websites. According to http://www.antiphishing.org, a group dedicated to eliminating phishing attacks worldwide, phishing involves "tricking" people in to providing their personal information to counterfeit websites. This often occurs by sending someone a link in an email that sends him to a counterfeit website that looks nearly identical to the website it is pretending to be. The unsuspecting victim then provides information such as usernames, passwords, social security numbers, and credit card information to the phishing website, which are used to steal the suspect's identity.

Anti-spam software removes or reduces the amount of spam that arrives in a person's inbox. According to http://www.ftc.gov/spam/, a Federal Trade Commission (FTC) website dedicated to protecting consumers from spam, spam is junk email that you receive from people you do not know. The purpose of the email message is to entice you into visiting a website to purchase products of services. At times, these purchased products or services never arrive. Such problems caused the US Congress to pass a law called the CANSPAM Act to protect consumers from wasting their time dealing with the junk email and to prevent people from being ripped off by bogus offers they received via email. Using anti-spam software helps people to not waste time dealing with SPAM as well as prevents them from being drawn to unscrupulous websites.

Anti-spyware software prevents spyware from being installed on personal computers. According to http://www.antispywarecoalition.org/, a group of anti-spyware software companies, academics, and consumer groups dedicated to controlling spyware, spyware is technology that is installed on a computer without the appropriate consent or implemented in such a way that impairs the user from making changes that affects their privacy or system security, uses system resources and programs installed on the computer without permission, or collects, uses, and distributes sensitive or personal information. When spyware is successfully installed on a computer it can cause problems for the user of the computer by tracking what they do on their computer and then using this information to market items directly to them, or in the worst case steal their identity. Utilizing anti-spyware software helps prevent such technology from being installed on a personal computer.

Anti-virus software is software that prevents viruses from infecting files on a personal computer. A virus is “a program that can 'infect' other programs by modifying them to include a possibly evolved copy of the virus. With the infection property, a virus can spread throughout a computer system or network using the authorizations of every user using it to infect their programs. Every program that gets infected may also act as a virus and thus the infection grows” (Cohen 1987). Once computers get viruses the virus can not only spread, but can also delete files, cause hard drives to crash, or open holes for people to gain unauthorized access to the system. Running anti-virus software helps prevent viruses from ever infecting a computer.

Auto account logoff serves the purpose of automatically logging a user off their personal computer account after a predetermined amount of inactivity. The purpose of this is it requires that a user re-establish their credentials to use system resources, preventing someone from using a workstation that someone has logged onto, but stepped away from. Using an auto account logoff feature helps prevent this threat.

Keeping physical control of workstations helps prevent unauthorized people from accessing them. This includes keeping workstations physically secured in a room with a lock when no one is present. When it comes to keeping physical control of laptops there are additional precautions needed. Laptop computers should remain physically with someone, physically secured to an immovable object such as a desk, or secured in a room with a lock when no one is present. Once a person has physical control of a computer it becomes much easier for them to access the information on it as a number of other security safeguards have been bypassed. Additionally, with physical access to a computer a person can use brute force attacks and eventually crack even the strongest passwords.

Data encryption is necessary to ensure that data stored on a computer or sent over the network remains confidential. According to http://www.us-cert.gov/, a Computer Emergency Response Team of the United States government that is tasked with coordinating defenses and responses to cyber attacks across the country, it is important to use encryption when using a laptop computer or when the data that you have on a computer is not sufficiently protected by the built in security mechanisms of the operating system on the computer used. Additionally, whenever sending personal information over the network, which is an open system that any one has access to, it is important to use encryption to ensure that only the people that are supposed to can view the personal information. Such encryption is generally built into web transactions, especially when credit card numbers are involved. Secure Socket Layers (SSL) is the technology utilized for online transactions and should always be present when making online purchases.

The purpose of a firewall is to guard the information that enters and leaves a personal computer or network. Firewalls come in two different types, hardware and software. Software firewalls are installed on the computer utilizing it, while hardware firewalls are separate devices that sit between a network or personal computer and the Internet connection. According to http://www.us-cert.gov/, firewalls are necessary to ensure that only information that is supposed to enter and leave a personal computer or network does. By having a firewall sit at the gate between a personal computer or network and the Internet it is possible to prevent people with malicious intent from gaining access to a computer and taking information from it that may be stored there. It is important to use at least a software firewall, but if a person's budgets allows for the additional cost of a hardware firewall the additional layer of protection provides added defense against outside attackers.

Installing operating systems patches is an important way to ensure that bugs identified by the operating system vendor are fixed. Fixing these bugs is an important step to ensure that outside intruders do not exploit vulnerabilities introduced by these bugs. Oftentimes bugs in operating systems can open up ways for unauthorized people to gain complete access to a system from a remote location. According to http://www.us-cert.gov/, keeping the operating system patched is one way to remove these vulnerabilities.

Installing software patches addresses similar problem as installing operating systems patches. When programs are released they often have bugs that result in unintended vulnerabilities that outside attackers can exploit. These vulnerabilities can be fixed by installing patches released by software vendors (http://www.us-cert.gov/).

Backing up the important files and folders on a computer ensures they can be recovered if anything happens to them. If a computer malfunctions or is destroyed by a malicious hacker, not having backups of important files means that those files are lost forever (http://www.us-cert.gov/). Backing up files to an online server also provides assurance that loss due to a natural disaster such as a fire or a flood will not mean the loss of the important files.

Passwords are most often the means by which access is gained to personal computers and other secure accounts that are accessed from personal computers. It is important not to share passwords with other people as that allows them to have unauthorized access to systems. Passwords should also be strong, that is they should not be common dictionary words, should be at least eight characters long and made up of a combination of upper and lower case letters, numbers and punctuation marks. Additionally, passwords should be changed on a regular basis to prevent people who may have gained access from continuing to have access to your account (http://www.us-cert.gov/). Following this approach ensures authorized people only access a computer system.

Web content filtering helps prevent the release of private information to malicious outsiders or through accidental release by detecting when such information is being sent over the network (Deloitte 2007). In addition, some websites exist to infect computers with viruses and spyware. Using web content filtering software can identify such unscrupulous websites. Utilizing filtering software to prevent the loss of information or the installing of viruses and spyware help keep a personal computer secure.

Wireless networks can be more prone to security breaches than wired networks (Deloitte 2007). Ensuring that the security settings of wireless networks are properly set helps mitigate some of the risk posed by wireless networks. In order to ensure the security of a wireless network it is necessary to restrict access to the network, encrypt connections to the network, and protect the service set identifier (SSID) or network name (Woon et al. 2005). By following these recommendations, it makes it more difficult for unauthorized people to access the wireless network or steal information broadcast over it.

In summary, there exist many security protection mechanisms. Building upon the mechanisms discussed above and following the instrument development procedures recommended by Straub (1989) results in a way to measure how well individuals are performing protection mechanisms that security professionals and researchers have agreed are necessary to protect information security.

General Deterrence Theory

An examination of Table 2.2 reveals that General Deterrence Theory (GDT) has been the most widely relied upon theory in behavioral IS security research. GDT originated in the criminology domain to explain the behavior of criminals and anti-social personalities (Blumstein 1978; Pearson et al. 1985). The premise of GDT is that people with intent to commit illegal acts can be dissuaded from committing these acts through the existence of severe disincentives and punishments for committing the acts. Within the IS security literature, GDT has been adapted to posit that security countermeasures can act as a deterrent by increasing the perceptions of the severity and certainty of punishment for misusing information systems (Straub 1990). Inherent in the foundation of GDT are the relationships illustrated in the Security Action Cycle (see Figure 2.1), which shows how efforts at deterrence, prevention, detection, and remedies all provide a deterrent effect towards future computer related criminal acts (Nance et al. 1988; Straub et al. 1998). However, this theory has shown contradictory findings with some studies supporting it (D' Arcy et al. In Press; Gopal et al. 1997; Kankanhalli et al. 2003; Straub 1990; Workman et al. 2007) and others not (Harrington 1996; Lee et al. 2004).

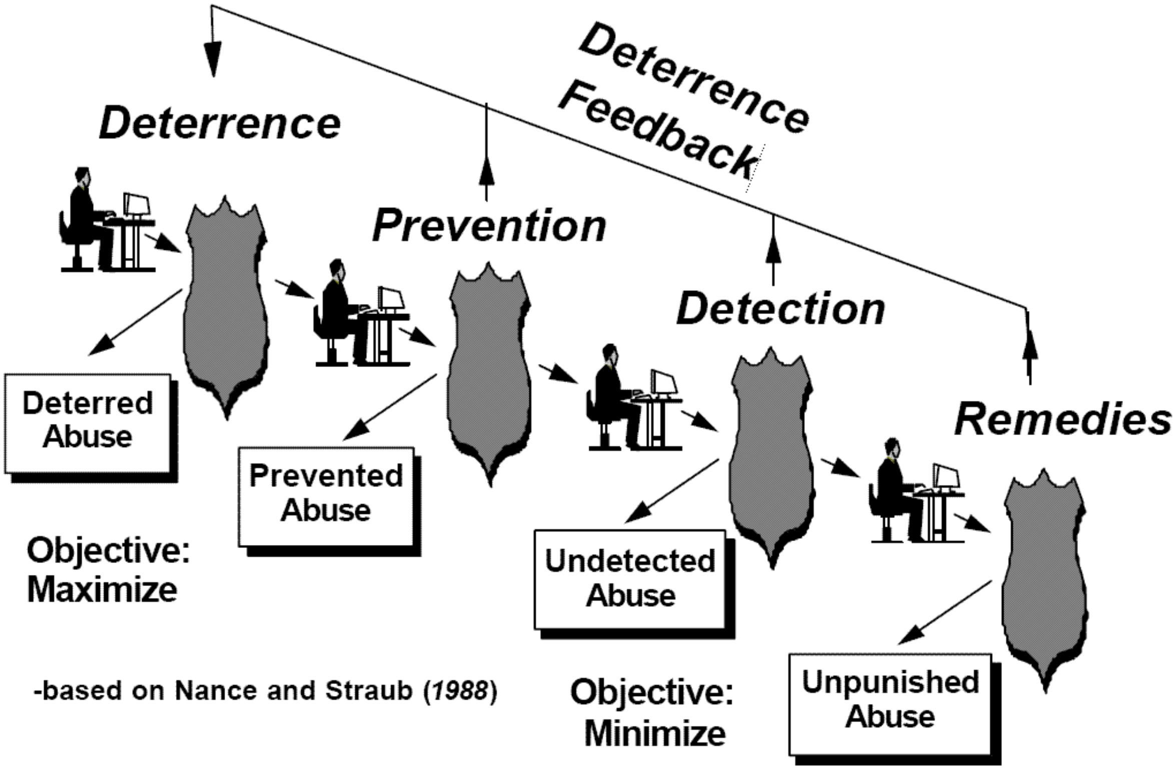

Figure 2.1 – The Security Action Cycle (Straub et al. 1998)
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Table 2.3 summarizes the significant variables used within GDT research. In essence, there have been three basic variables used in GDT security research – Deterrent Certainty, Deterrent Severity, and Rival Explanations; defined as risk of punishment, penalties for violations, and other factors that influence computer abuse respectively.

Table 2.3 – Significant General Deterrence Theory Variables

Independent Variable	Definition	Source
Deterrent Certainty	Risk of punishment	(Straub 1990)
Deterrent Severity	Penalties for violation	(Straub 1990)
Rival Explanations	Other factors that influence (reduce or increase) computer abuse	(Straub 1990)
IS-specific codes of ethics	Guidelines for appropriate technology usage	(Harrington 1996)
Deterrent Controls	Strategies to discourage criminal behavior through the threat of punishment	(Gopal et al. 1997)
Deterrent Efforts	Certainty of sanctions	(Kankanhalli et al. 2003)
Preventative Measures	Attempts to ward off criminal behavior through controls	(Kankanhalli et al. 2003)
Punishment	Negative consequences for breaking the rules	(Workman et al. 2007)
Ethics Training	A presentation of rules that encouraged people to take due care in handling information, establishing a code of ethics	(Workman et al. 2007)
Perceived Severity of Sanctions	The degree of punishment due to IS misuse	(D' Arcy et al. In Press)

In Straub's (1990) study, he relied on GDT to show that computer abuse could be reduced as deterrent certainty, deterrent severity, and rival explanations increased. Gopal and Sanders' (1997) research suggests that providing deterrent controls rather than preventative controls can help software providers reduce software piracy. Another study found that preventative efforts along with deterrent efforts led to greater IS security effectiveness, while deterrent severity did not (Kankanhalli et al. 2003). Workman and Gathegi (2007) found that punishment and ethics training, along with other individual motivational factors mitigated the threats of people illegally using software and going around controls to get access to information they needed or wanted.

Contrary to the research that found support for GDT, Harrington (1996) found that a general code of ethics had no effect on computer abuse judgments and intentions. However, she did find that an IS-specific code of ethics had an effect on computer sabotage and intentions. Conversely, in a study of Korean managers and MBA students, Lee et al. (2004) found that security policies and systems did not impact computer abuse behaviors.

Noting the discrepancy in these findings, a further study expanded on GDT and found that awareness of security policies, security education, training and awareness programs, and computer monitoring led to increases in perceived certainty and severity of sanctions, with perceived severity of sanctions being the only determinant to decreasing IS misuse intention (D' Arcy et al. In Press). These findings provide support for GDT, but differ from the results found in other papers (Kankanhalli et al. 2003). Although conflicting results exist about the consistency of GDT at explaining how to deter computer abuse, it has shown more success than failure. Therefore, this stream of research provides a good framework for expanding the explanation of security behaviors beyond the corporate setting, by expanding beyond deterrents to threats, such that the combination of threat severity, threat certainty, and rival explanations influences the choices individuals make to perform security behaviors. Such an expansion on the view of GDT falls in line with the Security Action Cycle that shows the effect that prevention, detection, and remedies have on deterring computer abuse. Figure 2.2 illustrates the resulting framework. The underlying question that remains unanswered is how individual differences lead to better security behaviors. In addition, deterrent efforts have been shown to work in an environment where sanctions can occur. Outside of an environment where sanctions can be imposed, other individual differences need to be explored to explain security behaviors.

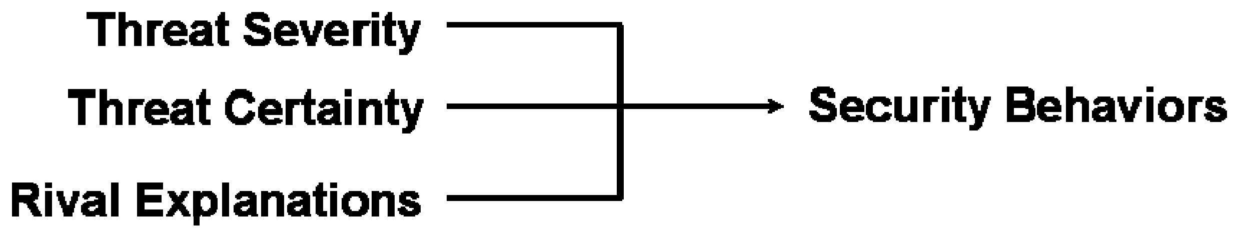


Figure 2.2 – General Deterrence Theory - Guiding Framework

Protection Motivation Theory

A recent panel on IS security at the 2007 Americas Conference on Information Systems (AMCIS) suggested that, in order to deal with the increased challenges of IS security, new theories from reference disciplines needed to be examined (Choobineh et al. 2007). One theory from the field of social psychology, which has recently been used in IS security literature (Woon et al. 2005), called Protection Motivation Theory (PMT), fits within the General Deterrence Theory (GDT) framework and can explain security behaviors outside of a corporate setting. Using GDT as a guiding framework, PMT can be adapted to provide a theoretical foundation for understanding security behaviors in a broader setting. PMT provides a theoretical explanation that can explain why people perform certain countermeasures to detect and prevent computer threats, which ultimately result in deterring continued attacks on computer systems.

The premise of PMT is that information is first received (sources of information), which leads to an evaluation of it by the person receiving that information (cognitive mediating process), and finally to the person taking some action based on the information received (coping mode). Sources of information are the input variables to the model and include environmental and intrapersonal sources. Environmental sources of information include verbal persuasion and observational learning. Intrapersonal sources include personality aspects and feedback from prior experience including experiences associated with performing the behavior of interest

(Floyd et al. 2000; Maddux et al. 1983; Rogers 1975). There are two types of cognitive mediating processes: the threat appraisal process, and the coping appraisal process. The outcome of the cognitive mediating processes is a decision to apply the applicable adaptive response or the behavior of interest. The two types of adaptive behaviors are adaptive coping (to protect the self or others) and maladaptive coping (not to protect the self or others) (Floyd et al. 2000; Maddux et al. 1983; Rogers 1975). Figure 2.3 models this process.

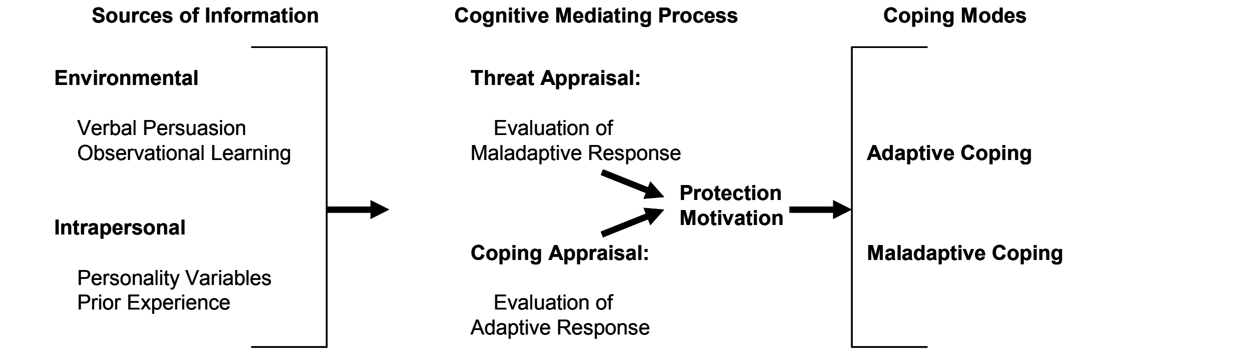


Figure 2.3 – Protection Motivation Theory (Floyd et al. 2000)
Used with permission of Wiley-Blackwell

Currently, one IS security study that empirical tests PMT in an IS context has been published. It was found that perceived vulnerability, response efficacy, self-efficacy, and response cost led to a person enabling home wireless security measures (Woon et al. 2005). These results suggest that adapting PMT under the framework provided by GDT will produce positive results. Some of the limitations that the paper by Woon et al. (2005) did not address that this adaption of PMT can address are the measurement of a dependent variable that is not dichotomous, the investigation of more aspects of security behavior than just home wireless networks, and a more context specific measure of self-efficacy as proposed by Marakas et al.

(2007). Recently, other studies that propose the use of PMT are appearing at IS conferences (Crossler et al. 2006; Lee et al. 2007b; Wunnava et al. 2008).

Alignment with the GDT Framework

The outcome of interest provided by the GDT framework is security behaviors, which are tasks people perform to protect themselves from the threats to their computer systems. When considering the dependent variable that PMT posits, it is necessary to ensure this fits within the framework provided by GDT. PMT posits that performance of coping methods occur for protecting your own health or the health of others. Adapting this to the protection of a computer system, an individual chooses to perform certain tasks to protect his computer from a given threat. A review of previous research suggests that dependent variables, such as password hygiene, use of protective technologies, and IS misuse, are all tasks an individual chooses to perform. That is, all of these behaviors can either be adopted as a form of adaptive coping, while some other behavior that is contrary to the end goal can be adopted, which is maladaptive coping. A person's security behavior comes down to whether he performs behaviors that lead to a safer computing environment.

The GDT framework suggests that security behaviors are influenced by an interaction between threat severity, threat certainty, and rival explanations. A discussion of these three factors and how PMT lines up with the guiding framework of GDT follows.

Threat severity is *an individual's assessment of the severity of the consequences resulting from a threatening security event*. One part of the cognitive mediating process of PMT is the severity of the threat (Maddux et al. 1983; Rogers 1975). The conceptualization provided by PMT lines up nicely with the framework provided by GDT.

Threat vulnerability is *an individual's assessment of the probability of a threatening security event occurring.* One part of the cognitive mediating process of PMT is the probability of the event occurring (Maddux et al. 1983; Rogers 1975). The conceptualization of threat vulnerability provided by PMT also lines up nicely with the framework provided by GDT. The combination of these two constructs, threat severity and threat vulnerability, have been referred to as the threat appraisal process, a multi-construct factor that determines a person's motivation to perform a coping response (Floyd et al. 2000).

Rival explanations are *other factors that influence security behaviors.* The definition of rival explanations is very broad and many potential factors could fit within this category. As such, rival explanations provide the greatest opportunity for expanding on the understanding of decisions to perform security behaviors. PMT posits that, in addition to the threat appraisal process described above, a coping appraisal process occurs that combines with the threat appraisal process to determine a person's motivation to perform a coping response (Floyd et al. 2000). This coping appraisal process is composed of response efficacy and self-efficacy. Response efficacy refers to *how effective a person thinks a response is at reducing or eliminating the effects of a threatening event* (Maddux et al. 1983; Rogers 1975). Self-efficacy refers to *a person's confidence in their ability to perform the coping action* (Maddux et al. 1983).

Additionally, both the threat appraisal and coping appraisal process include cost factors. In the threat appraisal process, the costs are rewards, either intrinsic or extrinsic, for continuing a maladaptive response. The coping appraisal process refers to response costs for performing an adaptive behavior (Floyd et al. 2000; Rogers 1975). However, prior literature conceptualizes cost factors as their own constructs (Neuwirth et al. 2000; Sheeran et al. 1996) or leaves them out altogether (Beck 1984). In the case of security behaviors there does not appear to be any rewards for not performing a behavior so response cost encompasses the cost factors. However, response cost implies that a person is responding to a given attack, therefore, this study uses the construct prevention cost to convey that it is the cost of preventing a threat from manifesting itself into an attack. Prevention cost is *the perceived opportunity costs – time, cognitive effort, financial – of adopting the recommend behavior to prevent or mitigate the threatening security event*.

Behavioral Security Research Model

Security Threat Appraisal

The threat appraisal is comprised of the threat perception (severity and vulnerability) of continuing with the maladaptive response. In the case of this study, threat appraisal is called security threat appraisal and is defined as *an individual's assessment about the level of danger posed by a security threat*.

