Fall 12-2019

A Step toward Ending Long Airport Security Lines: The Modified Boarding Pass

Joel Lee
Embry-Riddle Aeronautical University

A STEP TOWARD ENDING LONG AIRPORT SECURITY LINES: THE MODIFIED BOARDING PASS

By

Joel Lee

A Thesis Submitted to the College of Aviation, School of Graduate Studies,
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Aeronautics

Embry-Riddle Aeronautical University
Daytona Beach, Florida
December 2019

A STEP TOWARD ENDING LONG AIRPORT SECURITY LINES: THE MODIFIED BOARDING PASS

By

Joel Lee

This Thesis was prepared under the direction of the candidate's Thesis Committee Chair, Dr. Andrew R. Dattel, Assistant Professor, Daytona Beach Campus, and Thesis Committee Member E. David Williams, Assistant Professor, Daytona Beach Campus and has been approved by the Thesis Committee. It was submitted to the College of Aviation, School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science in Aeronautics

Thesis Committee:

Andrew R. Dattel, Ph.D.
Committee Chair

E. David Williams, M.B.A.
Committee Member

Donald S. Metscher, D.B.A.
Program Coordinator
Master of Science in Aeronautics

Steven Hampton, Ed.D.
Associate Dean, School of Graduate Studies, College of Aviation

Alan J. Stolzer, Ph.D.
Dean, College of Aviation

Christopher Grant, Ph.D.
Associate Vice President of Academics

2/3/2020
Date

Acknowledgements

First, I must thank my family for allowing me to pursue my studies overseas and for supporting me in all my endeavors throughout my life. I hope I made them proud. I also have to thank my committee chair, Dr. Andrew R. Dattel for expressing such enthusiasm when I first came to him with this idea in 2018. His encouragement, support, and guidance has allowed me to explore my idea to its fullest and its intended purpose.

Second, I would like to thank my committee member, Professor E. David Williams who displayed a similar level of enthusiasm and devotion to my idea over the course of the last year. In addition to his input, he helped me get in touch with Mr. Dan Blake and Mr. Jay Cassens at Daytona International Airport to discuss the possibility of conducting an airport survey. Accordingly, I would like to thank these gentlemen for allowing me to use the airport's facilities in order to conduct the survey.

I would also like to express my gratitude to the MSA program advisor, BeeBee Leong, for helping me schedule and reserve several classrooms for my study. Also, to Mrs. Susie Sprowl for helping me with obtaining the apparatus for my experiment. Finally, I would like to thank everyone else who in any capacity, encouraged, inspired or helped me along the way in completing this thesis.

Abstract

Researcher: Joel Lee

Title: A STEP TOWARD ENDING LONG SECURITY LINES: THE MODIFIED BOARDING PASS

Institution: Embry-Riddle Aeronautical University

Degree: Master of Science in Aeronautics

Year: 2019

Anyone who has traveled by air has most likely experienced long airport security lines. Yet not much is known about its cause because few have considered if passengers have created this problem for themselves. The present study attempts to fill this research gap by suggesting that when passengers are not well-prepared for security screening, they delay the process by making mistakes and not complying with procedures. This lack of preparedness can be attributed to several shortcomings of security signposts. This study proposes the use of a modified boarding pass as an alternative form of signage to help passengers better prepare for security screening. In a recall evaluation of the items to remove prior to security screening, the combination of the modified boarding pass and security signposts led to greater recall than when either stimuli were used alone. In an airport survey to gather public sentiment, three-quarters of the respondents saw value in the idea of the modified boarding pass. Although the majority of the respondents were receptive to it becoming an option for future travel, many also felt that the modified boarding pass would be more useful than security signposts or announcements at conveying helpful security screening information.

Keywords: security screening, saliency deficiencies, security signposts, modified boarding pass

Table of Contents

List of Tables

Page

Table

List of Figures

Page

Figure

Chapter I

Introduction

The purpose of airport security is to screen for and deter acts of terrorism, or criminal activity at screening checkpoints so that civilian passengers may travel safely (Alards-Tomalin et al., 2014). However, this purpose should be done in a manner where passengers are not delayed, or miss their flights because they have been stuck at screening checkpoints. Today, passengers spend a great deal of time waiting in long security lines (Jet, 2018). This problem can be attributed to the Transportation Security Administration (TSA) revamping the passenger screening process after its inception in 2001, following the terrorist attacks of September 11 (Pekoske, 2018). Ever since, the TSA has tried to shorten these lines while not compromising on its already robust security standards, but has unfortunately, not been able to do so (Halsey, 2016).