Security threat appraisal is similar to perceived risk, which is conceptualized as uncertainty and consequences (Conchar et al. 2004; Dowling et al. 1994; Jia et al. 1999; Nicolaou et al. 2006; Pavlou et al. 2004). These conceptualizations are similar in that both capture uncertainty and consequences, but security threat appraisals refers to uncertainty as vulnerability and captures how vulnerable a person thinks he is to a given threat. This study conceptualizes security threat appraisal as being comprised of perceived security vulnerability and perceived security threat. Perceived security vulnerability is *an individual's assessment of the probability of a threatening security event occurring*. Perceived security threat is *an individual's assessment of the severity of the consequences resulting from a threatening security event*.

PMT posits that threat appraisal is one determinant that impacts whether a person adopts a given behavioral response (Floyd et al. 2000). A number of studies suggest that as a person's perception of risk increases he is less likely to participate in risky activities or is more likely to take steps to protect himself from risks (Jarvenpaa et al. 2000; Keil et al. 2000; Lee et al. 2007a; Nicolaou et al. 2006; Pavlou 2003; Pavlou et al. 2004; Sitkin et al. 1992; Youn 2005). When investigating people's willingness to share private information on a government website, the perceived risk of anti-terrorism measures by the government led to a lower likelihood to share information. However, perceived risk in the Internet environment did not show the same effects (Lee et al. 2007a). Another study looking just at perceived risk found that as perceived risk increases a person's intention to enter into electronic transactions decreases (Pavlou et al. 2004). Further confirming this research is another study which found that increases in perceived risk led to a lower likelihood of people using inter-organizational data exchanges (Nicolaou et al. 2006). In a study investigating the online privacy behaviors of teenagers on the Internet, risk appraisal (susceptibility and severity of perceived risk) led to a lower willingness to provide information to websites. People that were less likely to provide information to websites were also more likely to practice other coping behaviors to protect their personal information, such as provide false information or provide incomplete information (Youn 2005). The difference between the study of privacy behavior and the use of electronic transactions and data exchanges is that practicing privacy behaviors is a task that limits risk, whereas the other two examples are entering into a transaction that puts an individual more at risk. In addition, results from research utilizing GDT have shown that deterrent certainty and severity impact IS misuse (Straub 1990) which is a behavior that limits or reduces risk (that of being punished). In this study, the performance of behaviors that are done to protect an individual from security risks are being investigated; therefore, I hypothesize that increases in security threat appraisal will lead to increases in security behavior.

H1: Higher levels of perceived security vulnerabilities will lead to higher levels of individual security behavior.

H2: Higher levels of perceived security threats will lead to higher levels of individual security behavior.

Security Coping Appraisal

The coping appraisal process consists of the individual's confidence that a coping response will reduce or mitigate a security threat (response efficacy) and that he believes he can perform the given response (self-efficacy). In this study, coping appraisal is called security coping appraisal and is defined as *an individual's assessment of his ability to cope with and avert the potential loss or damage resulting from the threatening security event*. This study conceptualizes the security coping appraisal as being comprised of response efficacy and security self-efficacy. Response efficacy is *an individual's confidence that a recommended behavior will prevent or mitigate the threatening security event*. Security self-efficacy is *an individual's confidence in his/her own ability to perform the recommended behavior to prevent or mitigate the threatening security event*.

Security Self-Efficacy

PMT posits that coping appraisal is one determinant that impacts whether a person adopts a given behavioral response (Floyd et al. 2000). An experimental study showed that as a person's coping appraisal increased his willingness to perform the coping behavior also increased (Neuwirth et al. 2000). PMT research has found similar results. As noted above, one of the components of coping appraisal is self-efficacy. Self-efficacy was initially conceptualized by Bandura (1977) and defined as "*the conviction that one can successfully execute the behavior required to produce outcomes*" (Bandura 1977). Since its initial conceptualization, a number of studies have applied the concept of self-efficacy to explain individual's performance at using computers (Burkhardt et al. 1990; Carlson et al. 1992; Compeau et al. 1999; Compeau et al. 1995a; Delcourt et al. 1993; Fagan et al. 2003; Fenech 1998; Gist et al. 1989; Johnson et al. 2000; Lee et al. 2003; Stephens 2005). Rather than simply use self-efficacy to test usage of computer systems, one study validated and tested an instrument called computer self-efficacy, which found that computer self-efficacy influenced the expectations of individuals on the outcome of using computers (Compeau et al. 1995b). However, there exists conflicting results with those of Compeau and Higgins. In one study that combined the technology adoption literature, computer self-efficacy was shown to not be a significant determinant in the proposed model (Venkatesh et al. 2003). That study used the original measures for computer self-efficacy that were proposed by Compeau and Higgins (1995b), and did not adapt it to the study's context. Noting the discrepancy in findings with computer self-efficacy in the Venkatesh et al. study and others (Bolt et al. 2001; Venkatesh et al. 1996), Marakas et al. (2007) conducted an analysis of the research done with this construct. They found that when computer self-efficacy is adapted to the setting being studied it shows to be a good predictor of performance. However, in the studies when computer self-efficacy is not adapted to setting, then it is not a significant predictor of performance. Marakas et al. justified these findings by going back to the work of Bandura (2001), the person that originally conceptualized self-efficacy to show that it needs to be context specific.

As this study is about security, it is necessary and appropriate to adapt the instrument to security and rename the construct security self-efficacy. Similar to prior research, it is expected that increases in security self-efficacy will lead to increases in security behavior.

H3: Higher levels of security self-efficacy will lead to higher levels of individual security behavior.

Response Efficacy

By definition, response efficacy is measuring the same thing as outcome expectations. Response efficacy is *the confidence a person has that a given response will mitigate or reduce a threat;* outcome expectations is defined as "*a person's estimate that a given behavior will lead to certain outcomes" (Bandura 1977)*. IS research has shown that outcome expectations influence individual performance or acceptance of technology (Chung et al. 2002; Compeau et al. 1999; Compeau et al. 1995b; Lam et al. 2006; Venkatesh et al. 2003). One study of end users found that along with computer self-efficacy, outcome expectations led to usage of technology (Compeau et al. 1999). Additionally, in a study that combined the variables from a number of different acceptance models it was shown that outcome expectations led to intention to use a technology (Venkatesh et al. 2003). As response efficacy is by definition the same thing as outcome expectations and IS research has shown that outcome expectations lead to a higher likelihood to use a technology, it is expected that as response efficacy increases the security behavior of individuals will also increase.

H4: Higher levels of response efficacy will lead to higher levels of individual security behavior.

Prevention Cost

PMT posits that as the response cost goes up the likelihood of performing the adaptive coping response goes down. Such a suggestion is in line with other security research that says a security countermeasure will not occur when the cost of responding to a security threat is greater than the damage of the resulting threat (Lee et al. 2002). This follows from security recommendations that suggest a weighted analysis be performed that considers the likelihood of the threat occurring, along with the expected consequences of the threat versus the expected cost of taking preventative measures (Karabacak et al. 2005). This is similar to technology adoption literature, which shows that as the cost for using a technology increase, an individual becomes less likely to use the technology (Ghorab 1997; Reardon et al. 2007; Wu et al. 2005). One study shows that cost is one of the greatest inhibitors of behavioral intention to use mobile commerce (Wu et al. 2005). Also, medical clinics that have the smallest number of physicians sharing the cost of purchasing an electronic medical record (EMR) system are the least likely to implement such a technology (Reardon et al. 2007). Similarly, bank managers are concerned with economic considerations when deciding whether or not to implement a technologically complicated system (Ghorab 1997). Such findings from previous research suggest that as the perceived cost of invoking a coping response increases then the likelihood of implementing the response goes down. Following this, it is expected that increases in prevention cost will lead to decreases in security behavior.

H5: Higher levels of prevention costs will lead to lower levels of individual security behavior.

Security Research Model

In summary, this chapter has presented evidence for the need of an all-encompassing instrument for measuring the security behaviors of individuals. It also developed a set of hypotheses for understanding individual security behaviors. An adaptation of PMT guided the development of the proposed hypotheses. A graphical representation of the hypotheses in this study is shown in Figure 2.4.

Interaction Effects

Protection Motivation Theory research has found inconsistent interaction effects to occur. The most consistent of these interactions has been between vulnerability, severity, self-efficacy, and response efficacy (Neuwirth et al. 2000). Such an approach is fitting for the information security context, as an individual's assessment of their ability to utilize a security protection behavior will not occur unless they feel that it is a threat that affects them. Therefore, this research tests the model presented in Figure 2.5.

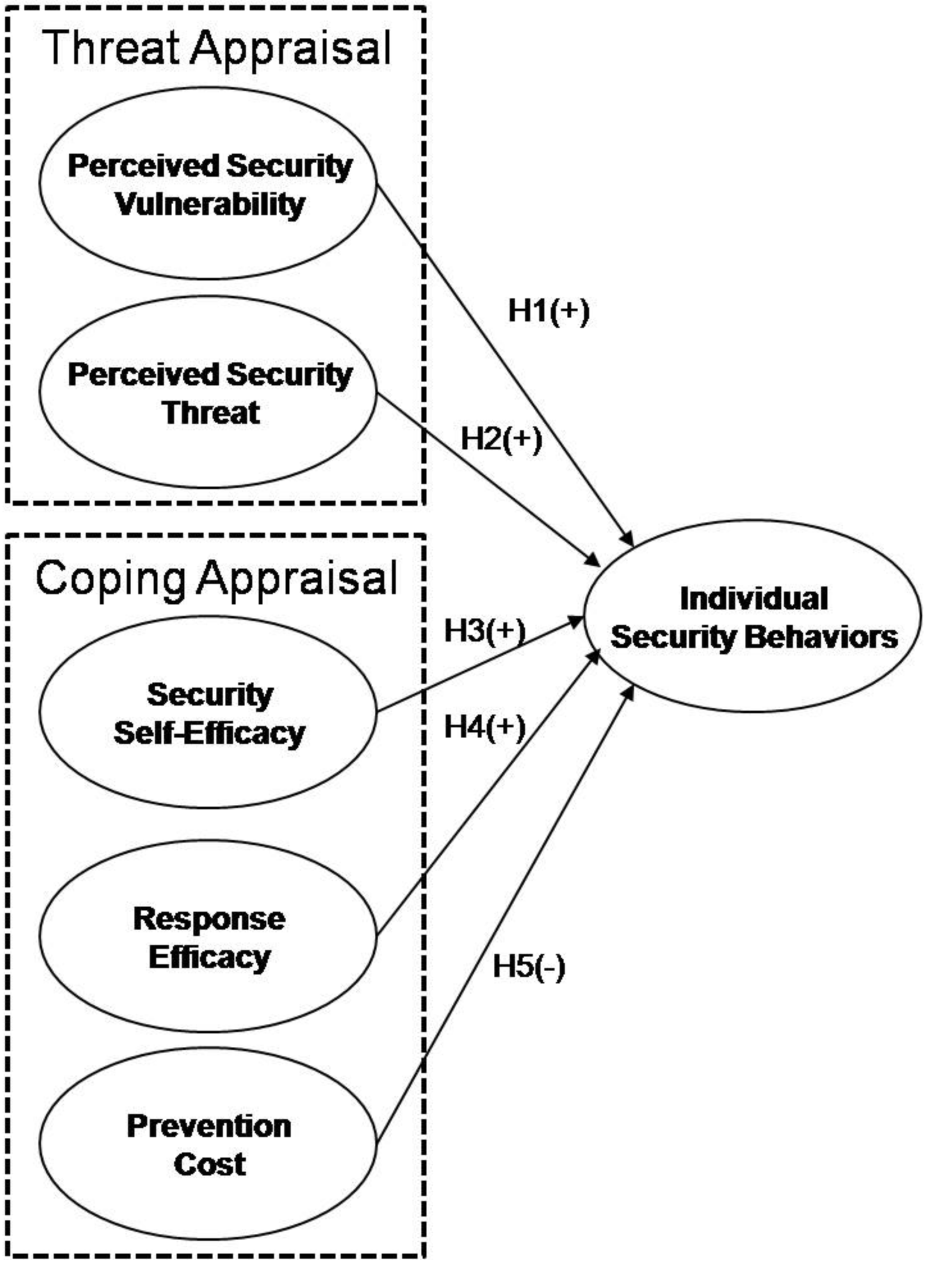


Figure 2.4 – Behavioral Security Research Model

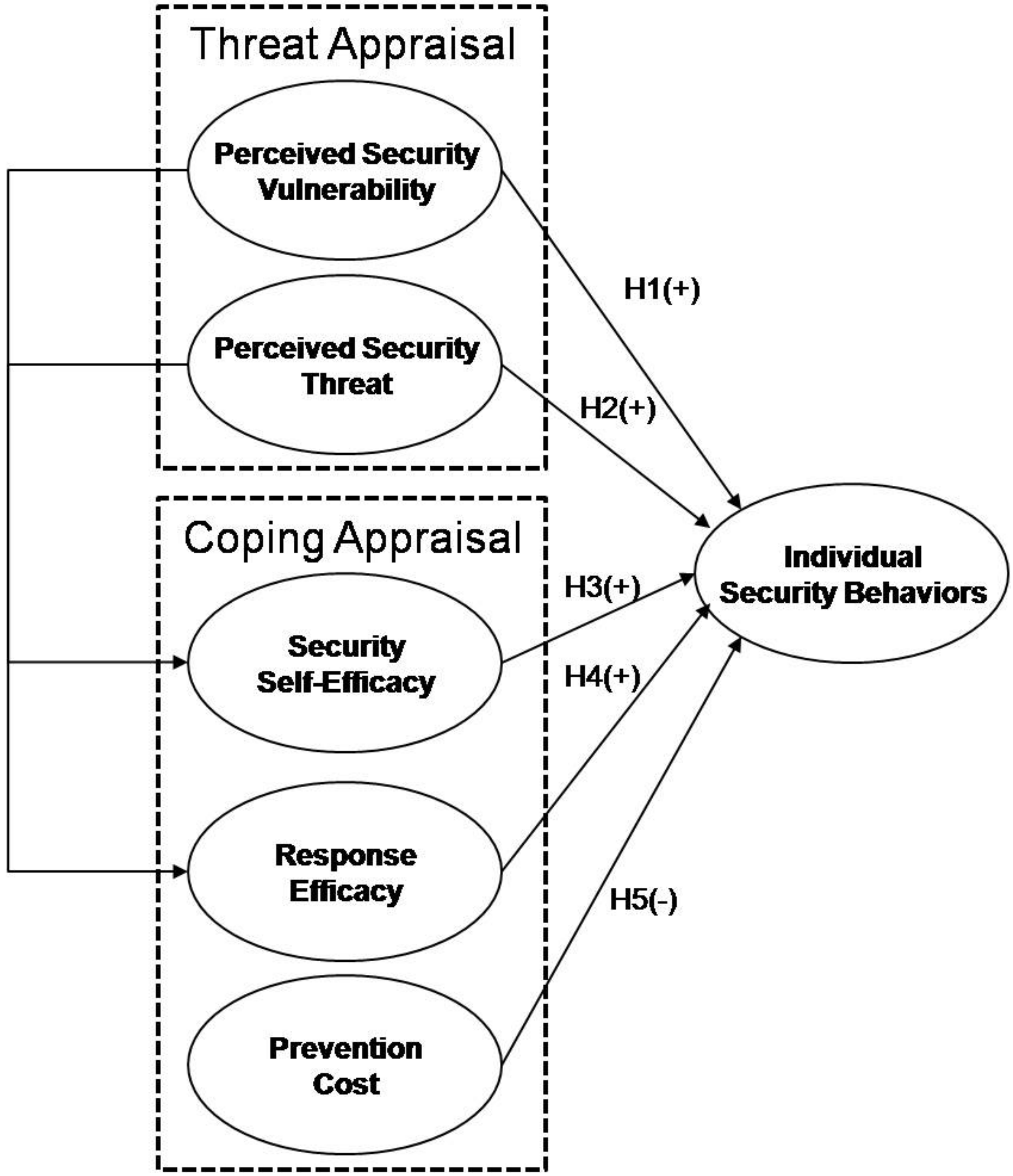


Figure 2.5 – Extended Behavioral Security Research Model

Chapter Three: Methodology

This study seeks to explain why individuals perform certain security behaviors. In order to accomplish this, it is necessary to understand what those behaviors are, and appropriately measure them. Once this is accomplished, I must measure antecedents that provide explanatory power in understanding this behavior. This chapter describes how individual security behavior were measured and how the following hypotheses, originally developed in Chapter Two, were tested.

H1: Higher levels of perceived security vulnerabilities will lead to higher levels of security behavior.

H2: Higher levels of perceived security threats will lead to higher levels of security behavior.

H3: Higher levels of security self-efficacy will lead to higher levels of security behavior.

H4: Higher levels of response efficacy will lead to higher levels of security behavior.

H5: Higher levels of prevention costs will lead to lower levels of security behavior.

The organization of this chapter follows. The first section discusses the process of instrument development. Then the validation process for the developed instrument is presented. Finally, a discussion of the methodology of data collection is presented, followed by the pre-test and pilot test results and the methods of data analysis.

Instrument Development

To measure the variables of interest in this study, two things need to occur. First, a method for measuring individual security behaviors (ISB) must be determined. ISB is the dependent variable in the study. The second process that needs to occur is the measurement of the independent variables hypothesized to affect ISB. This section discusses the appropriate process for both sets of variables.

The variables in this study could be successfully measured in a number of ways. One approach would be to observe the security of individuals directly, followed by a series of questions about the reasons why they perform the behaviors that they do. Although this approach would gain reliable information and understanding of an individual's actual behavior, it would be very time consuming to collect. An alternative to this approach would be to install some sort of a device on an individual's computer to measure how frequently he performs certain behaviors, and then follow up with a series of questions asking him to answer questions about the independent variables. This would be useful, but limited, since there are some behaviors that cannot be measured on an individual's computer, as the behaviors are not directly associated with tasks done on the computer (i.e. writing passwords down, educating others in the household, securing the computer properly, etc.). Interviewing people to ask them directly about their security behaviors is another possible approach, which would provide very rich information, but would provide a limited number of subjects for analysis. Creating and administering a survey is another approach that would allow for the collection of a significant amount of data from a variety of individuals. This also carries with it some concerns, most notably social desirability bias or a desire by individuals to respond in a way that makes them look good to others (Whitley 2002). In other words, some individuals may report what they think the researcher wants them to report or what they think the correct answer is as opposed to what their actual behavior is.

After weighing the pros and cons of each of the potential approaches to data collection, a survey approach was selected. However, as no validated scale exists to measure ISB and the proposed independent variables in this context, the first step is to identify the items and proper ways in which to measure them via survey items. To develop the instrument for this study, the recommended procedure by Straub (1989) was followed. These steps include conducting a pretest, technical validation, pilot test, and conducting the full-scale survey. Figure 3.1 illustrates the steps of the methodology followed. One stage was added to the approach advocated by Straub: grouping of behaviors, which is discussed more fully later in this chapter.

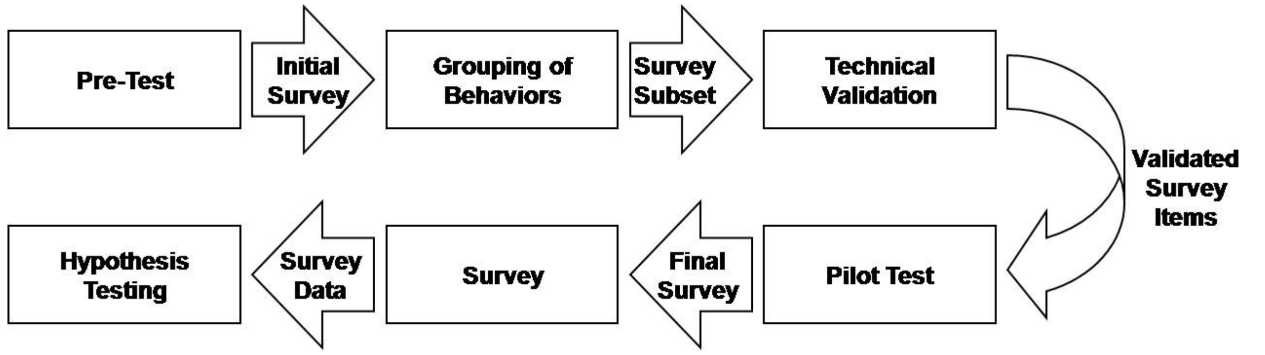


Figure 3.1 –Methodology Followed

Pretest

The first phase of instrument validation is the pretest (Straub 1989). This phase includes starting with a predetermined questionnaire based on previously validated instruments in prior research. This is followed by a series of three interviews with a panel of experts beginning with an unstructured interview, followed by a semi-structured interview, and ending with a highly structured process. The purpose of the first interview is to gain knowledge from the experts on what they think individual security behaviors are, as well as the threats that each behavior protects people from. They were also be asked to think of behaviors that they perform which impact the security of information they have on their computer or the security of information they have access to from their computer. Follow up questions were asked to gain clarification of the behavior being performed, as well as to uncover what threat the expert is protecting himself from by performing the behavior.

As discussed in Chapter Two, no validated instrument for measuring ISB currently exists. However, a number of behaviors have been identified as necessary to protect the security of computer systems. In order to develop an instrument to measure ISB it is necessary to start with expert interviews, comparing what the experts have to say with the predetermined list of behaviors to protect computer systems (the specific process of expert interviews is discussed later in this paper). However, previously validated measures do exist for the independent variables. PMT research regularly measures response cost (Neuwirth et al. 2000; Sheeran et al. 1996); however, previous research does not define the costs of performing security behaviors. Therefore, it is necessary to utilize the expert opinions to determine what these costs are. A scale to measure the remaining four independent variables has been developed and validated. This scale is the Risk Behavior Diagnosis (RBD) Scale, and encompasses severity of threat, susceptibility to threat, self-efficacy, and response efficacy (Witte 1996). Additionally, much work has been done in IS research on self-efficacy, developing this construct with validated measures (Compeau et al. 1995b; Marakas et al. 2007). Relying on the previously validated instruments results in a framework for questions to measure the items in this context (see Table 3.1). The specific way these questions were asked resulted from the pretest with experts.

Table 3.1 – Initial Item Framework.

Dimension	Item	Source
Perceived Security Vulnerabilities	I am at risk for getting [*threat*].	(Witte 1996)
	It is likely that I will contract [*threat*].	
	It is possible that I will contract [*threat*].	
Perceived Security Threats	I believe that [*threat*] is severe.	(Witte 1996)
	I believe that [*threat*] is serious.	
	I believe that [*threat*] is significant.	
Security Self-Efficacy	I am capable of performing [*recommended response*].	(Compeau et al. 1995b; Marakas et al. 2007; Witte 1996)
Response Efficacy	[*Recommended response*] works at preventing [*threat*].	(Witte 1996)
	Doing [*recommended response*] is effective at preventing [*threat*].	
	If I perform [*recommended response*], I am less likely to get [*threat*].	
Prevention Cost	[*Recommended response*] requires significant [prevention cost].	(Neuwirth et al. 2000; Sheeran et al. 1996)

In order to follow the approach recommended by Straub (1989), a panel of seven experts in information security was assembled, including representatives from academia, military, and corporations ranging in location from the Southeast to the Northwest of the United States. Experts were defined as individuals that trained others in information security, performed research in information security, or worked in information security. During the first round of interviews, the experts were asked to think of behaviors that they performed that influenced the security of information they had on their computer or the security of information they had access to from their computer. Follow up questions were asked to gain clarification of the behavior being performed, as well as to uncover what threat the individual was protecting himself or herself from by performing the behavior.

At the completion of the first round of interviews, the results were analyzed looking for agreement on a number of behaviors. The second round of interviews then occurred. The purpose of this round of interviews was to clarify differences between the comments experts provided during round one. For example, some experts gave conflicting advice about certain behaviors. Clarification was necessary to ensure that I reached a consensus about which the appropriate behaviors to perform. Round two interviews also provided an opportunity to gather an estimation of the cost of performing and measuring each of the behaviors.

The survey questions were refined based on the outcome of the interviews, and the experts reviewed the newly designed questionnaire. The experts read the items and noted any unclear or ambiguous items. The questionnaire was modified to incorporate their feedback on the items. Appendix A presents the resulting ISB instrument. An additional result from the interviews with experts is the identification of relationships between threats and behaviors, which is presented in Table 3.2. Combining these relationships with the framework for questions presented in Table 3.1 results in an initial survey with over 100 items.

Table 3.2 – Mapping of Behaviors and Threats

Behavior	Measure	Threat
Automate software updates	Auto Update 1 Auto Update 2 Auto Update 3	Corrupted hard drive Denial of service Downtime Loss of data Repair/Replace Cost Slow down computer Software stops
Backup data	Backup 1 Backup 2 Backup 3	Loss of files
Change password quarterly	PWD Change	Financial Loss Loss of control of email Loss of files Loss of information
Educate others in house about behaviors	Household	Access to Financial data Identity Theft Loss of data
Keep software updated	Software Updates 1 Software Updates 2	Corrupted hard drive Downtime Loss of files Slow down computer Software stops
Scan Computer for Spyware	Spyware 1 Spyware 2	Access to bank account Identity Theft Loss of data Monitor Action Slow Down Computer Stolen passwords
Secure Login to computer with password	Restrict Access Screen Saver 1 Screen Saver 2 Screen Saver 3	Loss of files Loss of Information
Secure mobile computer	Restrict Access	Access to information Financial Losses Stolen Information
Setup user access controls	Oth Access 1 Oth Access 2 Guest Access Admin Pwd	Corrupted Operating System Loss of files Loss of information Programs Installed Protect Program Settings
Setup wireless network securely	Wireless 1 Wireless 2 Wireless 3 Wireless 4 Wireless 5	Financial Information Identity Theft Stolen Information
Use AV Software	AV1 AV2 AV3	Computer Crash Corrupted hard drive Downtime Loss of files Slow down computer Software stops Stops programs from working

Behavior	Measure	Threat
Use caution when following links in email	Links 1 Links 2	Identity Theft
Use caution when opening attachments	Attachments	Financial Information Corrupted hard drive Loss of files/data Software stops
Use caution when storing credit card info online	CC	Identity Theft
Use Firewall	Firewall 1 Firewall 2	Computer Crash Corrupted hard drive Financial Losses Loss of data Slow down computer Software stops Stealing software
Use popup blocker	Popup 1 Popup 2	Loss of data Slow down computer Stolen privacy
Use software to manage passwords	PWD Store	Loss of network account Punitive actions

Technical Validation

The purpose of technical validation is to ensure that the developed items display adequate reliability and validity. The ISB instrument, being the only new instrument for this survey, is the only instrument that went through the technical validation process. The reliability and validity of the other items were analyzed during the pilot test phase. During this phase of instrument development, the questionnaire was adjusted to ensure it performs as expected. In order to perform the technical validation, it was first necessary to administer the developed scale to a population. Approximately 300 students from undergraduate and graduate level business classes were recruited to assist in the validation of the developed instrument. Participants were told that their responses would remain anonymous.

The scales were analyzed using the Rasch Rating Scale Model (RSM) (Wright et al. 1982). The Rasch model relies on a single-parameter item response model to depict measures of latent traits and characteristics of items on a single continuum (Osterlind 2006). Relying on RSM instead of classical test theory is appropriate in this study as RSM allows for items in one scale to have multiple response formats (Hambleton et al. 1991; Hays et al. 2000). The RSM formula is as follows:

$$\pi_{nix} = \frac{\exp\sum_{j=0}^{x}(\theta_n - \delta_i - \tau_j)}{\sum_{k=0}^{m}\exp\sum_{j=0}^{x}(\theta_n - \delta_i - \tau_j)}$$

This formula consists of the probability (π_{nix}) that an instrument participant (n) will respond to an item (i) with a certain category x. θ_n stands for a person's problem solving ability level, δ_i symbolizes an item's approvability, and τ_j symbolizes the threshold between two categories. In a polytomous model τ_j represents the difficulty of moving from one scoring category to another. It also assumes that the thresholds between scoring categories is constant across items.

Several analytical procedures were applied to the data to assess the quality of the instrument including dimensionality, reliability, fit, rating scale analysis, and validity evidence.

Dimensionality

The dimensionality of the data set was analyzed using factor analysis. For the ISB data, a scree plot of the data and eigenvalues of each construct were used to examine the dimensionality of the different scales. Eigenvalues over 1 are considered to be an added dimension above and beyond that explained by the Rasch model itself. However, for the other items, which were adapted from previous research, confirmatory factor analysis was used to test for dimensionality.

Reliability

I examined reliability to determine how dependable and repeatable the test scores are. This reliability factor calculates the ratio of true item variance to observed item variance and shows how consistent measurements are for individuals or groups of a population (Osterlind 2006). Reliability is provided as output from WINSTEPS version 3.63.2. As this is an initial creation of an instrument and high stakes decisions are not being made with it, reliability of greater than .7 are considered adequate.

Fit Analysis

An advantage of IRT is the ability to determine how appropriate the Rasch model is for the data. This includes testing the assumptions of the model, determining the accuracy of the model's predictions, assessing the overall fit of the model to the data, and assessing the fit of the individual components of the measurement context to the model (Wolfe 2007). Model assumptions were analyzed as part of the dimensionality analysis. The initial assumption of the model is that the model is unidimensional. Following this, other fit measures can be analyzed by investigating whether or not participants responded to items as predicted by the model. If not, certain items are flagged for substantive analysis. Following Hambleton (1985) the fit of latent trait models to the collected data was evaluated by determining whether the model assumptions are satisfied and the precision of model predictions.

I analyzed the fit between the Rasch model and the responses using the unweighted mean square statistic and the weighted mean square statistic. By using both the weighted and the unweighted mean square statistic, both unexpected responses for mismatched pairs and equally weighted items were captured. In this analysis, a bootstrap procedure is used to flag items for further analysis (Wolfe in press). This bootstrap procedure was conducted utilizing the following five-step procedure (Wolfe 2008): (1) Item and person parameters for the Rasch model were calculated for the original dataset using WINSTEPS version 3.63.2; (2) Simulated item response data that conform to the Rasch model were bootstrapped from the original calculations in step 1; (3) Item and person fit statistics were calculated for each dataset in step 2; (4) Extreme indexes at 2.5%, 5%, 95%, and 97.5% were calculated based on the statistics calculated in step 3; and (5) Item and person fit statistics from the original dataset were compared to the extreme indexes calculated in step 4. This final step determined whether any of the original data has fit that is more extreme than the bootstrapped critical values.

Biserial point measure correlation was used to analyze inter-item correlation. The biserial point measure correlation takes into account item difficulty in assessing the cohesiveness between items, where the standard point measure correlation does not. Items with biserial point measure correlations greater than .3 indicate a minimum level of cohesiveness or that each item is measuring the same thing.

Rating Scale Analysis

The rating scale analysis is used to determine whether the instrument works as it was intended. When an instrument is administered, it is done so using a scale with a certain number of responses available for the respondent (e.g. 7, 5, 3-point scales). This analysis determines whether or not the respondents answered using the intended scale or if some other scale would have been more appropriate. This is accomplished by looking at the thresholds of when one response becomes more likely than another response. As this study includes items on several different scales, it was necessary to perform the rating scale analysis on different groups of items. In doing so the criteria proposed by Linnacre (2002) was used to evaluate each rating scale. Linnacre's evaluation criteria includes 8 items and is as follows: (1) Each category needs at least 10 observations; (2) Each item's distribution should be unimodal which ensures that people use the rating scale the same way; (3) Average measures should increase across categories; (4) The outfit mean square statistic should be less than 2.0 for each category; (5)

Category thresholds should increase with the categories; (6) Ratings should imply measures and measures should imply ratings; (7) Thresholds should increase by at least 1.4 logits from one category to the next; and (8) Thresholds should not increase by more than 5.0 logits from one category to the next.

Validity

To ensure validity from these results, I tested the three criteria which Messick (1989) introduced as important when analyzing instruments. These three types of validity are substantive validity, structural validity, and generalizability. Substantive validity was ensured by the underlying theory that developed the measures as well as the fit analysis that was discussed above. Structural validity was ensured through the dimensionality analysis. Generalizability was ensured through an analysis of the person reliability.

Grouping of Behaviors

As noted above, the resulting questionnaire was greater than 100 items, which is too large for a survey. Therefore, it was necessary to reduce the number of items measured in the final data collection effort. This was accomplished by examining the mapping of behaviors that the group of experts recommended with the threats that each of these behaviors protect individuals from as displayed in Table 3.2. The resulting analysis revealed that in order for each of the behaviors in the ISB instrument to have a relevant threat that it protects people from that three threats needed to be included – Identity Theft, File and Information Loss, and Computer Slowdown. To facilitate a shorter survey instrument, three surveys were administered, one for each threat identified.

Pre-Test and Pilot Study

Each of the resulting three survey instruments from the grouping of behaviors were reviewed by four Ph.D. students to identify unclear wording and the approximate amount of time each survey will take to complete. Respondents reported that it took approximately 8 to 12 minutes to complete and that a few of the items required clarification. Modifications were made to the items identified during the Pre-Test.

The pilot study was conducted by recruiting three sections of the same graduate level business class and administering each section a different version of the survey. Ninety students completed surveys; 34 completed the identity theft survey, 24 completed the file and information loss survey, and 32 completed the computer slowdown survey. SmartPLS Version 2.0.M3 was used to analyze the reliability and validity of the items. It is necessary to use Partial Least Squares (PLS) to perform this process as the research model is composed of reflective and formative constructs. To test the reliability and validity of the items in the pilot study, a PLS algorithm was conducted for each behavior to threat mapping. The majority of constructs demonstrated acceptable reliability greater than .7 with the following exceptions – Threat Perception File and Information Loss (.658), Response Efficacy Identity Theft Secure Wireless Network (.627), Prevention Cost File and Information Loss Password Change (.593), Prevention Cost File and Information Loss Secure Access (.641), and Prevention Cost Identity Theft Following Links in Email (.694). Of these items, prevention cost makes up three of the five items with low reliability. Prevention cost is a formative construct so VIF values were examined to test for multicollinearity. With VIF values of less than 3.3, all three scales do not display multicollinearity, suggesting they are appropriate as designed (Petter et al. 2007). The remaining two scales are close to the .7 threshold, and with the different population set to be used for final data collection, it is expected that these items will prove to be reliable as designed.

Validity analysis revealed that the majority of items loaded as expected. Only one of three items for the Threat Perception Identity Theft scale loaded together. These two items were reworded to clarify the meaning of the questions. One of the three Response Efficacy Identity Theft Spyware items did not load (.363) with the other two items. The wording on this item was evaluated and it appeared to accurately capture the construct of interested, therefore no changes were made at this time. None of the Prevention Cost Computer Slowdown Firewall items loaded together. The VIF value for the items measuring the formative construct prevention cost construct were evaluated and did not show multicollinearity, suggesting that the items to measure this construct are appropriately worded. Appendix B contains the validation of the ISB instrument.

Full Scale Survey

After the survey was adjusted based on the results of the pilot test, a large-scale survey was conducted. It is suggested that the use of PLS requires a sample size of 10 times either the number of structural paths to a particular construct in a model or 10 times the number of formative indicators to a particular construct (Chin 2000). The security self-efficacy construct has the greatest number of formative indicators at seven, suggesting it is necessary to have at least a sample size of 70. However, it is also necessary to conduct a power analysis to ensure that a large enough sample size is used. A power analysis based on previous PMT research (Floyd et al. 2000), which found a medium effect size of .15, an alpha of .05, and power of .80, suggests that 97 responses are necessary to ensure enough power (Cohen 1992). Therefore, the goal for data collection was at least 100 subjects per survey from the population of people that use computers. This was conducted by using paper and web-based surveys. Paper-based surveys were used for manual data collection at events, while web-based surveys were used to collect data from people within a business. Both event data collection and solicitations from businesses were used to ensure a large enough population for data analysis.

Data Analysis

Nature of constructs

When hypothesizing theoretical models, not only is it important to test the hypotheses in the model, but it is also important to define and test the nature of the constructs in the model. Models can be composed of any combination of reflective, formative, and multi-dimensional constructs (Petter et al. 2007). Petter et al. define the above constructs accordingly: Reflective constructs are *observed measures that are affected by underlying latent construct.* Formative constructs are *a composite of multiple measures where changes in the formative measures cause changes in the underlying construct.* Multi-dimensional constructs are *constructs with more than one dimension, with each dimension representing some portion of the overall latent construct and with each dimension, itself being either reflective or latent.* A summary of these types of constructs along with the criteria for determining them are provide in Table 3.3.

Table 3.3 - Construct Types (Jarvis et al. 2003; Petter et al. 2007)

Construct Type	Definition	Determination Criteria
Reflective	Observed measures that are affected by underlying latent construct	1. Direction of causality is from construct to items. 2. Indicators should be interchangeable. 3. Indicators are expected to covary with one another. 4. Nomological net for the indicators should not differ.
Formative	A composite of multiple measures where changes in the formative measures cause changes in the underlying construct	1. Direction of causality is from items to construct. 2. Indicators need not be interchangeable. 3. Not necessary for indicators to covary with one another. 4. Nomological net for the indicators may differ.
Multi-Dimensional	Constructs with more than one dimension, with each dimension representing some portion of the overall latent construct and with each dimension, itself being either reflective or latent	1. Comprised of two or more sub-dimensions. 2. Fits the definition of a formative construct when each sub-dimension is treated as an indicator. 3. Each sub-dimension is comprised of two or more indicators.

In evaluating the criteria for determining the nature of constructs, it has been determined that the research model contains multi-dimensional constructs consisting of reflective factors (perceived security vulnerability, perceived security threat, and response efficacy), multi-dimensional items consisting of formative factors (prevention cost), and formative factors (ISB and security self-efficacy). The multi-dimensional items meet the criteria that the construct is comprised of two or more sub-dimensions; each sub-dimension fits the definition of a formative construct if it was treated as an indicator; and each sub-dimension is comprised of two or more indicators. The reflective constructs meet the criteria that the direction of causality is from the construct to the items, indicators are interchangeable, indicators are expected to covary with one another, and the nomological net for the indicators should be the same.   The formative constructs meet the criteria that direction of causality is from items to construct, indicators are not interchangeable, indicators do not necessarily covary from one another, and the nomological net for each of the indicators may be different (Jarvis et al. 2003; Petter et al. 2007). Figure 3.2 presents the research model tested. Figure 3.3 presents the nature of the multi-dimensional reflective constructs. Figure 3.4 presents the nature of the multi-dimensional formative construct. Figure 3.5 presents the nature of the formative constructs.

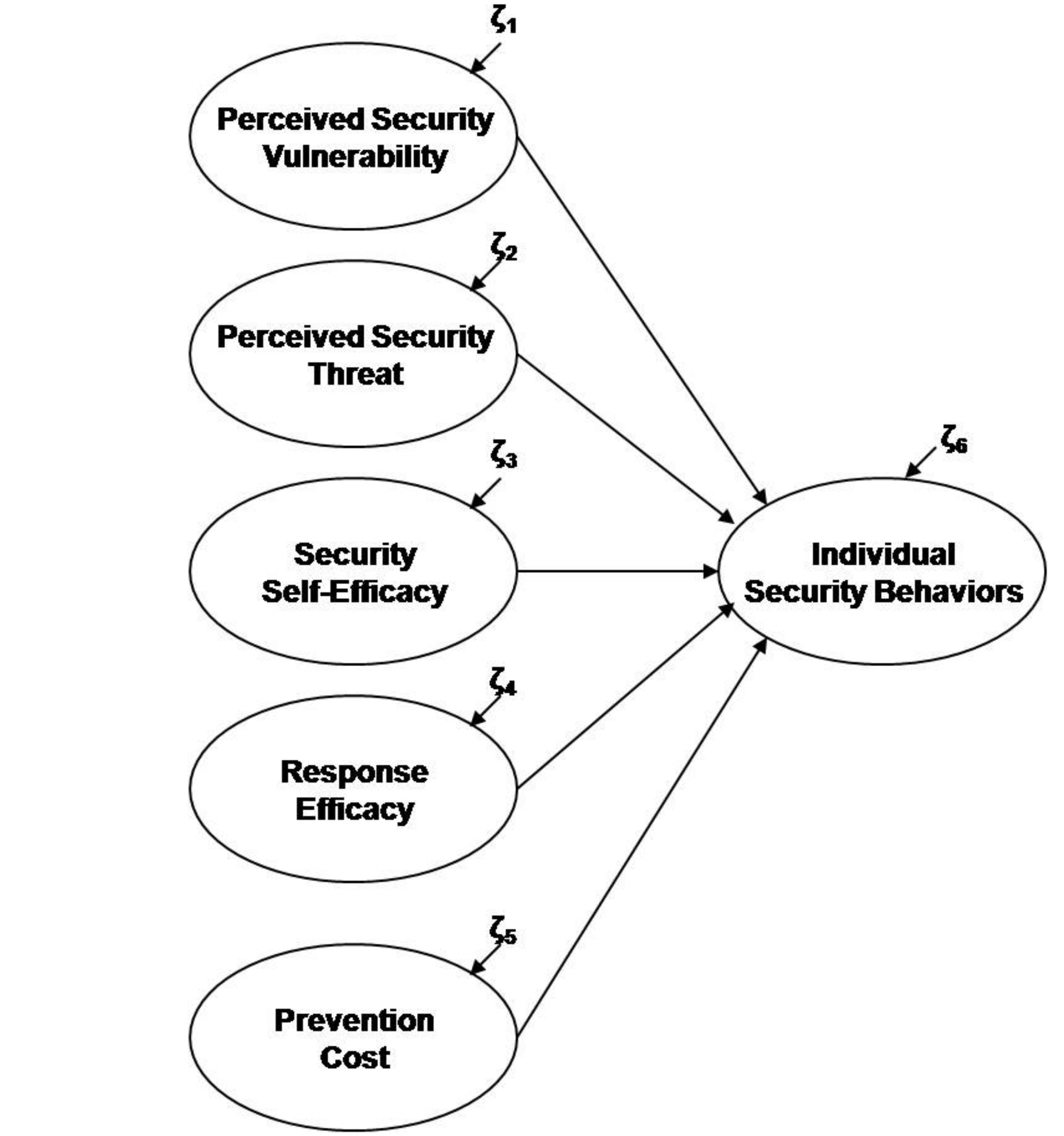
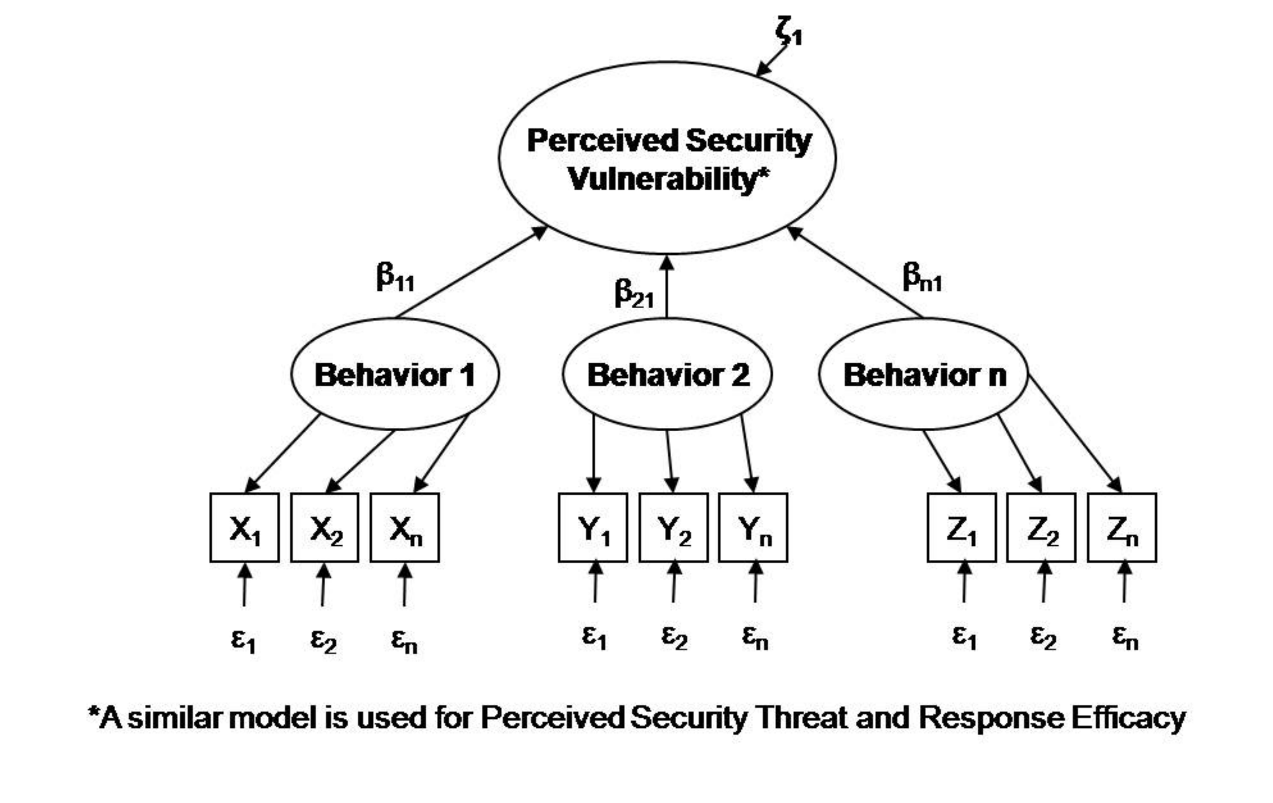