Faced with the problem of long security lines, the TSA has made heavy investments into newer screening technology, redesigning tasks to maximize human performance, or simply hiring thousands of additional TSA agents (Lastoe, 2019; Transportation Security Administration, 2016; Vasel, 2016). However, there is a lack of understanding and the de facto problem could be that passengers are simply not well-prepared for security screening. Their lack of preparedness and screening proficiency could have possibly led to consistently sub-optimal levels of passenger throughput at screening checkpoints. As such, congestion and long security lines have continued to exist at major U.S. airports (Marsh & Patterson, 2016).

To conceptualize the lack of preparedness and screening proficiency, the term *user failure* is used. Few studies have investigated how passengers have hindered

security screening, and even fewer have looked into ways to help passengers better prepare for it. Accordingly, there is the important question of why passengers are often unprepared for security screening, and how they can be better prepared in the future. The objective of this study is to answer both questions by further investigating *user failure*, and proposing a unique alternative security signage, in the form of a modified boarding pass to help passengers better prepare for security screening.

Significance of the Study

As a relatively unexplored field in airport security, understanding and exploring *user failure* may be significant in helping the TSA expedite security screening. To do so, this study analyzes why many passengers are unfamiliar with screening procedures, and evaluates a proposal that may help passengers better prepare for security screening. The proposed modified boarding pass can be more easily accessible and visible to passengers. This paper serves as a litmus test to investigate if the modified boarding pass can improve passenger preparedness for security screening. Bearing any positive outcome, the knowledge gained from this study could provide an actionable framework that gives security screening a fresh impetus to expediting the screening process. Finally, the concept of *user failure* introduced in this paper, will contribute to the existing literature on airport security, and may serve as a pioneering effort toward expediting security screening.

Statement of the Problem

Security screening can be an intricate and complex process for passengers. Unfortunately, if passengers are not prepared for it, they are likely to inadvertently, concede to error, which can lead to time-consuming stoppages at screening checkpoints.

With more passengers expecting to transverse through United States (U.S.) airports in the years to come (Rosen, 2017), maintaining security in its current form could become increasingly difficult. Therefore, there is a need for security checkpoints to process passengers at a quicker rate. Little is known about how passengers contribute to long security lines, and hence, there has been a lack of solutions that involve passengers.

Purpose Statement

The purpose of this study is to investigate if there is a simpler and cost-effective solution to expediting security screening and shortening long security lines. The proposed modified boarding pass aims to help passengers better prepare for security screening so that they make fewer time-consuming mistakes, and are better at complying with screening guidelines. It is hoped that the modified boarding pass is a step toward shortening passenger lines at security screening checkpoints.

Research Questions

There are two studies in this paper. Study 1 is a recall evaluation, and Study 2 is an airport survey.

Study 1 Research question. The research question was to investigate if there were any differences in the ability to recall 10 specific items that are to be removed prior to security screening such as shoes, belts, and tablets (hereafter referred to as interference items). The same 10 interference items were displayed on three types of stimuli in the recall evaluation. The three types of stimuli are stated below and can be found in Appendix B.

1. Regular, non-modified boarding passes with two standing signposts

2. Modified boarding passes only

3. Modified boarding passes with two standing signposts.

Hypotheses

The researcher tested the null hypotheses for Study 1.

$H_0$1: There will be no significant difference in recalling interference items between participants given regular, non-modified boarding passes with two standing signposts and participants given modified boarding passes only.

$H_0$2: There will be no significant difference in recalling interference items between participants given modified boarding passes with two standing signposts and participants given regular, non-modified boarding passes with two standing signposts.

$H_0$3: There will be no significant difference in recalling interference items between participants given modified boarding passes with two standing signposts and participants given modified boarding passes only.

Study 2 Research question. Study 2 involved a survey that was conducted at a local airport to ascertain passenger opinion toward the idea of the modified boarding pass. The research question was if passengers felt that the modified boarding pass would be useful to them during security screening if it became an option at airports in the future.

Delimitations

The scope of the research pertaining to the recall evaluation was limited to students from Embry-Riddle Aeronautical University (ERAU) partly because it was not possible to obtain the necessary permissions and authorizations needed to run this experiment in an airport environment using regular passengers and security equipment.

However, the use of ERAU students was deemed adequate as they were fully expected to exhibit behaviors similar to regular passengers. As for the research pertaining to the airport survey conducted for this paper, the passenger feedback gathered was considered to be representative of the greater traveling population.

Limitations and Assumptions

The results of the recall evaluation can only be generalized across the students from ERAU. Although effort was made to maximize mundane realism, the evaluation was conducted in a simulated environment (classroom). Hence, the results may not accurately reflect that of an airport environment. An evaluation in an airport environment would likely improve mundane realism and produce more accurate results and conclusions. For the airport survey, the results were taken from passengers that traveled through Daytona International Airport (DAB). It was assumed that these passengers would be representative of passengers traversing through other U.S. airports.