Figure 3.2 – Research Model


ζ1
Perceived Security Vulnerability*
β11
β21
βn1
Behavior 1
Behavior 2
Behavior n
X1
X2
Xn
Y1
Y2
Yn
Z1
Z2
Zn
ε1
ε2
εn
ε1
ε2
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ε2
εn
*A similar model is used for Perceived Security Threat and Response Efficacy

Figure 3.3 – Multi-Dimensional Reflective Constructs

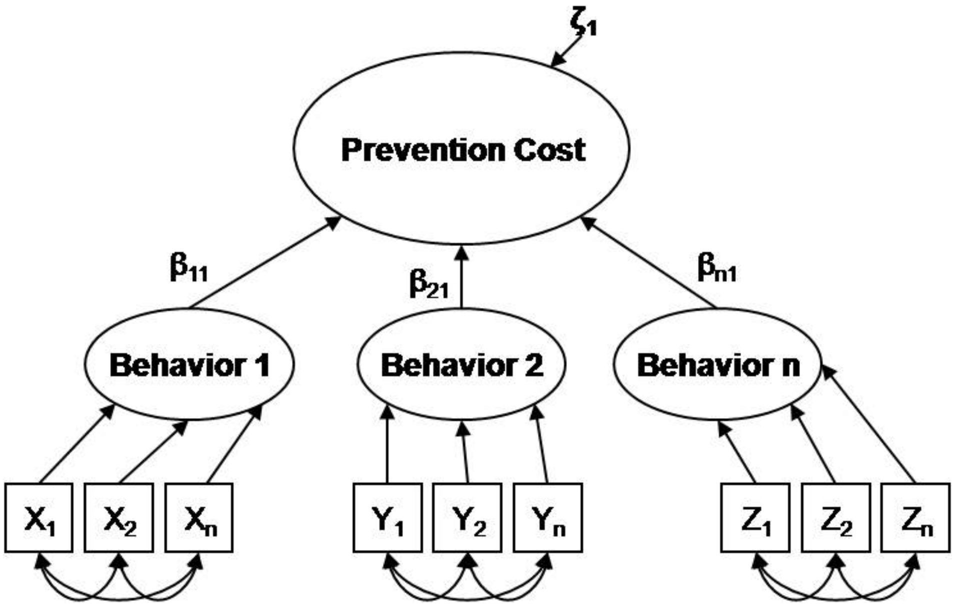


Figure 3.4 – Multi-Dimensional Formative Constructs

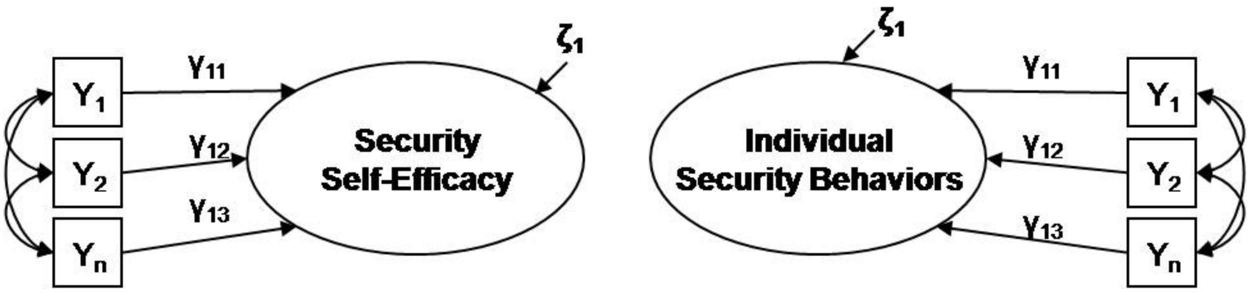


Figure 3.5 – Formative Constructs

Hypothesis Testing

As the relationships in the proposed model include formative constructs, it is necessary to test them using Partial Least Squares (PLS). Marcoulides and Saunders (2006) propose that prior to using PLS a researcher must first consider the following: 1. Propose a model that is consistent with theory. 2. Perform data screening such as testing for normality, the presence of outliers, and the presence of missing data. 3. Examine the psychometric properties of all variables involved, such as the reliability and validity of all scales and factors involved in the model. 4. Examine the magnitude of the standard errors of the estimates as well as the confidence intervals of the constructs. 5. Assess and report the power of the study. Table 3.4 presents a summary of above recommendations and how this study addresses them.

Table 3.4 – PLS Considerations (Marcoulides et al. 2006)

Consideration	**Addressed**
1. Propose a model consistent with theory.	The model tested was consistent with existing theories (PMT and GDT).
2. Perform data screening.	Data tested for normality, outliers, and the presence of missing data.
3. Examine psychometric properties.	Reliability and validity tests conducted on the collected data.
4. Examine magnitude of standard errors and confidence intervals of constructs.	Standard errors and confidence intervals tested and reported.
5. Assess and report the power of the study.	In order to obtain enough power 100 responses per survey was collected.

Chapter Four: Data Analysis

The survey instrument used for this research was created through the process of expert interviews and by adapting scales and items from existing literature. This chapter presents a detailed description of the data analysis for this study. Chapter Five discusses the results found in this chapter and the implications they have for academics and practitioners, along with avenues for future research. Chapter Six concludes the dissertation with a discussion of the limitations, and a summary of the contributions of this study.

This chapter is organized as follows. The first section provides a descriptive analysis of the data. Reliability, convergent and discriminant validity are presented in the measurement model. This is followed by PLS regressions, which are used to test the research model and hypotheses. The structural model is tested through estimates of the path coefficient, which indicate the strength of the relationships between the independent and dependent variables, and the r-squared values, which represent the variance in the dependent variable that is explained by the independent variables. Taken as a whole, the path coefficients and the r-squared values indicate how well the data support the proposed model. Finally, the extended model, which includes an interaction between the threat appraisal and coping appraisal, is presented.

Descriptive Analysis

Online and paper-based versions of the survey were administered to participants. Different sources completed each version of the survey. The paper version of the survey was administered to attendees of a soccer tournament in Virginia, USA. Distribution of the online version of the survey occurred in a number of ways. Initially, data was collected by emailing a number of contacts of the researcher a request to participate in the survey and then forward on the request. Collection of additional data occurred through the distribution of a request to participate in the survey to subscribers of the graduate student listserv at Virginia Polytechnic Institute and State University. Finally, a number of small businesses disseminated a request to have their employees complete the survey. A total of 324 surveys were received, 55 on paper and 269 online. 44 incomplete surveys were eliminated along with one survey from a participant who was under the age of 18. Hence, 279 surveys were used for data analysis: 52 paper responses and 227 online responses. Table 4.1 illustrates the number of responses received from each online and paper-based source. Response rates varied by group and are approximated. Approximately 50 percent of the people approached at the soccer tournament completed the survey, while approximately 25 percent of the small business employees who received the survey responded and 3.5 percent of graduate students responded. Response rates are not estimated from the forwarding of the email as the total population it was sent to is unknown. These response rates are rather low, but expected. The response rate from the graduate listserv is consistent with previous Information Systems research using this particular source (Carter 2006). Previous security research found a response rate of 1.6% for a paper-based mail survey (Kotulic et al. 2004). Research also shows that web-based surveys have a lower response rate than paper-based surveys (Shih et al. 2008).

Table 4.1 – Sample Sources

Source	Frequency	Percent	Cumulative	Approximate Response Rate	Type
Graduate Listserv	142	50.9	50.9	3.5%	Online
Forward	63	22.6	73.5		Online
Soccer Tournament	52	18.6	92.1	50%	Paper
Small Businesses	22	7.9	100.0	25%	Online

Differences between online and paper responses were identified using independent sample t-tests. The two samples displayed differences on a small subset of items, mostly related to the dependent variable. However, the differences could likely be attributed to differences in the age of the online population sample versus the paper sample. The implications of these differences are discussed in the next chapter. For the following data analyses, a combined sample was used.

After combining the samples, the data were tested for outliers and normality. Outliers can significantly alter the outcome of analysis. Outliers can occur due to errors of data entry, missing values, unintended sampling, and non-normal distribution (Cohen 1969). Outliers were identified by proofreading the data for obvious data entry errors. This was followed by checking the data for missing values and then running statistical tests. A response was considered an outlier if it was more than three standard deviations away from the expected value of the variable (Cohen 1969). For the majority of models tested, all cases were within the suggested range. However, the dataset for two of the behaviors related to the threat of a computer slowing down had one data point removed (auto update and pop ups) and two of the data points from the dataset measuring the use of spyware software to address the identification theft threat were removed. As previously mentioned, 44 incomplete surveys were eliminated along with one survey that represented unintended sampling, resulting in a sample of 279 responses.

Table 4.2 and 4.3 display the summary demographics. Over half of the respondents are female (55.3%). The majority of respondents are Caucasian (85.6%). Almost all of the respondents hold a college degree or higher (90.2%). The income is well distributed with no group containing more than 35% and no group containing less than 20%. The average age of respondents was 35.30 with a minimum age of 20 and a maximum age of 83. Respondents have been using computers for an average of 16.67 years with a minimum of two years and a maximum of 53. The average number of hours respondents spend on the Internet is 27.73 ranging from one hour to 100 hours. The average number of hours respondents spend on their computer is 35.62 ranging from one hour to 110 hours per week.

Table 4.2 – Categorical Variable Summary Demographics

Question	Categories	Number	Percentage
Gender	Male	123	44.7
	Female	152	55.3
Ethnicity	Caucasian	232	85.6
	African American	4	1.5
	Hispanic	4	1.5
	Asian	25	9.2
	Other	6	2.2
Education	Some High School	4	1.5
	High School Graduate	6	2.2
	Some College	17	6.2
	Undergraduate Degree	138	50.2
	Graduate Degree	110	40.0
Income	Less than $25,000	87	32.6
	$25,000 to $50,000	54	20.2
	$50,000 to $100,000	63	23.6
	Over $100,000	63	23.6

Table 4.3 – Continuous Variable Summary Demographics

Question	Mean	Minimum	Maximum
Age	35.30	20	83
Years Using a Computer	16.67	2	53
Hours Using Internet Per Week	27.73	1	100
Hours Using Computers Per Week	35.62	1	110

Table 4.4 shows the mean and standard deviation of each of the reflective constructs in the research model. Each of the formative items in this study displayed VIF values of less than 3.3, which shows that they were not highly correlated with one another.

Table 4.4 – Summary of Study Reflective Variables

Construct	Number of Items	Mean (scale of 1 to 5)	Standard Deviation
Perceived Security Vulnerability File Loss	3	3.201	.906
Perceived Security Vulnerability ID Theft	3	3.486	.541
Perceived Security Vulnerability Slow Down	3	3.192	.955
Perceived Security Threat File Loss	3	4.144	.872
Perceived Security Threat ID Theft	3	4.617	.634
Perceived Security Threat Slow Down	3	4.006	.789
Response Efficacy File Loss Anti Virus	3	4.049	.747
Response Efficacy File Loss Access Control	3	3.625	.824
Response Efficacy File Loss Back Up	3	4.246	.666
Response Efficacy File Loss Password Change	3	3.284	.930
Response Efficacy File Loss Secure Access	3	3.674	.856
Response Efficacy File Loss Software Updates	3	3.466	.893
Response Efficacy File Loss Wireless	3	3.557	.787
Response Efficacy ID Theft Credit Cards	3	3.542	.933
Response Efficacy ID Theft Education	3	3.653	.586
Response Efficacy ID Theft Links	3	3.791	.705
Response Efficacy ID Theft Spyware	3	3.518	.736
Response Efficacy ID Theft Wireless	3	3.560	.623
Response Efficacy Slow Down Anti Virus	3	3.784	.836
Response Efficacy Slow Down Auto Update	3	3.406	.798
Response Efficacy Slow Down Firewall	3	3.363	.899
Response Efficacy Slow Down Popup	3	3.632	.824
Response Efficacy Slow Down Software Updates	3	3.491	.842
Response Efficacy Slow Down Spyware	3	3.863	.793

Measurement Model

The data was analyzed using Partial Least Squares (PLS), which is necessary when testing formative constructs because it allows for the proper identification of relationships in the model. This translates into a proper assessment of both the measurement model as well as the structural model (Petter et al. 2007).

Prior to testing the hypotheses in the proposed model, it is necessary to assess the accuracy of the measurement model. This process ensures that the measures are valid and properly reflect the theoretical constructs. The reliability, or the internal consistency, of the model is tested along with the convergent and discriminant validity of the measurement items.

Reliability is assessed using Cronbach's Alpha and composite reliability. Table 4.5 shows the reliability of the constructs. All of the constructs except for the Perceived Security Vulnerability construct of the ID Theft threat model and the Response Efficacy of Education for the ID Theft threat model displayed satisfactory reliability above the 0.70 threshold (Nunnally 1978). The response efficacy construct displayed acceptable reliability after removing one item from the construct. Due to not displaying reliability even after dropping several items, the Perceived Security Vulnerability construct was removed from further analysis related to the Identity Theft threat.

Table 4.5 - Construct Reliability

Construct	Number of Items	Cronbach's Alpha	Composite Reliability
Perceived Security Vulnerability File Loss	3	.829	.894
Perceived Security Vulnerability ID Theft*	3	.566	.429
Perceived Security Vulnerability Slow Down	3	.856	.913
Perceived Security Threat File Loss	3	.927	.953
Perceived Security Threat ID Theft	3	.886	.929
Perceived Security Threat Slow Down	3	.884	.928
Response Efficacy File Loss Anti Virus	3	.903	.939
Response Efficacy File Loss Access Control	3	.939	.961
Response Efficacy File Loss Back Up	3	.896	.936
Response Efficacy File Loss Password Change	3	.930	.955
Response Efficacy File Loss Secure Access	3	.931	.956
Response Efficacy File Loss Software Updates	3	.900	.938
Response Efficacy File Loss Wireless	3	.870	.920
Response Efficacy ID Theft Credit Cards	3	.875	.917
Response Efficacy ID Theft Education	2**	.707	.870
Response Efficacy ID Theft Links	3	.746	.853
Response Efficacy ID Theft Spyware	3	.790	.875
Response Efficacy ID Theft Wireless	3	.852	.910
Response Efficacy Slow Down Anti Virus	3	.877	.924
Response Efficacy Slow Down Auto Update	3	.891	.912
Response Efficacy Slow Down Firewall	3	.920	.950
Response Efficacy Slow Down Popup	3	.931	.956
Response Efficacy Slow Down Software Updates	3	.932	.955
Response Efficacy Slow Down Spyware	3	.896	.934

* Construct removed from further analysis due to unacceptable reliability
** Removed one item to achieve acceptable reliability

Convergent and discriminant validity were assessed by examining whether items intended to measure one construct were more highly correlated with themselves or with other constructs. Items that loaded the most strongly on their own constructs were considered to have convergent validity. Convergent validity was additionally tested by calculating the Average Variance Extracted (AVE) for each construct, which is the amount of variance that a latent variable component captures from its indicators in relation to the amount due to measurement error. The AVE value for all constructs were above the recommended threshold of 0.50 (Fornell et al. 1981), indicating good convergent validity of the items in each construct.

Discriminant validity was tested by assessing whether the AVE from a construct was greater than the variance shared with other constructs in the model (Chin 1998). Appendix D displays the squared pair-wise correlation of the latent construct correlations along with the AVE. The diagonal of the correlation matrix presents the AVEs. Satisfactory discriminant validity is indicated for all models, as the AVE is greater than the squared pair-wise correlation of the latent variables.

Discriminant validity was additionally assessed using the cross-loading method (Chin 1998). As seen in Appendix E, the items loaded higher in their own columns than in the column for other constructs. Furthermore, when evaluating the items across rows, the items loaded most strongly on their intended constructs. Therefore, the measurements satisfy the criteria recommended by Chin (1998).

Structural Model

Based on the acceptable analysis of the measurement model, testing of the structural model and proposed hypotheses can ensue. The structural model was tested using SmartPLS to estimate the path coefficients, which calculates the strength of the relationships between independent and dependent variables. R-squared values were also estimated, in order to display the variance explained by the independent variables. The proposed hypotheses were tested using t-statistics for the standardized path coefficients, by specifying the same number of cases as existed in the dataset and bootstrapping 500 re-samples. One-tailed t-tests were used, as the hypotheses were all direction specific. The model was run twice for each threat measured, because the initial model does not include any interaction effects and the extended model captures the interaction between the threat appraisal and the coping appraisal process. Since each threat was tested individually, each hypothesis was given a subset letter such that hypotheses related to file loss are referred to as a, hypotheses related to identity theft are referred to as b, and hypotheses related to computer slow down are referred to as c.

Figure 4.1 presents the results from running the initial model to test hypotheses that related to behaviors designed to protect from losing files on the computer. Hypothesis 1a was not supported, but significant findings were found for running software updates and securing wireless networks in the opposite direction hypothesized. Hypothesis 2a was not supported for any of the behaviors. Hypothesis 3a significantly explained backing up data on a regular basis, and securing access to accounts by using strong passwords. Hypothesis 4a displayed a significant relationship in determining whether people changed their password on a regular basis. Hypothesis 5a displayed a significant relationship with the use of anti-virus software and backing up data on a regular basis. The variance in behavior explained for each behavior ranged from 18.5 percent to 60.4 percent. The greatest amount of variance was explained for backing up data regularly (60.4%), followed by properly securing a wireless network (46.9%), setting up user access controls (45.7%), running software updates (26.1%), using anti-virus software (24.7%), securing access to accounts with strong passwords (20.5%), and changing passwords quarterly (18.5%).

Figure 4.1 - Significant Paths for File Loss Initial Model

H1 a - Perceived Security Vulnerability	H2a - Perceived Security Threat	H3a - Security Self-Efficacy	H4a - Response Efficacy	H5a - Prevention Cost	Behavior
				-.270	Anti-Virus $r^2 = 0.247$
		.559			Access Control $r^2 = 0.457$
		.611		-.247	Backup $r^2 = 0.604$
			.324		Password Change $r^2 = 0.185$
		.402			Secure Access $r^2 = 0.205$
-.248*					Software Updates $r^2 = 0.261$
-.336*					Wireless Network $r^2 = 0.469$

* Significant in opposite direction hypothesized

Figure 4.2 presents the results from running the initial model to test the hypotheses related to behaviors designed to protect from identity theft. Hypothesis 1b was not tested due to poor reliability of the items measuring this construct. Hypothesis 2b was not supported for any of the behaviors but a relationship between perceived security threat and properly securing a wireless network did display significance in the opposite direction hypothesized. Hypothesis 3b significantly explained using caution when storing credit card information, educating others in one's household, and using spyware software. Hypothesis 4b was not supported, but significance was found in the opposite direction hypothesized between response efficacy and properly securing a wireless network. Hypothesis 5b displayed a significant relationship with educating others in one's household. The variance in behavior explained for each behavior ranged from 12.3 percent to 31.9 percent. The greatest amount of variance was explained for properly securing a wireless network (31.9%), followed by using spyware software (30.4%), educating others in one's household (25.8%), using caution when storing credit card information (13.4%), and using caution when following links in emails (12.3%).

Figure 4.2 - Significant Paths for ID Theft Initial Model**

H2b - Perceived Security Threat	H3b - Security Self-Efficacy	H4b - Response Efficacy	H5b - Prevention Cost	Behavior
	.327			Credit Cards $r^2 = 0.134$
	.508		.238*	Education $r^2 = 0.258$
				Links $r^2 = 0.123$
	.462			Spyware $r^2 = 0.304$
-.190*		-.291*		Wireless Network $r^2 = 0.319$

* Significant in opposite direction hypothesized

** Perceived Security Vulnerability construct dropped due to low reliability

Figure 4.3 presents the results from running the initial model to test the hypotheses related to behaviors designed to protect from having computers slow down. Hypothesis 1c was not supported, but significant findings were found for running software updates in the opposite direction hypothesized. Hypothesis 2c was not supported for any of the behaviors. Hypothesis 3c significantly explained using anti-virus software, using pop-up blocking software, running software updates, and using spyware software. Hypothesis 4c displayed a significant relationship in determining whether people ran automatic updates for Windows and ran other software updates regularly. Hypothesis 5c displayed a significant relationship with the use of anti-virus software, the use of a firewall and the use of spyware software. The variance in behavior explained for each behavior ranged from 24.5 percent to 30.4 percent. The greatest amount of variance was explained for using pop-up blocking software (30.4%), followed by using spyware software (30.2%), running automatic updates (26.5%), running software updates (25.3%), using anti-virus software (25.3), and using a firewall (24.5%).

Figure 4.3 - Significant Paths for Slow Down Initial Model

H1c - Perceived Security Vulnerability	H2c - Perceived Security Threat	H3c - Security Self-Efficacy	H4c - Response Efficacy	H5c - Prevention Cost	Behavior
		.263		-.283	Anti-Virus $r^2 = 0.253$
			.290		Auto Updates $r^2 = 0.265$
				-.284	Firewall $r^2 = 0.245$
		.518			Pop Ups $r^2 = 0.304$
-.283*		.331	.160		Software Updates $r^2 = 0.253$
		.248		-.287	Spyware $r^2 = 0.302$

* Significant in opposite direction hypothesized

Figure 4.4 presents the results from running the extended model to test the hypotheses that related to behaviors designed to protect from losing files on the computer as well as interactions between the threat appraisal process and the coping appraisal process. Hypothesis 1a was not supported, but significant findings were found for running software updates and securing wireless networks in the opposite direction hypothesized. Hypothesis 2a was not supported for any of the behaviors. Hypothesis 3a significantly explained using proper access controls, backing up data on a regular basis, and changing passwords on a regular basis. Hypothesis 4a displayed a significant relationship in determining whether people changed their password on a regular basis. Hypothesis 5a displayed a significant relationship with the use of anti-virus software, backing up data on a regular basis, and running software updates. There was a significant relationship found between Perceived Security Vulnerability and Security Self-Efficacy for running software updates with 15.6% of variance explained. Perceived Security Vulnerability had a negative significant relationship with Response Efficacy for anti-virus usage, securing access to accounts with strong passwords and properly securing a wireless network, with 4.6, 10.3, and 13.4 percent of variance explained respectively. Perceived Security Threat did not have a significant relationship with Security Self-Efficacy or Response Efficacy. The variance in behavior explained for each behavior ranged from 19.2 percent to 57.6 percent. The greatest amount of variance was explained for backing up data regularly (57.6%), followed by properly securing a wireless network (48.4%), setting up user access controls (42.6%), running software updates (22.7%), using anti-virus software (20.9%), changing passwords quarterly (19.3%), and securing access to accounts with strong passwords (19.2%).

Figure 4.4 - Significant Paths for File Loss Threat Extended Model

H1a - Perceived Security Vulnerability	H2a - Perceived Security Threat	H3a - Security Self-Efficacy	H4a - Response Efficacy	H5a - Prevention Cost	Behavior	Vulnerability → Security Self-Efficacy	Vulnerability → Response Efficacy	Severity → Security Self-Efficacy	Severity → Response Efficacy
				-.263	Anti-Virus $r^2 = 0.209$		$r^2 = 0.046$ -.212		
		.596			Access Control $r^2 = 0.426$				
		.597		-.255	Backup $r^2 = 0.576$				
		.597	.360		Password Change $r^2 = 0.193$				
					Secure Access $r^2 = 0.192$		$r^2 = 0.103$ -.317		
-.227*				-.233	Software Updates $r^2 = 0.227$	$r^2 = 0.156$ -.270			
-.397*					Wireless Network $r^2 = 0.484$		$r^2 = 0.134$ -.367		

* Significant in opposite direction hypothesized

Figure 4.5 presents the results from running the extended model to test the hypotheses related to behaviors designed to protect from identity theft as well as interactions between the threat appraisal process and the coping appraisal process. Hypothesis 1b was not tested due to poor reliability of the items measuring this construct. Hypothesis 2b was not supported for any of the behaviors. Hypothesis 3b significantly explained using caution when storing credit card information, educating others in one's household, and using spyware software. Hypothesis 4b was not supported, but significance was found in the opposite direction hypothesized between Response Efficacy and properly securing a wireless network. Hypothesis 5b displayed a significant relationship with educating others in one's household. There were no relationships found between the coping appraisal process and the threat appraisal process. The variance in behavior explained for each behavior ranged from 9.8 percent to 31.2 percent. The greatest amount of variance was explained for properly securing a wireless network (31.2%), followed by using spyware software (30.1%), educating others in one's household (24.9%), using caution when storing credit card information (13.4%), and using caution when following links in emails (9.8%).

Figure 4.5 - Significant Paths for ID Theft Threat Extended Model**

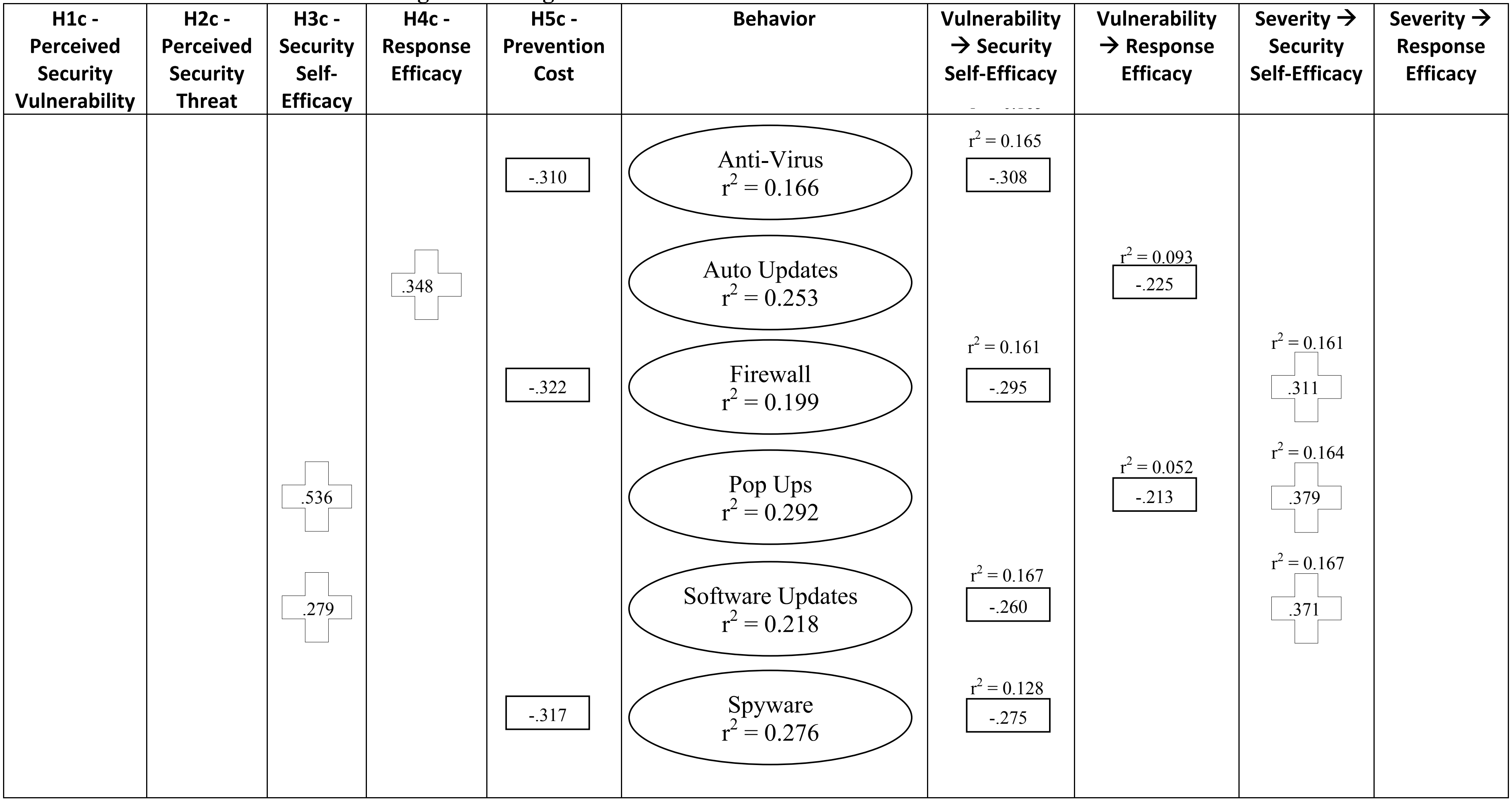
H2b - Perceived Security Threat	H3b - Security Self-Efficacy	H4b - Response Efficacy	H5b - Prevention Cost	Behavior	Severity → Security Self-Efficacy	Severity → Response Efficacy
	✚ .324			Credit Cards $r^2 = 0.134$		
	✚ .508		✚ .255*	Education $r^2 = 0.249$		
				Links $r^2 = 0.098$		
	✚ .463			Spyware $r^2 = 0.301$		
		-.339*		Wireless Network $r^2 = 0.312$		

* Significant in opposite direction hypothesized

** Perceived Security Vulnerability construct dropped due to low reliability

Figure 4.6 presents the results from running the extended model to test the hypotheses related to behaviors designed to protect from having computers slow down as well as interactions between the threat appraisal process and the coping appraisal process. Hypothesis 1c and 2c were not supported for any of the behaviors. Hypothesis 3c significantly explained using pop-up blocking software and running software updates. Hypothesis 4c displayed a significant relationship in determining whether people ran automatic updates for Windows. Hypothesis 5c displayed a significant relationship with the use of anti-virus software, the use of a firewall and the use of spyware software. There was a significant negative relationship found between Perceived Security Vulnerability and Security Self-Efficacy for using anti-virus software, using a firewall, running software updates, and using spyware software with 16.5, 16.1, 16.7, and 12.8 percent of variance explained respectively. Perceived Security Vulnerability had a negative significant relationship with Response Efficacy for running auto updates and using pop-up blocking software with 9.3 and 5.2 percent of variance explained respectively. Perceived Security Threat had a positive significant relationship with Security Self-Efficacy for using a firewall, using pop-up blocking software, and running software updates with 16.1, 16.4, and 16.7 percent of the variance explained respectively. Perceived Security Threat did not influence Response Efficacy for any of the behaviors. The variance in behavior explained for each behavior ranged from 16.6 percent to 29.2 percent. The greatest amount of variance was explained for using pop-up blocking software (29.2%), followed by using spyware software (27.6%), running automatic updates (25.3%), running software updates (21.8%), using a firewall (19.9), and using anti-virus software (16.6%).

Figure 4.6 - Significant Paths for Slow Down Threat Extended Model



H1c - Perceived Security Vulnerability	H2c - Perceived Security Threat	H3c - Security Self-Efficacy	H4c - Response Efficacy	H5c - Prevention Cost	Behavior	Vulnerability → Security Self-Efficacy	Vulnerability → Response Efficacy	Severity → Security Self-Efficacy	Severity → Response Efficacy
				-.310	Anti-Virus r^2 = 0.166	r^2 = 0.165 -.308			
			.348		Auto Updates r^2 = 0.253		r^2 = 0.093 -.225		
				-.322	Firewall r^2 = 0.199	r^2 = 0.161 -.295		r^2 = 0.161 .311	
		.536			Pop Ups r^2 = 0.292		r^2 = 0.052 -.213	r^2 = 0.164 .379	
		.279			Software Updates r^2 = 0.218	r^2 = 0.167 -.260		r^2 = 0.167 .371	
				-.317	Spyware r^2 = 0.276	r^2 = 0.128 -.275			

In summary, figures 4.1 through 4.6 shows that different hypotheses are supported for different behaviors and the specific threat it addresses. The results and implications of these findings are discussed more fully in the next chapter.

Chapter Five: Discussion

This chapter provides a discussion of the results presented in Chapter Four, the implications of these findings and ideas for future research. This study empirically investigated how well Protection Motivation Theory (PMT) explained individual security behaviors. Five determinants were hypothesized to have an effect on individual security behaviors. The determinants were perceived security vulnerability, perceived security threat, security self-efficacy, response efficacy, and protection costs. No study to date has used PMT to explore such a plethora of information security behaviors. As illustrated in the previous chapter, the determinants proposed to have an effect on individual security behaviors differed greatly depending on the behavior studied.

This chapter first discusses the findings and implications for each threat individually, which includes losing files on a computer, identity theft, and having the computer slow down. Then, a discussion of similarities and differences between the findings for the three threats occurs. This chapter concludes with a discussion of the overall implications of this research coupled with ideas for future research.

Significant Findings

As identified in Chapter One, the goal of this study was to understand what determined the security behaviors of individuals. This study found that the determinants of individual security behaviors vary depending on the behavior studied. In this section, each threat is explored individually to see how the threat appraisal process coupled with the coping appraisal process affects individual security behaviors.

File Loss

The first model tested investigated behaviors identified to protect files from being lost on a computer, which includes using anti-virus software, using proper access control, backing up data, changing passwords quarterly, securing access with strong passwords, updating software on a regular basis, and properly securing a home wireless network.

Initial Model

The initial model studied direct relationships from perceived security vulnerability, perceived security threat, security self-efficacy, response efficacy, and prevention costs to individual security behaviors. Table 5.1 summarizes the findings from the initial model.

Table 5.1 – Summarized File Loss Protection Findings – Initial Model

Security Behavior	H1a PSV	H2a PST	H3a SSE	H4a RE	H5a PC
Anti-Virus					✓
Access Controls			✓		
Backup Data			✓		✓
Password Change				✓	
Secure Access			✓		
Software Updates				✓	
Wireless Network	✗				

✓- Hypothesis supported

✗ - Significant in opposite direction than hypothesized

The coping appraisal constructs, security self-efficacy, response efficacy, and prevention costs, proved to be the most telling in what caused a person to take actions to keep from losing files on their personal computer. Five of the seven behaviors measured that protect an individual from losing files were significantly impacted by coping appraisal constructs. In particular, security self-efficacy (H3a) showed up more frequently than any other reason for people to protect themselves from file loss. Security self-efficacy (H3a) was the only factor that significantly differed when it comes to using access controls to protect one's personal computer and securing access to accounts with strong passwords. Security self-efficacy (H3a) coupled with protection costs (H5a) significantly affected whether people backup the data on their personal computer. This suggests that as people gain confidence in their ability to secure their computer the likelihood that they will backup their data, setup proper access controls, and use strong passwords to secure their accounts should increase. In addition, people who perceive the cost of backing up their data as low are more likely to perform this behavior. Kim (2005) found that people who received security training were twice as likely to backup their data. This suggests that when people receive training on security the likelihood they are backing up their data should increase. Future research could use an experiment to determine whether the increase in data backup is due to changes in security self-efficacy and prevention cost or some other factors.

Response efficacy (H4a) displayed significance only for changing passwords quarterly. This suggests that individuals who are confident that changing their password will protect them from losing files actually perform this behavior. Other research has found that training, awareness, monitoring, and rewards resulted in a greater likelihood to change passwords regularly (Stanton et al. 2005). These findings suggest that combining training on the effectiveness of changing passwords regularly to protect from losing files with a monitoring and reward system to encourage the changing of passwords will result in an increase in frequent password changes. Part of this process should be coupled with other research findings that people should be allowed to use the same password for multiple systems (Kim 2005). Companies can improve the number of employees changing their passwords regularly through the implementation of training systems targeted at the effectiveness of password changes at protecting files from being lost, monitoring people to ensure passwords are changed regularly, rewarding those who regularly change passwords, and allowing people to use the same password for multiple systems.

Prevention costs (H5a) affected anti-virus software usage such that those who perceived the cost of using anti-virus software as low were more likely to use it. Previous research found that 25 percent of respondents either did not use anti-virus software or did not update it (Kim 2005). Of those that did have anti-virus software installed on their computer, the majority did so because it came pre-installed with the purchase of their personal computer, thus making the financial cost near zero. Further research found that 85 to 93 percent of respondents use anti-virus software (Furnell et al. 2007; Furnell et al. 2006). However, only 63 percent of individuals reported to be updating their anti-virus software regularly (Furnell et al. 2007). The findings related to anti-virus usage suggest that it is important for anti-virus software to come pre-packaged with computers or setup before it ends up in users' hands and that automatic updates be turned on. Using these technological solutions will lower the perceived cost of using anti-virus software and result in protecting people from viruses, even if they do not know they have the software turned on. Researchers should be aware that, with the nearly universal automation of anti-virus software, users might not know they are using the software and their responses to questions about the use of this software could be unintentionally wrong. Training that makes people aware that they are using anti-virus software could help address this lack of knowledge issue and result in more accurate survey responses.

Perceived security vulnerability (H1a) is the only threat appraisal construct that significantly affects individual security behaviors performed to protect from file loss. However, for the two behaviors (running software updates and securing wireless networks) where significance is found, it is in the opposite direction than hypothesized. This suggests that people who feel that they are vulnerable to losing files on their computer are less likely to keep the software updated on their computer or secure their home wireless network. These findings are contrary to the findings by Woon et al. (2005), who found all the constructs except perceived vulnerability significantly impacted home wireless security. The dependent variable in this study and the study by Woon and his colleagues is different, as is the nature of the threat measured. This study investigated the single threat of files being lost or stolen. While Woon and his colleagues investigated multiple threats including identity theft, having files stolen, lost network bandwidth, and hacker attacks. Even with these differences, it is interesting to note that there is no similarity in findings. This implies that although people are not using a secure wireless network to protect from losing files, they may be doing so to protect from one of a number of threats that Woon and his colleagues propose. In other words, people are not securing their wireless network properly in order to protect from the threat of files being lost or stolen. Further research is necessary to determine the true relationship between which threat people are actually concerned about protecting themselves from when they secure their wireless network.

Extended Model

The extended model, summarized in Table 5.2, introduces a relationship from perceived security vulnerability and threat to security self-efficacy and response efficacy. In this extended model, the threat appraisal constructs show up as significant indicators to the coping appraisal constructs.

Table 5.2 – Summarized File Loss Protection Findings – Extended Model

Security Behavior	H1a PSV	H2a PST	H3a SSE	H4a RE	H5a PC	PSV → SSE	PSV→ RE	PST → SSE	PST→ RE
Anti-Virus					✓		✓		
Access Controls			✓						
Backup Data			✓		✓				
Password Change			✓	✓					
Secure Access							✓		
Software Updates	×				✓	✓			
Wireless Network	×						✓		

✓- Hypothesis supported
× - Significant in opposite direction than hypothesized

Perceived security vulnerability negatively significantly affected response efficacy for using anti-virus software, securing access to accounts with strong passwords, and properly securing wireless networks. This suggests that people who feel vulnerable to losing files on their computer are less likely to believe that using anti-virus software, securing access to accounts with strong passwords, and properly securing wireless networks are effective at protecting themselves from this vulnerability. However, response efficacy (H4a) does not have a significant impact to any of these behaviors. This means that there is a negative relationship between the perceptions of a threat and a person's confidence in how well a behavior protects from that threat but it ultimately does not affect behaviors. Future research can explore the nature of this relationship to determine whether there is another factor not measured in this study at play. It could be that people have differences in their experience performing each of these behaviors to deal with potential file loss. For example, some people may have lost files in the past while they were performing a behavior that should have protected them from this happening. The result is that they feel vulnerable to losing files again, but do not believe that properly securing a wireless network is effective at protecting them from it happening again. If they are securing their wireless network, they are doing it for a reason not captured in this particular model.

The introduction of the threat appraisal constructs as antecedents to the coping appraisal constructs results in more characteristics having a direct impact on behaviors. This could be happening because perceived security vulnerability and threat better explain differences in security self-efficacy and response efficacy than differences in individual security behaviors. When the variance explained by the threat appraisal constructs is lower in explaining differences in individual security behaviors, then other coping appraisal constructs are able to explain more of the variance in individual security behaviors. Backing up data, changing passwords quarterly, and running software updates now have significant relationships with two determining factors. Identical to the initial model, security self-efficacy (H3a) and prevention costs (H5a) affected backing up data, providing additional evidence that people with confidence in their ability to perform security tasks coupled with a view that backup data is a low cost behavior are more likely to backup their data regularly. Security self-efficacy (H3a) and response efficacy (H4a) affect changing passwords quarterly. This implies that in order for people to change their passwords quarterly they need to have confidence in their ability to perform security tasks and believe that changing their password quarterly will protect them from file loss. Perceived security vulnerability (H1a) and prevention costs (H5a) affect the frequency of running software updates, such that people who feel vulnerable to file loss and view the costs of running software updates as high are less likely to run software updates. In addition, perceived security vulnerability negatively affects security self-efficacy (H3a), which does not have a direct effect on running software updates. This implies that those who feel less vulnerable to losing files have greater confidence in their ability to perform security tasks. However, it is not their confidence in performing security tasks that causes them to run software updates, but that not feeling vulnerable and believing the cost of running software updates is low are the determining factors of whether someone runs software updates. This begs the question as to why those that feel less vulnerable to file loss are more likely to perform software updates. Future research can explore whether this relationship is cyclical, in the sense that experience running software updates leads to feeling less vulnerable to file loss and, based on that experience, the individual continues to run software updates.

Although the majority of hypotheses related to behaviors that protect from file loss are not supported, the amount of variance explained in the difference of the behaviors for some models is relatively high. Backing up data, properly securing a wireless network, and using appropriate user access control all have more than 40 percent of their variance explained in both models while backing up data has over 60 percent of its variance explained in the initial model. This suggests that although not all of the paths are significant, the model still does a good job of explaining the differences in behaviors. Even the behaviors with lower variance explained such as changing passwords quarterly and securing access to accounts with strong passwords have over 18 percent of variance explained. These findings demonstrate that the model that explains behaviors related to protecting from losing files is more parsimonious than the models tested. This allows researchers and practitioners to have confidence that, as they influence the few factors that affect individual security behaviors that protect from file loss, they will make a significant difference in improving behaviors, especially those behaviors with over 40 percent of their variance explained.

In summary, many of the hypothesized relationships did not explain the differences in why people perform different behaviors to protect themselves from losing files. However, of those that were significant, coping appraisal was much more likely to affect behaviors. When threat appraisal constructs had a significant relationship, either it was in the wrong direction than hypothesized or it affected a coping appraisal construct that did not have a direct impact on behaviors. Given these findings, the model still explained a fair amount of variance in the different behaviors people take to keep from losing files on their computer.

Identity Theft

The next models tested investigated behaviors identified to protect an individual from identity theft, which includes using caution when storing credit card information, educating others in one's house about proper security behaviors, using caution when following links in emails, using spyware software, and properly securing a home wireless network. The perceived security vulnerability construct did not display acceptable reliability and was excluded from analysis in these models. Any findings are tempered by the fact that these models were not tested as theoretically proposed.

Initial Model

As mentioned before, the initial model studied direct relationships from perceived security threat, security self-efficacy, response efficacy, and prevention costs to individual security behaviors. Table 5.3 summarizes the findings from the initial model.

Table 5.3 – Summarized Identity Theft Protection Findings – Initial Model

Security Behavior	**H2b**	**H3b**	**H4b**	**H5b**
	PST	**SSE**	**RE**	**PC**
Credit Cards		✓		
Education		✓		✖
Links				
Spyware		✓		
Wireless Network	✖		✖	

✓- Hypothesis supported

✖ - Significant in opposite direction than hypothesized

Behaviors that protect people from identify theft are best explained by the coping appraisal constructs. The initial model found that four of the five behaviors to protect from this threat were explained by coping appraisal constructs. Security self-efficacy (H3b) significantly affected using caution when storing credit cards, educating others in one's household about security behaviors and using software to protect from spyware. That is people who felt confident in their ability to perform security tasks were more likely to practice these behaviors to protect themselves from identity theft. Previous research on the use of spyware found that perceived behavioral control, attitude, and technology awareness affected a person's intention to use spyware software (Dinev et al. 2007). Dinev and her colleagues found that self-efficacy did not affect perceived behavioral control. An interesting expansion on this research would be to replace the reflective measure of self-efficacy used by Dinev and her colleagues with a formative measure of security self-efficacy as used in this study to see if it better explains differences in perceived behavioral control.

In addition to security self-efficacy (H3b), prevention costs (H5b) significantly affected educating others in one's house in the opposite direction hypothesized. This would suggest that people who view the cost of educating others in their household as high would be more likely to do so. This may be an experience issue for people, as people who are educating others in their house realize the cost of it, but it is important enough for them to do so anyway. The implementation of training programs for people, especially parents, about the importance of educating others in their house about appropriate security behaviors could result in the increase of the education of others.

Only one of these behaviors, properly securing wireless networks, was explained by a threat appraisal construct. However, contrary to findings by Woon et al. (2005), properly securing wireless networks was explained by significant relationships from perceived security threat (H2b) and response efficacy (H5b) in a direction that was opposite as hypothesized. This means that people who feel that identity theft is a severe threat, as well as those that believe properly securing a wireless network is effective at protecting them from identity theft, are less likely to perform this behavior. This could of happened because, when it comes to identity theft, people who believe that properly securing a wireless network is not effective at protecting from identity theft and that the threat is not severe, but for other reasons have decided the properly securing their wireless network is an appropriate measure to take. That is, they are securing their wireless network for reasons not captured in this study. The following section discusses the implications of this finding.

Extended Model

The extended model, summarized in Table 5.4, introduces a relationship from perceived security threat to security self-efficacy and response efficacy.

Table 5.4 – Summarized Identity Theft Protection Findings – Extended Model

Security	H2b	H3b	H4b	H5b	PST →	PST→
Behavior	**PST**	**SSE**	**RE**	**PC**	**SSE**	**RE**
Credit Cards		✓				
Education		✓		×		
Links						
Spyware		✓				
Wireless Network			×			

✓- Hypothesis supported
× - Significant in opposite direction than hypothesized

In the extended model the only differences between it and the initial model is the missing relationship between perceived security threat (H2b) and properly securing a home wireless network. This suggests that although people think that properly securing their wireless network is effective at protecting them from identity theft, they are not doing so. The fact that none of the other relationships are significant suggests that people are not terribly concerned with identity theft and are not performing those behaviors that they know will protect them. It could also be this study does now capture what people are doing to protect themselves from identity theft. One marketing study suggests that the best way to protect from identity theft is to freeze credit reports through reporting bureaus (Eisenstein 2008). This suggests that people may be taking a broader view of identity theft than just as it relates to their personal computer and are taking measures to protect themselves from any form of identity theft. Further investigation in this area is necessary before making any definitive conclusions, especially considering that perceived security vulnerability was not included in the model testing.

Although very few of the hypotheses related to behaviors that protect from identity theft are supported, a fair amount of variance in the performance of different behaviors is explained. The amount of variance explained ranges from 12.3 percent to 31.9 percent for the initial model and 9.8 percent to 31.2 percent in the extended model. Properly securing a wireless network had the greatest amount of variance explained in both models. This is interesting, considering the relationships that affect properly securing a wireless network are in the opposite direction hypothesized. This suggests that these findings are robust in explaining why people properly secure their wireless network. With the hypotheses related to this behavior being supported in the opposite direction hypothesized, it could be that people are securing the wireless network for reasons other than to protect from identity theft, but their feelings are strong enough that securing a wireless network is not effective at protecting them from identity theft that it explains differences anyway. Such findings suggest that an avenue for future research is to understand what causes people to properly secure their wireless network. Not surprisingly, using caution when clicking on links had the lowest variance explained in both models. Using caution when clicking on links also did not have any hypotheses supported. This suggests that this model is not appropriate to explain differences in this behavior. It could also indicate that people are knowledgeable enough about this behavior that they are all taking proper measures and thus there is no variance in behavior.

In summary, this model does not do a very good job of explaining the differences in why people protect themselves from identity theft. Compared to the other models, this model could have the least number of supported hypotheses because it deals with something that is social in nature, while the other two threats deal with more technical related threats. It is possible that people's behavior when it comes to social threats are influenced differently than more technically related threats whose losses are more readily and easily observable. It should be kept in mind that perceived security vulnerability was not tested in these models and including it could have influenced the findings. Without having this variable, the findings from this model should be used cautiously, if at all.

Computer Slow Down

The final model tested investigated behaviors identified to prevent a person's computer from slowing down, which includes using anti-virus software, automating Windows updates, using a software firewall, using pop-up blocking software, updating software on a regular basis, and using spyware software.

Initial Model

Similar to before, the initial model studied direct relationships from perceived security vulnerability, perceived security threat, security self-efficacy, response efficacy, and prevention costs to individual security behaviors. Table 5.5 summarizes the findings from the initial model.

Table 5.5 – Summarized Computer Slow Down Protection Findings – Initial Model

Security Behavior	H1c	H2c	H3c	H4c	H5c
	PSV	PST	SSE	RE	PC
Anti-Virus			✓		✓
Auto Updates				✓	
Firewall					✓
Pop Up Blocking Software			✓		
Software Updates	×		✓	✓	
Spyware			✓		✓

✓- Hypothesis supported
× - Significant in opposite direction than hypothesized

The initial computer slow down threat model displayed similar findings as the previous two threats discussed, with the coping appraisal constructs explaining most of the difference in behaviors people take to prevent their computer from slowing down. Similar to the file loss model, prevention costs (H5c) affect anti-virus software usage. However, in dealing with the threat of having the computer slow down, security self-efficacy (H3c) also affects anti-virus software usage. This indicates that people who perceive the costs of using anti-virus software as low along with having confidence in their ability to perform security tasks are more likely to run anti-virus software to keep their computer from slowing down. In addition to the implications discussed above, that it is important for anti-virus software to come pre-packaged with computers or setup before it ends up in users hands and that automatic updates be turned on, it is also important to focus training on overall confidence at performing security tasks. In receiving security training, people will become aware of the fact that they are running anti-virus software, even if it is automated. Doing so will allow future research to more accurately reflect self-report data on whether people are using anti-virus software to protect their computers.

Security self-efficacy (H3c) and prevention costs (H5c) also affect the use of anti-spyware software. Similar to using anti-virus software, people who perceive the costs of using anti-spyware software as low, along with having confidence in their ability to perform security tasks, are more likely to run anti-spyware software to keep their computer from slowing down. Previous studies find different results in the number of people who use anti-spyware software with one study finding that less than 30 percent of respondents use anti-spyware software (Kim 2005) and another finding that 77 percent of respondents use anti-spyware software (Furnell et al. 2007). This difference could be attributed to the time that passed between these two studies. As spyware has become a bigger threat (Deloitte 2007), more people have become aware of the need to do something about it. Therefore, continuing to educate people about how to perform security tasks, including how to use anti-spyware software, will result in significant improvement in this behavior. In particular, education in this area will increase people's confidence at performing security tasks, increase their knowledge about the what anti-spyware software does as well as how to use it, and decrease their perception of the costs associated with running anti-spyware software.

Security self-efficacy (H3c), prevention cost (H5c), and perceived security vulnerability (H1c) affect the running of software updates; with perceived security vulnerability affecting the running of software updates in a direction opposite than hypothesized. This indicates that people that feel the most vulnerable to having their computer slow down are less likely to run software updates. However, people with confidence in their ability to perform security tasks and a belief that downloading software updates prevents their computer from slowing down are more likely to do so. These relationships change in the extended model, thus discussion of the implications of these results occurs in the next section.

Security self-efficacy (H3c) also affects the use of pop-up blocking software to protect from having computers slow down.   This suggests that people who are confident in their ability to perform security tasks are more likely to use pop-up blocking software. Similar to other behaviors that protect from having computers slow down, training programs designed to improve confidence when performing security tasks will result in more people using pop-up blocking software.

Response efficacy (H4c) affects the running of automatic updates for the Windows operating system. In other words, a person is more likely to run automatic updates if they are confident that doing so protects them from having their computer slow down. Previous research found that more than half of respondents did not update their operating system, let alone use automatic updates (Kim 2005). A more recent study found that 70 percent of respondents ran automatic updates (Furnell et al. 2006), but a further study found that only 40 percent of respondents did so regularly (Furnell et al. 2007). The study by Kim (2005) found that of those that had received security training nearly one-third did not regularly update their operating system. This suggests that the training provided did not adequately inform people about the effectiveness that running automatic updates had on preventing the computer from slowing down. An increase in the frequency of operating system updates should result by informing people how automatic updates prevents their computer from slowing down during training programs.

Prevention costs (H5c) affect the use of firewall software. People who perceive the costs of using firewall software as low are more likely to run anti-virus software to keep their computer from slowing down. Previous studies found that approximately half of respondents did not use firewall software (Furnell et al. 2006; Kim 2005), with over 20 percent not aware of the firewall feature within Windows XP (Furnell et al. 2006). These findings suggest that educating people about how to configure and setup firewall software on their computer will result in significant improvements in this behavior. In particular, education in this area will increase people’s knowledge about the firewall software already built into most operating systems, and decrease their perception of the costs associated with running a firewall.

Extended Model

The extended model, summarized in Table 5.6, introduces a relationship from perceived security vulnerability and threat to security self-efficacy and response efficacy.

Table 5.6 – Summarized Computer Slow Down Protection Findings – Extended Model

Security Behavior	**H1c PSV**	**H2c PST**	**H3c SSE**	**H4c RE**	**H5c PC**	**PSV → SSE**	**PSV→ RE**	**PST → SSE**	**PST→ RE**
Anti-Virus					✓	✓			
Auto Updates				✓			✓		
Firewall					✓	✓		✓	
Pop Up Blocking Software			✓				✓	✓	
Software Updates			✓			✓		✓	
Spyware					✓	✓			

✓- Hypothesis supported

In the extended model, there are no direct effects on security behaviors from the threat appraisal constructs. However, for three of the six behaviors studied there is an effect on security behaviors through the coping appraisal constructs. Perceived security vulnerability negatively affects response efficacy (H4c), which positively affects running automatic updates. For this behavior, people who feel more vulnerable to having their computers slow down are less likely to believe that running automatic updates will address this issue, and ultimately are less likely to perform automatic updates. Furthermore, people who feel that having their computer slow down is a severe problem are more likely to have higher security self-efficacy and those with higher security self-efficacy (H3c) are more likely to run pop-up blocking software. The third impact the threat appraisal has through the coping appraisal constructs is on running software updates. Both perceived security vulnerability and threat affect security self-efficacy, with perceived security vulnerability having a negative effect. This means that people who feel vulnerable to having their computer slow down have less confidence in their ability to perform security tasks, while people that feel that their computer slowing down is a severe problem have more confidence in their ability to perform security tasks. This is interesting as security self-efficacy (H3c) is the only characteristic that has a significant impact on individual's updating of software regularly. These findings inform the development of information security programs aimed at protecting computers from slowing down. In order to reduce this threat, people need to be running software updates regularly. Since security self-efficacy directly affects running software updates, programs that target this characteristic should yield greater results in individual behavior. These findings suggest that targeting training on increasing people's threat perception of their computer slowing down and decreasing how vulnerable they feel to this threat will affect their confidence in performing security tasks. By adding training that focuses on the perceived vulnerability and severity of having computers slow down, further impact can be had on security self-efficacy.

Other relationships exist between the threat appraisal constructs and the coping appraisal constructs, but not in a way that led directly to behaviors. For example, only prevention costs (H5c) affect running anti-virus software and spyware software, but perceived security vulnerability negatively affects security self-efficacy for these behaviors. Similar findings exist for using a software firewall with perceived security threat negatively affecting security self-efficacy. Additionally, the impact security self-efficacy (H3c) had on behaviors fell from four behaviors impacted to two when using the extended model. These findings suggest the relationship between perceived security threat and security self-efficacy confounded the initial findings and suggests that security self-efficacy may not influence behaviors related to protecting computers from slowing down as much as the initial findings indicated. Further studies that investigate antecedents to security self-efficacy should include perceived security vulnerability so the true relationship between these constructs can be understood.

The models that explain behaviors that protect computers from slowing down have the most consistently supported hypotheses. However, the majority of the proposed hypotheses were not supported and the variance explained in the dependent variables was not as high as it was for the model that explained behaviors that protected people from losing files. In the initial model, all the behaviors had over 24 percent of their variance explained with using spyware software and using pop-up blocking software having the most at over 30 percent of the variance explained. In the extended model none of the behaviors had over 30 percent of their variance explained with the use of pop-up blocking software dropping to 29.2 percent, spyware software usage dropping to 27.6 percent and anti-virus software usage dropping to 16.6 percent of variance explained. This suggests that the initial model does a better job of explaining the variance in behaviors, but using the extended model may do a better job of explaining the true nature of the characteristics that influence these security behaviors. The variance explained in these models suggests that the theory used is parsimonious and caution should be used not to use overly complicated models as future research tries to further understand differences in individual security behaviors that protect from having computers slow down.

In summary, consistent with the previous models studied, coping appraisal constructs affected performing behaviors to protect one's computer from slowing down more often than threat appraisal constructs. In this particular model, the threat appraisal regularly interacted with the coping appraisal to influence security behaviors. Although the hypotheses were more consistently supported, the overall variance explained by the models was less than the models dealing with the threat of losing files.

Threat Comparisons

Each of the three models discussed above dealt with findings related to a different threat. This section discusses security behaviors as a whole and compares the above-discussed models to one another. Although each threat used a different sample, analyzing these models as a whole can provide a number of insights.

Certain independent variables more regularly affect individual security behaviors for all of the models studied. In particular, security self-efficacy (H3) affected behaviors the most frequently, followed by response efficacy (H4), prevention cost (H5), perceived security vulnerability (H1) and perceived security threat respectively (H2). When these last two constructs did directly influence security behaviors, they were in the opposite direction as hypothesized. When testing the hypotheses with the extended model, perceived security vulnerability (H1) only affected two of the behaviors related to not losing files (running software updates and properly securing wireless networks). Other than that, neither perceived security vulnerability (H1) nor perceived security threat (H2) influenced behaviors in the extended models.

The most consistent finding throughout all three threats was that the coping appraisal process consistently outperformed the threat appraisal process in explaining differences in individuals' behaviors. There were differences between models on how the threat appraisal interacted with the coping appraisal process to explain behaviors. The models that included behaviors that protect people from identity theft did not show any interaction between the threat appraisal and the coping appraisal constructs. This could have been due to perceived security vulnerability not being included in this model, as perceived security vulnerability more frequently led to differences in security self-efficacy and response efficacy. In the model that included behaviors that protected people from losing computer files, the interaction between threat appraisal and coping appraisal never led to a direct effect on behaviors. However, when it comes to protecting computers from slowing down there were three out of six behaviors that did show the threat appraisal constructs having a significant impact through the coping appraisal constructs. Perceived security threat only affected security self-efficacy and never response efficacy.

In summary, no consistent set of characteristics explained the behaviors studied. In general, there was consistency in the coping appraisal having the greatest impact on behaviors. The threat appraisal process more consistently affected the coping appraisal process than security behaviors. When the threat appraisal did influence security behaviors, it was in the opposite direction hypothesized. The next section discusses the implications of these findings.

Implications and Future Research

Investigation of differences in individual security behaviors was conducted by asking users of personal computers questions regarding their use of computers at home. This approach was utilized in order to understand how people acted in an environment where they were responsible for making their own security decisions. This section describes the implications of the findings presented above, as well as directions for future research.

Impacts on Security Research

The above findings show a lack of consistency in what causes an individual to protect himself from a given threat with any of a number of responses. These findings have implications for both academics and practitioners. From an academic perspective, it illustrates that there may be different models that explain differences in individual security behaviors. However, the tested model explains a significant amount of the variance in performance for some behaviors, even with very few of the hypotheses supported. As researchers begin to investigate what causes people to perform certain security behaviors, it is important that they concentrate on a certain behavior that addresses a certain threat and use the findings in this study as a foundation for what characteristics to include in their research model.

One of the most consistent findings was the positive impact that security self-efficacy has on individual security behaviors. Computer self-efficacy is a regularly studied construct within the information systems field (Marakas et al. 2007) and these findings confirm the influence that this characteristic has on individual security behaviors. As research in the realm of information security moves forward, one avenue of research should be to explore what individual characteristics explain differences in people's security self-efficacy. To begin with, researchers could look at antecedents to computer self-efficacy found in previous research to determine if they apply within an information security setting. Researchers could then develop and test further theoretical explanations for what determines differences in security self-efficacy.

There was little direct impact found on individual security behaviors from the threat appraisal constructs. Namely, perceived security vulnerability and perceived security threat rarely influenced individual security behaviors directly. When they did, the relationships were in the opposite direction hypothesized, meaning people who thought that they were vulnerable to a given threat, or that a given threat was severe, were less likely to perform a behavior to protect them from that threat. This is a very important finding for security researchers as it indicates that when people recognize they are vulnerable to a given threat, or that it is severe, they are less likely to be doing something about it. These findings are contrary to findings in the social psychology literature where increases in the threat appraisal process led to a greater likelihood to perform a recommended behavior (Floyd et al. 2000; Neuwirth et al. 2000). It is possible that this occurred due to the influence that perceived security vulnerability and threat had on the coping appraisal process, suggesting that the threat appraisal constructs are antecedents to the coping appraisal constructs and not directly related to the performance of security behaviors. Future research could explore this further, either experimentally or through a qualitative study. Experimentally, researchers could set up a study that manipulates the threat appraisal constructs and test the impact that changes have on the coping appraisal constructs compared to the individual security behaviors. Qualitatively, researchers could interview computer users to ferret out the reasons why people who feel vulnerable to a given threat are not performing the necessary behaviors to protect from it. If people are not performing the behaviors because they do not feel like they can perform the task or that the behavior will address the threat, it will confirm the findings in this study. It may also be that people who are less knowledgeable about a threat perceive the threat to be higher, but are less likely to act on to protect themselves. As further understandings of people's behavior are uncovered qualitatively, follow up studies can be conducted to empirically test the newly uncovered relationships between individual characteristics and behaviors.

This study only investigated three threats necessitating protection by performing individual security behaviors. Future research needs to explore the relationships between additional threats and behaviors not investigated in this study, which will provide further insight into why people are performing other security behaviors and from what threat they are seeking protection. One example in particular is using anti-spyware software, which also protects from having one's actions monitored. Different individual characteristics than found in this study may explain differences in the use of anti-spyware software when looking at the threat of direct invasion of one's privacy.

There has been little consensus among security researchers as to which theories to use to explain individual security behaviors and how to measure these behaviors. Table 5.7 presents different theories previously used to explain these different behaviors. Based on this dissertation, it is now possible for researchers to use a consistent dependent variable across many theories by using the ISB scale developed herein. The use of a validated instrument provides trust in future research endeavors (Straub 1989) and allows for the comparison and accumulation of findings to develop a synthesis for what is known about what factors influence security behaviors (Churchill 1979). The analyses in Appendix B demonstrate that it is appropriate to use a 3-point scale instead of a 5-point scale when measuring the performance of security behaviors. This allows researchers to know that they are measuring the construct consistently with how people are answering Likert scale items.

Table 5.7 - Behavioral Security Theories

Study	**Theoretical Foundation**
(Straub 1990)	General Deterrence Theory
(Kankanhalli et al. 2003)	General Deterrence Theory
(Woon et al. 2005)	Protection Motivation Theory
(Workman et al. 2007)	General Deterrence Theory Theory of Planned Behavior
(Dinev et al. 2007)	Theory of Planned Behavior
(D' Arcy et al. In Press)	General Deterrence Theory

Combining constructs from previously used theories with the findings in this dissertation could further the understanding of differences in individual security behaviors. Such an approach would provide a foundation upon which future research can test theories that are more extensive and provide more insight into the characteristics that explain differences in individual security behaviors. Some possible avenues to explore are whether a person's coping styles, from the psychology literature, affect the level of individual security behaviors this person performs. Other individual differences such as gender, ethnicity, emotional intelligence, and risk aversion could be influencing the perceptions of security threats and the resulting behaviors. Another interesting concept to explore would be the potential feedback loop that might exist between individual security behaviors and individual differences. For example, the results of poor security behaviors might have dire consequences (such as loss of crucial data) that will affect a person's coping reactions, leading to different individual security behaviors in the future.

Another use of the ISB instrument is in providing evidence of the effectiveness of security training and awareness programs often used to increase individuals' performance of security tasks (Crossler et al. 2006; Deloitte 2007; Richardson 2007; Schultz 2004). Utilizing a validated instrument to measure changes in security behaviors before and after training in an experimental setting would provide trust in the effectiveness of different training and awareness programs. Some training programs may be effective on certain aspects of individual security behaviors while other training programs may be effective on other behaviors. For example, setting up a secured wireless network is a onetime process and then the network will remain secure, while using a strong password and changing it regularly requires constant efforts by individuals. Research might show that these two aspects of individual security behaviors require different types of training to improve individuals' behaviors at those tasks.

Impacts for Security Practitioners

For security practitioners, these findings provide insight that can help address security training and awareness programs. Given the multiple threats and behaviors presented in this study, practitioners can tailor training and awareness programs to address factors shown to have a direct impact on the behavior of interest. For example, if training and awareness programs were designed to address getting people to run software updates then it would be important to address the prevention costs that people perceive as preventing them from running these updates.

This may include showing people ways to automate the process to cut down on the time involved in performing this task or the increased knowledge provided through training may cut down on the cognitive costs people perceive that it takes to run software updates. This training approach would be effective whether it was addressing the threat of computers slowing down or file loss. However, when dealing with increasing individuals' usage of spyware software the threat that one is concerned with being protected from makes a difference on which individual characteristic should be addressed. When addressing the concern of identity theft it is important to tailor programs towards an individual's confidence using security protection tools. In addressing the threat of having computers slow down, it is more important to address the perception of prevention costs, as prevention cost is the singular characteristic that influences usage of spyware software to prevent computers from slowing down.

This study also provides an instrument to measure individual security behaviors. This instrument provides security practitioners with a tool to assess the effectiveness of their employees at performing these behaviors. By analyzing the data collected with the ISB instrument, managers will be able to determine the areas that their employees are succeeding at and those that need improvement. By administering this instrument on a regular basis, they will also be able to determine whether improvements in security behavior occur over time. For example, information security departments could perform a random sampling of individuals' security performance. Then they could assess the areas that need improvement and develop ways to provide additional training in these areas or implement technological solutions that would force people to perform appropriate security behaviors. The instrument could then be randomly administered a second time to determine whether changes in performance have been found.

Chapter Six: Conclusion

This dissertation investigated the behaviors of individuals that influence the security decisions they make. Specifically, this research used Protection Motivation Theory (PMT) as a theoretical underpinning to explore the effect perceived security vulnerability, perceived security threat, security self-efficacy, response efficacy, and prevention costs have on individual security behaviors. The findings indicate that no consistent characteristic explains differences in all the security behaviors an individual performs. However, the information security community gains insights from this study about what affects each behavior individually.

Contributions

This research makes significant contributions, beyond those discussed in Chapter Five, to information security researchers and information security professionals. The research question investigated in this dissertation is of interest to social researchers who want to understand human behavior related to information security. In addition, it is of interest to information security professionals who are concerned with the everyday issue of keeping their systems secure. Investigating what determines differences in individual security behaviors with home computer users removes the impact of rules and policies from a corporation, leaving a true picture of a person's intent for performing security behaviors.

For information security researchers, this study shows how the developed security research model explains a plethora of individual security behaviors, which begins to fill the gap in information security research at the individual level. Although the model used in this research was not entirely supported, a number of insights were provided to the determinants of the different behaviors studied. Future research can use these findings as a starting point for what affects a given behavior and expand on that to further understand what causes differences in that particular phenomenon. The model used should not be taken as the end all theory of individual security behaviors, but should be combined with other theories, such as the Theory of Planned Behavior, General Deterrence Theory, and Perceived Behavioral Control to continue to further understand the differences in these behaviors. The model used in this study could be used in any area where the performance of a behavior or use of a technology is necessary to protect from a threat. A few examples of these areas are information privacy, physical security protection, and home security. Further enabling the expansion of research into individual security behaviors is the development of an instrument to measure individual security behaviors. Providing this as a consistent dependent variable allows researchers to build upon one another's work while exploring the same underlying behavior, ultimately resulting in a broader understanding of what determines individual security behaviors.

For information security professionals this research provides insight into what causes different security behaviors. Information security professionals are concerned with protecting the corporation's information and assets from threats. The human factor is believed to be the "weakest link" in securing a computer system (Deloitte 2007). The insight provided in this study gives information security professionals the ability to tailor training and awareness programs to address the underlying reasons why people do not perform security tasks. For example, security self-efficacy emerged as the most frequent determinant of individual security behaviors. However, focusing training and awareness strictly at improving security self-efficacy will not result in changes for all the behaviors necessary to protect from security threats. One behavior in particular where training would need to focus on something other than security self-efficacy is the use of firewall software. The only determinant to firewall software usage was prevention costs. Therefore, training to improve firewall software usage needs to focus on lowering the perceived cost of using this software.

Information security professionals can also utilize the findings in this research to improve their assessment of their security awareness and training programs. This is necessary as 32 percent of companies do not assess the effectiveness of their security awareness and training programs (Richardson 2008). The ISB instrument developed in this research provides security professionals a tool to assess the effectiveness of their training and awareness programs. Utilizing this measurement instrument before and after training programs will quantitatively demonstrate how effective the training was.

Limitations

When conducting research on a social phenomenon, such as individual security behaviors, decisions have to be made that cause limitations on the study. This study used a combination of previously validated instruments and extensively designed and validated new instruments based on insights from security experts. The instruments were pre-tested, pilot tested, and subjected to reliability and validity measures. Statistical analyses on the data led to the elimination of outliers and incomplete responses. However, there still exist limitations to this study that are discussed in this section.

Perceived Security Vulnerability

This research included perceived security vulnerability as one of its theoretical constructs. For two of the three models studied, this construct displayed acceptable levels of reliability. However, the perceived security vulnerability of identity theft construct failed to display acceptable reliability. This construct did display acceptable reliability during the pilot test, so it was surprising that the full-scale survey did not display acceptable reliability. Further investigation is needed to ensure that the items used to measure the perceived security vulnerability of identity theft construct measure the underlying concept in a way consistent with how people are responding to it. This model could then be retested to see what difference having a reliable perceived security vulnerability measure makes.

Sample Demographics

This study measured a number of demographics about the respondents, including gender, ethnicity, education, income, age, years using a computer, and hours of computer and Internet usage per week. Data was collected from a convenience sample, leading to some of the demographics being not representative of the population studied. In particular, ethnicity and education were not representative of the population at large. The sample used in this study was mostly Caucasian (85.6%) and over 90% of the population held at least an undergraduate degree. This suggests that these findings apply to educated Caucasians and caution should be used when trying to apply these findings to other groups of people. Future research should utilize a stratified random sample consisting of people with different ethnic and educational backgrounds.

Social Desirability Bias

One of the limitations inherent with self-reported data is social desirability bias or the tendency for respondents to complete surveys in a way that makes themselves look good to others (Whitley 2002). Additionally, researchers in security have found that it is difficult to get good response rates from research that is as sensitive as security behaviors (Kotulic et al. 2004). In order to address these concerns, it is recommended that respondents are assured that their results are anonymous and to use a web-based data collection effort (Whitley 2002). Following these recommendations, the majority of data was collected utilizing online survey instruments. The results presented in this study are from those that chose to respond to the collection mechanisms used. There is likely a certain characteristic about those who chose not to respond that is lost using this approach. It is possible that those who are overly concerned about information security did not respond to the survey as they are predisposed not to share that information. Therefore, these findings are likely not representative of those that are overly security conscious.

One limitation of using online-based data collection efforts is the likelihood that those people who are not Internet savvy may not have completed this survey at all. Future research could try to collect data using both paper-based approaches and Internet based approaches to see if there is a significant difference in the types of people who responded. This study did collect some paper-based data but the number of people who responded using paper surveys was not large enough to make significant claims about these differences.

Common Method Bias

Common Method Bias is a primary cause of measurement error that arises when researchers use the same method, such as surveys, to measure correlation between variables (Podsakoff et al. 2003). This bias is one of most frequently cited concerns with information systems research (Malhotra et al. 2006; Straub et al. 2004). Common Method Bias can be minimized by assuring respondents that their responses will be anonymous, that there is no correct or incorrect answer, and that the questions should be answered as honestly as possible (Dinev et al. 2006; Podsakoff et al. 2003). I followed these guidelines, assuring respondents that their response would be anonymous, that there was no correct answer, and that they should respond honestly. After data collection, I tested for the effects of Common Methods Bias using Harman's single factor test (Harman 1967), which is the most widely used method of testing for Common Method Bias in a single-method research study (Malhotra et al. 2006). The premise of this test is that if one factor explains the majority of the variance than there is strong evidence that Common Method Bias is present.   A Harman's single factor test was run for the data used in each of the three threat models in this study by running an exploratory factor analysis and examining the unrotated factor solution to determine the number of factors necessary to account for the variance in the data. The results show that the data for the file loss threat model loaded on 14 factors accounting for 79% of variance explained, the data for the identity theft threat model loaded on nine factors accounting for 70% of variance explained, the data for the computer slow down threat model loaded on 11 factors accounting for 80% of variance explained. These results lead me to the conclusion that Common Method Bias did not overly affect responses in this study.

Concluding Comments

In conclusion, this research developed and tested the use of a newly developed security research model, guided by Protection Motivation Theory, as an empirical way to explain the differences in individual security behaviors. Although this theoretical model did not consistently explain the differences in the number of behaviors studied, it did provide insight into what causes these differences. The findings in this dissertation also illustrate the importance of knowing the threats faced along with the possible behaviors to protect from these threats. Implications of these findings were discussed along with avenues for future research.

The study of differences in individual security behaviors is becoming an active area of exploration for information security researchers. The findings of this research provide a platform, upon which many avenues of research can be explored. This includes the study of a number of different behaviors, suggestions for different research methodologies, and a tool to measure individual security behaviors. Future research in information security will be more fruitful if researchers begin building upon one another’s work and allow for cumulative knowledge gain, rather than continue to explore this phenomenon in an inconsistent manner. A few ideas that emerged from this study that would be particularly telling areas of future research are expanding on the use of security self-efficacy in explaining individual security behaviors, experimentally testing how well training and awareness programs increase individual security behaviors, and using qualitative research to uncover further individual characteristics that lead to security behavior choices.

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Appendix A – Initial ISB Instrument

		Yes	No
1.	Does your personal computer have the Windows operating system on it (**if no, skip to question 5**)?	□	□
2.	Do you have Windows automatic updates turned on?	□	□
3.	Does Windows automatically check for updates?	□	□
4.	Does Windows automatically install updates?	□	□
5.	Do other people have access to your personal computer (**if no, skip to question 7**)?	□	□
6.	Do they have different accounts?	□	□
7.	Have you disabled guest access to your personal computer?	□	□
8.	Have you created or modified the default administrator password on your personal computer?	□	□
9.	Do you have a wireless network in your house (**if no, skip to question 16**)?	□	□
10.	Are you responsible for administering your wireless network (**if no, skip to question 16**)?	□	□
11.	Is your wireless network using Wireless Encryption Protection (is it WEP enabled) or Wi-Fi Protected Access (WPA)?	□	□
12.	Has the default network name been changed on your wireless network?	□	□
13.	Has the default password been changed on your wireless network?	□	□
14.	Is the network name of your wireless network being broadcast?	□	□
15.	Do you restrict access to your wireless network by specifying permitted computers or MAC addresses?	□	□

		Weekly	Monthly	Quarterly	Yearly	Never
16.	How often do you check for software updates that are not automatic?	□	□	□	□	□
17.	How often do you manually check for software updates?	□	□	□	□	□
18.	How often is your personal computer scanned for spyware?	□	□	□	□	□
19.	How often do you scan your personal computer for spyware?	□	□	□	□	□
20.	How often do you backup the entire hard drive on your personal computer?	□	□	□	□	□
21.	How often do you backup the important documents your personal computer?	□	□	□	□	□

		Yes	No
22.	Do you store email on your personal computer using software (e.g. Outlook, Outlook Express, Eudora, Thunderbird, etc.) (**if no, skip to question 24)**?	□	□

		Weekly	Monthly	Quarterly	Yearly	Never
23.	If you answered yes to question 22, how often do you backup the email on your personal computer?	□	□	□	□	□

		Yes	No
24.	Are there others living in your house of age to use personal computers (**if no skip to question 26**)?	□	□

	Never	Rarely	Sometimes	Often	Always
25. How frequently do you educate others in your house about proper security behaviors such as using anti-virus software, using firewalls, opening email attachments, etc.?	□	□	□	□	□

26. How do you restrict access to your personal computer, please check all that apply?

□ With a Password
□ Keep the computer locked in a secure place
□ Keep the computer on me when it is not in a secure place
□ Locked directly to a desk
□ Other ______________________
□ I do not restrict access

	Yes	No
27. Does your personal computer actively use a screen saver (**if no, please skip to question 30**)?	□	□
28. Does your personal computer require a password to deactivate the screen saver (**if no, please skip to question 30**)?	□	□

29. After how many minutes of inactivity does your screen saver come on (**please fill in the blank**)? __________ **Minutes**

	Yes	No
30. Do you use pop-up blocking software when browsing the Internet?	□	□
31. Do you use software to block pop-ups when browsing the Internet?	□	□
32. Do you use a firewall on your computer (**if no, please skip to question 34**)?	□	□
33. Do you use a firewall other than the Operating System (Windows) firewall?	□	□

	Yes	No
34. Is anti-virus software installed on your personal computer (**if no, skip to question 37**)?	□	□

	Weekly	Monthly	Quarterly	Yearly	Never
35. How often does the anti-virus software scan your personal computer for viruses?	□	□	□	□	□
36. How often do you scan your personal computers for viruses?	□	□	□	□	□

37. Approximately, how many accounts do you have that require passwords (**please fill in the blank**)? _________ **Accounts**

38. Approximately, how many of the accounts that require passwords have different passwords (**please fill in the blank**)? _________ **Accounts**

39. What percentage of those passwords do you change quarterly (0 to 100%)? _________ **%**

	Yes	No
40. Do you write any of your passwords down?	□	□
41. Do you use software to store any of your passwords?	□	□

42. What percentage of your passwords do you keep a record of with software or write down (0 to 100%)? ____________ **%**

43. What percentage of your banking passwords do you keep a record with software of or write down (0 to 100%)? ____________ **%**

44. What percentage of your email passwords do you keep a record of with software or write down (0 to 100%)? ____________ **%**

A “strong” password meets the following guidelines:

1. **is at least 8 characters long**
2. **uses a non-dictionary word**
3. **uses upper and lowercase letters (A-Z; a-z)**
4. **uses numbers (0-9) and punctuation marks (@, !, $, &)**
5. **is not based on personal information (name, birth date, anniversary, pet, etc.)**
6. **is easily remembered**

45. What percentage of your passwords meets the criteria for being “strong”? ____________ **%**

46. What percentage of your banking passwords meets the criteria for being “strong”? ____________ **%**

47. What percentage of your email passwords meets the criteria for being “strong”? ____________ **%**

		Yes	**No**
48.	Some e-mails contain links to web pages. Do you ever click on these links (**If no, skip to question 50)**?	□	□

49. When do click on these links (check all that apply)?

□ All e-mail
□ E-mail from friends
□ E-mail from your bank
□ E-mail from banks that are not yours
□ E-mail from stores you do business with online
□ E-mail from stores you have not done business with online
□ Other _____________
□ I do not click on Internet links from within email messages

50. Please check all types of e-mail attachments you open (**check all that apply**):

□ All attachments
□ Attachments from people I know whether I expect the attachment or not
□ Attachments from people I know when I was expecting the attachment
□ Attachments from companies I do business with whether I expect the attachment or not
□ Attachments from companies I do business with when I was expecting the attachment
□ Attachments from people I do not know or have a relationship with
□ I do not open any e-mail attachments

51. Please check all types of websites in which you store your credit card information (**check all that apply**):

□ Government Websites
□ Bank Websites
□ Companies You Regularly Do Business With
□ Companies You Rarely Do Business With
□ Companies that have a history of poor security
□ All companies that use a secure connection for web transactions (SSL)
□ I never store my credit card information on websites

Appendix B – Analysis of ISB Instrument

Prior to the administration and collection of full-scale data, it was first necessary to ensure that the developed dependent variable, ISB, performed as intended. The revised instrument was given online to 296 undergraduate business students at a large eastern United States university who received course credit for participation.

Dimensionality Analysis

I examined the dimensionality of the data set via principal component analysis of the residuals from the RSM. Items were condensed to reflect the construct of interest that was measured reducing the number of items from 51 to 45. For instance, certain yes/no questions such as the presence of a wireless network in the home were removed from analysis, and only those respondents that used home wireless networks were analyzed on this trait. Items were grouped based on similarity of scales, with two scales being present. One scale was on a 5-point scale and the other was a dichotomous scale. An initial analysis of the data showed that there was not a unimodal distribution of the items on the 5-point scale as shown in Figure B.1. Therefore, scales were analyzed and reduced from a 5-point to a 3-point scale. This suggests that individual security behaviors were regularly performed, sometimes performed, or never performed. The resulting 3-point scale did display a unimodal distribution (see Figure B.2) and was used for the subsequent analyses.

```
P      ++--------------+--------------+--------------+--------------++
R  1.0 +                                                             +
O      |0                                                            |
B      | 000000                                                     4|
A      |       0000                                            44444 |
B   .8 +           000                                      444      +
I      |              00                                4444         |
L      |                00                            44             |
I      |                  00                        44               |
T   .6 +                    0                     44                 +
Y      |                     00                 44                   |
    .5 +                       0              44                     +
O      |                        0            4                       |
F   .4 +                         00        44                        +
       |                           0     44                          |
R      |                            0   4                            |
E      |                             0**3333333333333                |
S   .2 +                       22222****2222         333333          +
P      |                 11****1****    00  22222          3333333   |
O      |      11111111***22  33*44 1111111000    22222            333|
N      |1111**222222223333***44           111*****    2222222222     |
S   .0 +**************4444                        *******************+
E      ++--------------+--------------+--------------+--------------++
```

Figure B.1 – Initial Distribution of Scaled ISB Items (5-point scale)

```
   CATEGORY PROBABILITIES: MODES - Structure measures at intersections
P      ++--------------+--------------+--------------+--------------++
R  1.0 +                                                             +
O      |                                                             |
B      |                                                             |
A      |                                                             |
B   .8 +0000                                                     2222+
I      |    000                                               222    |
L      |       000                                         222       |
I      |          000                                   222          |
T   .6 +             000                             222             +
Y      |                00                         22                |
    .5 +                  000                   222                  +
O      |                     00  11111111111  22                     |
F   .4 +                   1111**0         2**1111                   +
       |              11111       00     22       11111              |
R      |          1111              00*22              1111          |
E      |      1111                 222 000                 1111      |
S   .2 + 11111                  222       000                  11111 +
P      |1                   2222             0000                   1|
O      |               22222                     00000               |
N      |     2222222222                               0000000000     |
S   .0 +22222                                                   00000+
E      ++--------------+--------------+--------------+--------------++
       -2             -1              0              1              2
```

Figure B.2 – Final Distribution of Scaled ISB Measures (3-point scale)

In order to analyze the dimensionality of the data set, the variance of the data set must first be extracted from WINSTEPS and converted to transformed Eigenvalues. These transformed Eigenvalues represent how much of the unexplained variance is explained by each dimension. When a transformed Eigenvalue greater than 1 is calculated, then it suggests that the dimension is explaining enough variance to be of substantive interest and the items should be considered as a possible dimension in the resulting construct. Figure B.3 shows a scree plot of this data as well, which is a graphical representation of the Eigenvalues calculated from this data set. As seen in Table B.1, residual 1 accounts for 3.4 of the 45 units of the variance not explained by the Rasch model. This transforms to an Eigenvalue of 1.11. Residual 2 accounts for 2.8 of the 45 units of the variance not explained by the Rasch model for an Eigenvalue of .92. This suggests that there may be one dimension beyond the Rasch model explaining enough variance to be of substantive interest. This required further analysis as presented below.

Table B.1 – Dimensionality of Scale.

Number of Items	45		
Total Variance	137.5		
Measure Variance	92.5 (This represents instrument variance)		
Component	**Eigenvalue**	**Transformed**	**% of Variance**
ISB Measures	92.50	30.27	67.27
Residual 1	3.40	1.11	2.47
Residual 2	2.80	0.92	2.04
Residual 3	2.60	0.85	1.89
Residual 4	2.50	0.82	1.82
Residual 5	2.10	0.69	1.53

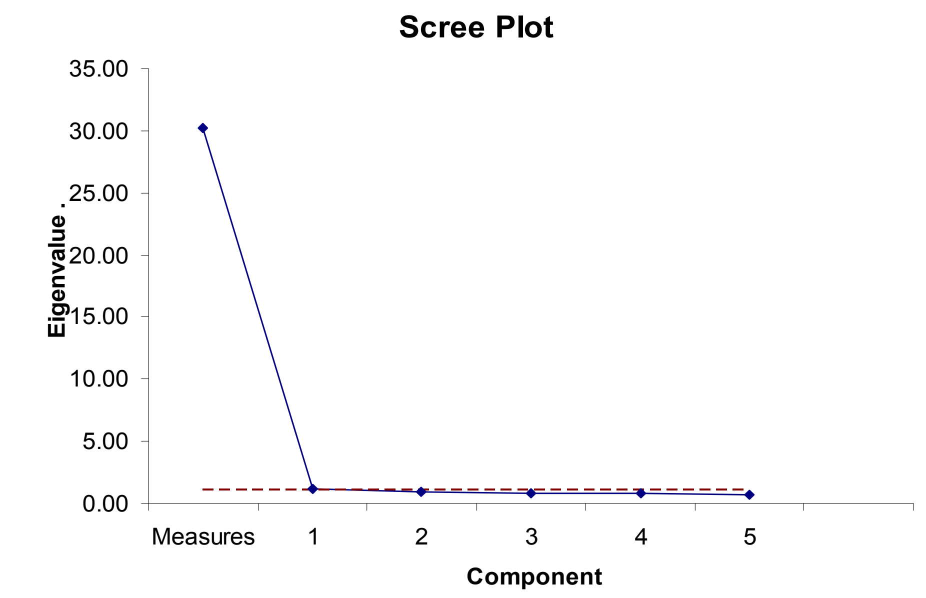

Figure B.3 – Scree Plot of ISB Data

To further analyze the dimensionality of this instrument, and determine whether there should be more dimensions than just the one provided by the Rasch model, a parallel analysis is performed to calculate a more precise Eigenvalue. This analysis bootstraps a dataset that perfectly fits the model and then compares the Eigenvalues to those calculated from the original dataset. When the transformed Eigenvalue from the bootstrapped dataset is greater than the original dataset, it is considered to be its own dimension. Table B.2 shows the parallel analysis. The original transformed Eigenvalue is more than the bootstrapped value only for the ISB instrument (and not for the residuals), which suggests that the data is unidimensional and is accurately represented by the Rasch model. Figure B.4 shows the scree plot of the parallel analysis. The appropriate number of factors is indicated by the location where the two curves cross. Although hard to see, this happens before the second component.

Table B.2 – Parallel Analysis

Number of Items	45
Total Variance	143.2
Measure Variance	98.2 (This represents instrument variance)

Component	**Eigenvalue**	**Transformed**	**% of variance**	**Original Eigenvalue**
ISB Measures	98.2	30.86	68.58	30.27
Residual 1	1.90	0.60	1.33	1.11
Residual 2	1.70	0.53	1.19	0.92

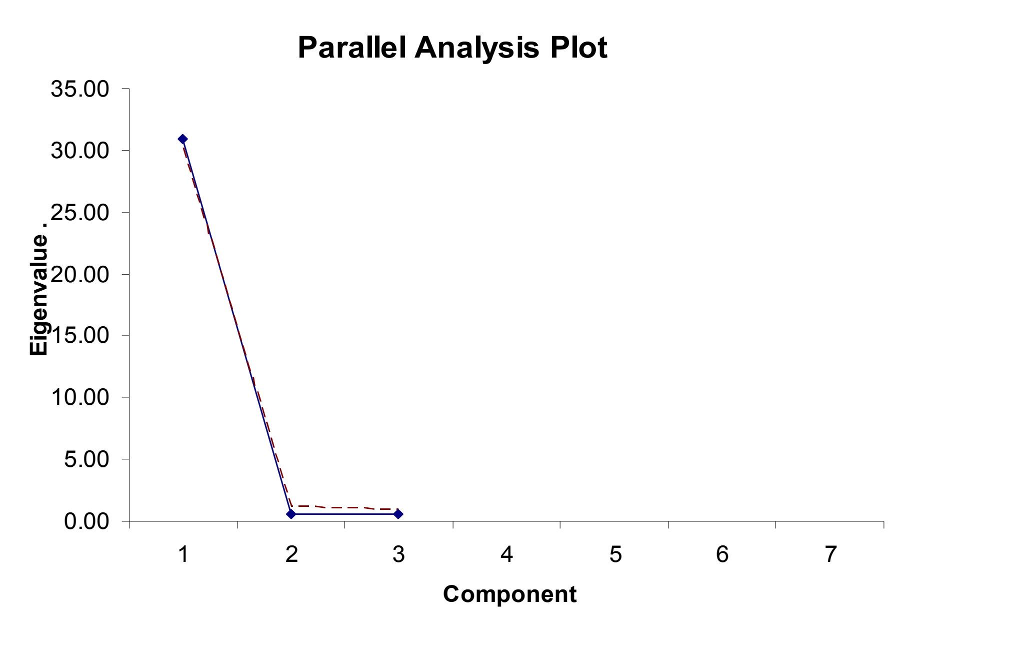

Figure B.4 – Parallel Scree Plot of ISB Data

The component loadings were then analyzed. Items with more than 9% of their variance explained by the bi-serial point measure correlation were considered to load together as part of the Rasch model. The bi-serial correlation represents the correlation between the item score and the total score, with difficulty of the items taken into consideration. Item scores that do not correlate with the total score above the 9% cutoff need to be dropped from further analysis.

Table B.3 illustrates how items loaded (bolded items have more than 9% variance explained) on the Rasch model with both the bi-serial point measure correlation and variance explained.

A total of 14 items were dropped as a result of not being part of the Rasch model. Five items relating to the writing and storing of passwords were dropped. This seems appropriate since there was disagreement between the experts in developing these items on whether or not this was a good or a bad thing to do. Information security professionals also seem to disagree on this behavior (Kotadia 2005; Ranalli 2003). One item from access to computer by others, three from wireless network settings, one item from firewall usage, one item from popup blocking software, and one item from following links from within email were dropped. In each of these cases, there were multiple items measuring similar concepts. In these instances, the other items measuring the behaviors have simply captured more variance and are reflected in the Rasch model. The restriction of access to computers item was dropped, and I believe this concept was captured by access to computers by others and the screen saver items, which are accomplishing similar tasks. Finally, the using caution when opening attachments item was dropped, and I believe that this concept is captured by the usage of anti-virus software. Therefore, the 31 items that remain were used for further analyses.

Reliability

I examined reliability to determine how dependable and repeatable the test scores are. This reliability factor calculates the ration of true item variance to observed item variance and shows how consistent measurements are for individuals or groups of a population (Osterlind 2006). Reliability is provided as output from WINSTEPS version 3.63.2. The reliability of the 31-item instrument shows an acceptable reliability of .72.

Table B.3 – Item Loading on Rasch Model

Item	Bi-serial Correlation	Variance Explained
Automatic Update Item 1	.34	**0.12**
Automatic Update Item 2	.43	**0.18**
Automatic Update Item 3	.38	**0.14**
Access to Computer by Others Item 1	.27	0.07
Access to Computer by Others Item 2	.37	**0.14**
Guest Access	.30	**0.09**
Administrator's Password Options	.34	**0.12**
Wireless Network Item 1	.90	**0.81**
Wireless Network Item 2	.20	0.04
Wireless Network Item 3	.26	0.07
Wireless Network Item 4	.30	**0.09**
Wireless Network Item 5	.25	0.06
Software Updates Item 1	.78	**0.61**
Software Updates Item 2	.61	**0.37**
Anti-Spyware Item 1	1.00	**1.00**
Anti-Spyware Item 2	1.00	**1.00**
Backup Item 1	.48	**0.23**
Backup Item 2	.43	**0.18**
Backup Item 3	.42	**0.18**
Educate Others In Household	.43	**0.18**
Restrict Access to Computer	.21	0.04
Screen Saver Item 1	.31	**0.10**
Screen Saver Item 2	.43	**0.18**
Screen Saver Item 3	1.00	**1.00**
Popup Blocking Software Item 1	.28	0.08
Popup Blocking Software Item 2	.33	**0.11**
Firewall Item 1	.39	**0.15**
Firewall Item 2	.28	0.08
Anti-Virus Item 1	.52	**0.27**
Anti-Virus Item 2	1.00	**1.00**
Anti-Virus Item 3	1.00	**1.00**
Different Passwords Used	.75	**0.56**
Change Passwords	.51	**0.26**
Write Passwords	.4	**0.16**
Store Passwords	.14	0.02
Percent of Passwords Written Item 1	.4	0.16
Percent of Passwords Written Item 2	.10	0.01
Percent of Passwords Written Item 3	.11	0.01
Use of Strong Passwords Item 1	1.00	**1.00**
Use of Strong Passwords Item 2	1.00	**1.00**
Use of Strong Passwords Item 3	1.00	**1.00**
Follow Links Item 1	.28	0.08
Follow Links Item 2	.67	**0.45**
Open Attachments	.0	0.00
Store Credit Card Information	1.00	**1.00**

Item Quality

One advantage of using RSM is the ability to determine how appropriate the model is for the data. This includes testing the assumptions of the model, determining the accuracy of the model's predictions, assessing the overall fit of the model to the data, and assessing the fit of the individual components of the measurement context to the model (Wolfe 2007). Model assumptions were analyzed as part of the dimensionality analysis. The initial assumption of the model is that the model is unidimensional. Following this, other fit measures can be analyzed by investigating whether or not participants responded to items as predicted. If not, then certain items were flagged for substantive analysis. Following Hambleton (1985), the fit of latent trait models to the collected data was evaluated. The main criteria for this are whether the model assumptions are satisfied and the precision of model predictions, or how well the model predicts (or fits) the responses. All analyses show acceptable level of fit, confirming the structural validity of the ISB instrument.

Rating Scale Analysis

The rating scale analysis is used to determine whether or not the instrument works as intended. When an instrument is administered, a certain set of responses are available for the respondent. This analysis determines whether or not respondents answered using the intended scale, or if some other scale would have been more appropriate. In general, the analysis suggests that the ISB scale is working as intended.

Testing the ISB Instrument

While the development of the ISB instrument followed a set of rigorous procedures, the instrument is not considered valid until a test of the instrument is performed using its finalized form, which can be found in Appendix C. For this final test, I collected data using paper surveys of the final instrument from 90 graduate business students at a large American university. A rating scale analysis performed on the collected data revealed that all eight of Linacre’s (2002) suggested criteria were met (see Appendix D for details on the criteria), including the requirement that thresholds between categories increased by at least 1.4 logits. These results confirm that respondents answered using the ISB scale as presented.

Appendix C – Final ISB Instrument

Individual Security Behaviors (ISB)

For the following questions, please think about what you do with your personal computer and indicate your response by checking your answer. If you have more than one computer and are ever in doubt about which computer to answer, please think about the computer you use most often.

		Yes	No
1.	Does your personal computer have the Windows operating system on it (**if no, skip to question 5**)?	□	□
2.	Do you have Windows automatic updates turned on?	□	□
3.	Does Windows automatically check for updates?	□	□
4.	Does Windows automatically install updates?	□	□
5.	Do other people have access to your personal computer (**if no, skip to question 7**)?	□	□
6.	Do they have different accounts?	□	□
7.	Have you disabled guest access to your personal computer?	□	□
8.	Have you created or modified the default administrator password on your personal computer?	□	□
9.	Do you have a wireless network in your house (**if no, skip to question 13**)?	□	□
10.	Are you responsible for administering your wireless network (**if no, skip to question 13**)?	□	□
11.	Is your wireless network using Wireless Encryption Protection (is it WEP enabled) or Wi-Fi Protected Access (WPA)?	□	□
12.	Is the network name of your wireless network being broadcast?	□	□

		Regularly	Sometimes	Never
13.	How often do you check for software updates that are not automatic?	□	□	□
14.	How often do you manually check for software updates?	□	□	□
15.	How often is your personal computer scanned for spyware?	□	□	□
16.	How often do you scan your personal computer for spyware?	□	□	□
17.	How often do you backup the entire hard drive on your personal computer?	□	□	□
18.	How often do you backup the important documents your personal computer?	□	□	□

		Yes	No
19.	Do you store email on your personal computer using software (e.g. Outlook, Outlook Express, Eudora, Thunderbird, etc.) (**if no, skip to question 21)**?	□	□

		Regularly	Sometimes	Never
20.	If you answered yes to question 19, how often do you backup the email on your personal computer?	□	□	□

		Yes	No
21.	Are there others living in your house of age to use personal computers (**if no skip to question 23**)?	□	□

		Regularly	Sometimes	Never
22.	How frequently do you educate others in your house about proper security behaviors such as using anti-virus software, using firewalls, opening email attachments, etc.?	□	□	□

		Yes	No
23.	Does your personal computer actively use a screen saver (**if no, please skip to question 26**)?	□	□
24.	Does your personal computer require a password to deactivate the screen saver (**if no, please skip to question 26**)?	□	□

25. After how many minutes of inactivity does your screen saver come on (**please fill in the blank**)? **Minutes**

		Yes	No
26.	Do you use software to block pop-ups when browsing the Internet?	□	□
27.	Do you use a firewall on your computer?	□	□
28.	Is anti-virus software installed on your personal computer (**if no, skip to question 33**)?	□	□

		Regularly	Sometimes	Never
29.	How often does the anti-virus software scan your personal computer for viruses?	□	□	□
30.	How often do you scan your personal computers for viruses?	□	□	□

31. Approximately, how many accounts do you have that require passwords (**please fill in the blank**)? **Accounts**

32. Approximately, how many of the accounts that require passwords have different passwords (**please fill in the blank**)? **Accounts**

33. What percentage of those passwords do you change quarterly (0 to 100%)? **%**

A "strong" password meets the following guidelines:

1. **is at least 8 characters long**
2. **uses a non-dictionary word**
3. **uses upper and lowercase letters (A-Z; a-z)**
4. **uses numbers (0-9) and punctuation marks (@, !, $, &)**
5. **is not based on personal information (name, birth date, anniversary, pet, etc.)**
6. **is easily remembered**

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35. What percentage of your passwords meets the criteria for being "strong"? ____________ **%**

36. What percentage of your banking passwords meets the criteria for being "strong"? ____________ **%**

37. What percentage of your email passwords meets the criteria for being "strong"? ____________ **%**

	Yes	No
38. Some e-mails contain links to web pages. Do you ever click on these links (**If no, skip to question 40)**?	□	□

39. When do click on these links (check all that apply)?

- □ All e-mail
- □ E-mail from friends
- □ E-mail from your bank
- □ E-mail from banks that are not yours
- □ E-mail from stores you do business with online
- □ E-mail from stores you have not done business with online
- □ Other ______________
- □ I do not click on Internet links from within email messages

40. Please check all types of websites in which you store your credit card information (**check all that apply**):

- □ Government Websites
- □ Bank Websites
- □ Companies You Regularly Do Business With
- □ Companies You Rarely Do Business With
- □ Companies that have a history of poor security
- □ All companies that use a secure connection for web transactions (SSL)
- □ I never store my credit card information on websites

Thank you for your participation in filling out this survey.

Appendix D – Squared Pair-Wise Correlations and Average Variance Extracted

Table D.1 - File Loss Anti-Virus Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.739**		
Perceived Security Threat	0.019	**0.872**	
Response Efficacy	0.045	0.003	**0.838**

Table D.2 – File Loss Access Control Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.738**		
Perceived Security Threat	0.140	**0.843**	
Response Efficacy	0.005	0.017	**0.891**

Table D.3 – File Loss Backup Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.690**		
Perceived Security Threat	0.002	**0.760**	
Response Efficacy	0.001	0.002	**0.829**

Table D.4 – File Loss Password Change Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.741**		
Perceived Security Threat	0.037	**0.873**	
Response Efficacy	0.015	0.012	**0.877**

Table D.5 – File Loss Secure Access Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.743**		
Perceived Security Threat	0.035	**0.872**	
Response Efficacy	0.104	0.007	**0.879**

Table D.6 – File Loss Software Updates Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.732**		
Perceived Security Threat	0.029	**0.870**	
Response Efficacy	0.014	0.006	**0.834**

Table D.7 – File Loss Wireless Network Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.753**		
Perceived Security Threat	0.012	**0.862**	
Response Efficacy	0.123	0.000	**0.794**

Table D.8 – ID Theft Credit Cards Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Threat	**0.812**	
Response Efficacy	0.032	**0.787**

Table D.9 - ID Theft Education Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Threat	**0.624**	
Response Efficacy	0.000	**0.770**

Table D.10 – ID Theft Links Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Threat	**0.814**	
Response Efficacy	0.029	**0.659**

Table D.11 – ID Theft Spyware Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Threat	**0.808**	
Response Efficacy	0.001	**0.701**

Table D.12 – ID Theft Wireless Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Threat	**0.868**	
Response Efficacy	0.000	**0.771**

Table D.13 – Slow Down Anti-Virus Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.777**		
Perceived Security Threat	0.038	**0.811**	
Response Efficacy	0.011	0.008	**0.803**

Table D.14 – Slow Down Auto Update Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.777**		
Perceived Security Threat	0.085	**0.800**	
Response Efficacy	0.047	0.048	**0.820**

Table D.15 – Slow Down Firewall Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.760**		
Perceived Security Threat	0.020	**0.811**	
Response Efficacy	0.033	0.005	**0.863**

Table D.16 – Slow Down Popup Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.767**		
Perceived Security Threat	0.027	**0.808**	
Response Efficacy	0.037	0.007	**0.879**

Table D.17 – Slow Down Software Updates Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.776**		
Perceived Security Threat	0.038	**0.807**	
Response Efficacy	0.010	0.001	**0.877**

Table D.18 – Slow Down Spyware Squared Pair-Wise Correlation and AVE

Variable	**Perceived Security Vulnerability**	**Perceived Security Threat**	**Response Efficacy**
Perceived Security Vulnerability	**0.776**		
Perceived Security Threat	0.038	**0.806**	
Response Efficacy	0.000	0.040	**0.825**

Appendix E – Item Loading

File Loss

Table E.1 – File Loss Anti-Virus Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.096	-.109	.874
Perceived Security Vulnerability 2	-.050	-.101	.861
Perceived Security Vulnerability 3	.194	-.075	.823
Perceived Security Threat 1	.940	-.053	.026
Perceived Security Threat 2	.956	-.024	.094
Perceived Security Threat 3	.892	.022	.118
Response Efficacy 1	-.027	.938	-.076
Response Efficacy 2	-.040	.935	-.089
Response Efficacy 3	.012	.856	-.127

Table E.2 – File Loss Access Control Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	-.066	.098	.879
Perceived Security Vulnerability 2	-.083	-.048	.864
Perceived Security Vulnerability 3	-.107	.200	.816
Perceived Security Threat 1	.010	.942	.029
Perceived Security Threat 2	.054	.955	.098
Perceived Security Threat 3	.066	.887	.120
Response Efficacy 1	.933	.066	-.111
Response Efficacy 2	.937	.002	-.066
Response Efficacy 3	.947	.063	-.096

Table E.3 – File Loss Backup Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.090	.023	.883
Perceived Security Vulnerability 2	-.041	-.066	.866
Perceived Security Vulnerability 3	.184	.072	.825
Perceived Security Threat 1	.942	.068	.034
Perceived Security Threat 2	.955	.061	.096
Perceived Security Threat 3	.869	.203	.117
Response Efficacy 1	.314	.829	.037
Response Efficacy 2	-.003	.925	-.094
Response Efficacy 3	.057	.842	.079

Table E.4 – File Loss Password Change Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.096	-.026	.883
Perceived Security Vulnerability 2	-.050	-.020	.868
Perceived Security Vulnerability 3	.203	-.119	.816
Perceived Security Threat 1	.942	.009	.029
Perceived Security Threat 2	.953	.081	.099
Perceived Security Threat 3	.889	.071	.116
Response Efficacy 1	.059	.925	-.035
Response Efficacy 2	.023	.960	-.064
Response Efficacy 3	.074	.914	-.067

Table E.5 – File Loss Software Update Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.095	.005	.882
Perceived Security Vulnerability 2	-.049	.063	.864
Perceived Security Vulnerability 3	.194	-.031	.827
Perceived Security Threat 1	.941	-.038	.033
Perceived Security Threat 2	.956	.028	.096
Perceived Security Threat 3	.892	.028	.113
Response Efficacy 1	.031	.954	.045
Response Efficacy 2	-.019	.946	-.004
Response Efficacy 3	.005	.866	.001

Table E.6 – File Loss Secure Access Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.096	-.164	.867
Perceived Security Vulnerability 2	-.049	-.111	.861
Perceived Security Vulnerability 3	.194	-.147	.811
Perceived Security Threat 1	.941	-.034	.027
Perceived Security Threat 2	.957	.033	.104
Perceived Security Threat 3	.891	-.067	.101
Response Efficacy 1	-.018	.941	-.129
Response Efficacy 2	-.003	.926	-.137
Response Efficacy 3	-.051	.914	-.179

Table E.7 – File Loss Wireless Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.097	-.104	.876
Perceived Security Vulnerability 2	-.045	-.061	.866
Perceived Security Vulnerability 3	.197	-.125	.813
Perceived Security Threat 1	.939	.011	.036
Perceived Security Threat 2	.955	.022	.098
Perceived Security Threat 3	.894	.012	.106
Response Efficacy 1	-.047	.901	-.005
Response Efficacy 2	.085	.866	-.082
Response Efficacy 3	.004	.873	-.222

ID Theft

Table E.8 – ID Theft Credit Cards Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.375	-.007	.714
Perceived Security Vulnerability 2	-.213	-.019	.675
Perceived Security Vulnerability 3	-.017	-.177	.736
Perceived Security Threat 1	.844	-.041	.051
Perceived Security Threat 2	.934	.029	-.054
Perceived Security Threat 3	.903	.058	-.017
Response Efficacy 1	.041	.885	-.071
Response Efficacy 2	.020	.893	-.212
Response Efficacy 3	-.019	.851	.025

Table E.9 – ID Theft Educate Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.372	.138	.732
Perceived Security Vulnerability 2	-.220	.006	.615
Perceived Security Vulnerability 3	-.023	-.098	.761
Perceived Security Threat 1	.841	.022	.057
Perceived Security Threat 2	.934	.018	-.063
Perceived Security Threat 3	.904	-.020	-.036
Response Efficacy 1	.018	.817	-.033
Response Efficacy 2	-.096	.845	-.203
Response Efficacy 3	.084	.619	.209

Table E.10 – ID Theft Links Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.365	.024	.722
Perceived Security Vulnerability 2	-.225	-.008	.650
Perceived Security Vulnerability 3	-.004	-.155	.754
Perceived Security Threat 1	.831	.108	.074
Perceived Security Threat 2	.935	.053	-.058
Perceived Security Threat 3	.903	.078	-.026
Response Efficacy 1	.031	.881	.013
Response Efficacy 2	.021	.831	-.206
Response Efficacy 3	.151	.707	.009

Table E.11 – ID Theft Spyware Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.369	.065	.684
Perceived Security Vulnerability 2	-.206	-.127	.650
Perceived Security Vulnerability 3	-.025	.036	.774
Perceived Security Threat 1	.844	.012	.064
Perceived Security Threat 2	.936	.001	-.056
Perceived Security Threat 3	.905	.008	-.026
Response Efficacy 1	.005	.877	-.069
Response Efficacy 2	-.061	.870	-.222
Response Efficacy 3	.088	.762	.295

Table E.12 – ID Theft Wireless Item Loading

	Component		
Item	1	2	3
Perceived Security Vulnerability 1	.364	.111	.729
Perceived Security Vulnerability 2	-.217	-.257	.592
Perceived Security Vulnerability 3	-.035	.019	.773
Perceived Security Threat 1	.842	.006	.078
Perceived Security Threat 2	.936	-.038	-.048
Perceived Security Threat 3	.905	-.049	-.029
Response Efficacy 1	.018	.827	-.077
Response Efficacy 2	-.036	.782	-.267
Response Efficacy 3	-.065	.773	.272

Slow Down

Table E.13 – Slow Down Anti-Virus Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.022	-.111	.877
Perceived Security Vulnerability 2	.003	.035	.930
Perceived Security Vulnerability 3	.192	-.058	.820
Perceived Security Threat 1	.881	.101	.111
Perceived Security Threat 2	.923	.014	.046
Perceived Security Threat 3	.882	.030	.054
Response Efficacy 1	.039	.927	-.105
Response Efficacy 2	.081	.906	-.043
Response Efficacy 3	.023	.832	.006

Table E.14 – Slow Down Auto Update Item Loading

	Component		
Item	1	2	3
Perceived Security Vulnerability 1	.012	-.146	.870
Perceived Security Vulnerability 2	.010	-.030	.932
Perceived Security Vulnerability 3	.181	-.168	.806
Perceived Security Threat 1	.881	-.082	.102
Perceived Security Threat 2	.919	-.058	.044
Perceived Security Threat 3	.880	-.079	.046
Response Efficacy 1	-.163	.861	-.125
Response Efficacy 2	-.129	.896	-.112
Response Efficacy 3	.056	.888	-.105

Table E.15 – Slow Down Firewall Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	-.090	.001	.871
Perceived Security Vulnerability 2	-.053	-.005	.924
Perceived Security Vulnerability 3	-.068	.176	.813
Perceived Security Threat 1	-.055	.895	.126
Perceived Security Threat 2	-.011	.928	.005
Perceived Security Threat 3	.016	.880	.043
Response Efficacy 1	.943	.007	-.065
Response Efficacy 2	.933	-.069	-.053
Response Efficacy 3	.909	.013	-.102

Table E.16 – Slow Down Pop Up Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	.017	-.003	.886
Perceived Security Vulnerability 2	-.142	.001	.915
Perceived Security Vulnerability 3	-.132	.188	.801
Perceived Security Threat 1	.034	.892	.132
Perceived Security Threat 2	.036	.928	.006
Perceived Security Threat 3	.056	.880	.041
Response Efficacy 1	.939	.097	-.114
Response Efficacy 2	.921	-.021	-.079
Response Efficacy 3	.920	.058	-.065

Table E.17 – Slow Down Software Updates Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	-.039	.016	.883
Perceived Security Vulnerability 2	.018	.010	.928
Perceived Security Vulnerability 3	-.117	.189	.815
Perceived Security Threat 1	.031	.887	.109
Perceived Security Threat 2	-.020	.921	.045
Perceived Security Threat 3	-.031	.883	.051
Response Efficacy 1	.937	-.063	-.043
Response Efficacy 2	.935	.040	-.094
Response Efficacy 3	.928	.001	-.005

Table E.18 Slow Down Spyware Item Loading

	Component		
Item	**1**	**2**	**3**
Perceived Security Vulnerability 1	-.043	.021	.879
Perceived Security Vulnerability 2	.058	-.001	.926
Perceived Security Vulnerability 3	-.027	.193	.824
Perceived Security Threat 1	.132	.875	.109
Perceived Security Threat 2	.042	.923	.049
Perceived Security Threat 3	.123	.875	.052
Response Efficacy 1	.875	.067	.135
Response Efficacy 2	.913	.109	-.066
Response Efficacy 3	.917	.122	-.088

Appendix F – List of Acronyms

AMCIS	Americas Conference on Information Systems
AV	Anti-Virus
AVE	Average Variance Extracted
CSI	Computer Security Institute
DRM	Digital Rights Management
FBI	Federal Bureau of Investigation
FTC	Federal Trade Commission
GDT	General Deterrence Theory
HCI	Human-Computer Interaction
ID	Identity
IS	Information Systems
ISB	Individual Security Behavior
IT	Information Technology
MBA	Masters of Business Administration
PC	Prevention Cost
Ph.D.	Doctor of Philosophy
PLS	Partial Least Squares
PMT	Protection Motivation Theory
POSeM	Process-Oriented Security Model
PST	Perceived Security Threat
PSV	Perceived Security Vulnerability
RBD	Risk Behavior Diagnosis
RE	Response Efficacy
RSM	Rasch Rating Scale Model
SSE	Security Self-Efficacy
SSID	Service Set Identifier
VIF	Variance Inflation Factor