Definitions of Terms

Backtracking	Passengers having to go through the Walk-Through Metal Detector (WTMD) more than once.
Decision criterion	Criteria or benchmark used to plan on a sensory output
Dual-coding theory	Pictures are cognitively coded twice whereas words are only coded once.
False alarm	Bags mistakenly flagged for a suspicious item that turned out to be inconsequential.

Hassle factor	Inconveniences and stresses of flying resulting in people looking for other alternative modes of transport.
Inattentional blindness	Being temporarily blinded to salient objects because of engagement in other tasks
Low-prevalence target	A rare, infrequent target.
Mundane Realism	Extent to which an experiment is similar to its intended real environment and the ability for the results to be generalized to the real world
Picture superiority effect	Human cognitive inclination toward pictures over texts
Receiver operator characteristic (ROC)	Graph depicting the trade-off between sensitivity and specificity
Selective attention	Mechanism that guides an individual's attention
Signal detection theory	The theory of having to pick out and distinguish relevant signals from background noise
Speed-accuracy trade-off	Inverse relationship between speed and accuracy
Subsequent search misses (SSM)	The identification of a specific target improves the ability to find a subsequent similar target but at the same time reduces the ability to search for dissimilar targets.

User failure	The development of long security lines owing to passengers being unprepared, unfamiliar and their lack of proficiency at security screening.
Vigilance decrement	Performance lapses associated with sustained focus and attention on a task
Voluntary attention	Ability of a stimulus to capture attention because it is relevant to a desired behavioral goal

List of Acronyms

COA	College of Aviation
DAB	Daytona International Airport
ERAU	Embry-Riddle Aeronautical University
FBS	Full Body Scanner
HHMD	Hand-Held Metal Detector
ROC	Receiver Operator Curve
SDT	Signal Detection Theory
SSM	Subsequent Search Miss
TSA	Transportation Security Administration
WM	Working Memory

Chapter II

Review of the Relevant Literature

In airport security, *user failure* proposes that the end users —passengers— are responsible for long security lines, instead of more conventional arguments such as poor human performance, not enough security personnel, or older, rudimentary screening technology. As such, *user failure* has not been thoroughly investigated in the literature pertaining to airport security. Although this study proposes that understanding *user failure* can help expedite security screening, it is important to first understand the passengers' role in *user failure*.

Lack of Screening Proficiency and Familiarity

Unfamiliarity with screening procedures may have led to passengers walking through metal detectors without realizing they had to remove their belts and watches, while others unknowingly try to carry filled water bottles through screening checkpoints. With presumably little or fractional knowledge of screening procedures, passengers can be susceptible to mistakes and non-compliance. These individuals may have to repeat certain aspects of the screening process and hence, fewer passengers can be screened at any one time. Unfortunately, the screening process is disrupted, and result in bottlenecks at security checkpoints (de Barros & Tomber, 2007).

To further complicate matters, international passengers are possibly, less likely to be experienced or adept at the screening procedures of a foreign country. At times, they may inadvertently not comply with screening guidelines. Screening procedures can also occasionally differ between U.S. domestic airports. It is conceivable that the average passenger takes a longer time to successfully clear security screening as the passenger takes time to adjust and acquaints to unfamiliar and different screening guidelines. To

further illustrate how passengers can adversely affect the screening process, *user failure* will be addressed in greater detail.

Illustration of user failure. In the U.S., most passengers —excluding TSA pre-check and passengers above 75 years old— are required to remove specific items from their pockets and carry-on bags such as shoes, light jackets, mobile phones, and tablets (Blalock, Kadiyali, & Simon, 2009). These items are to be placed onto trays at the screening carousel during x-ray screening because they can interfere with security screening (Transportation Security Administration, 2019). These items are referred to as interference items. Because the classification of interference items can vary between countries and domestic airports, passengers unfamiliar with U.S. screening guidelines may not satisfactorily comply with the removal of all pertinent interference items. When this confusion occurs, passengers and their carry-on bags will most likely be flagged by security personnel or set off alarms while walking through metal detectors or, body and x-ray scanners. Flagged passengers are then called over to assist in the resolution of the alarm while the rest of the line comes to a halt, and passenger processing is temporarily suspended (de Barros & Tomber, 2007).

The alarm resolution process consists of a combination of actions ranging from wand searches by a Hand-Held Metal Detector (HHMD), pat-downs, manual inspection of carry-on bags, and repeated metal detector or body scanner walk-throughs (Pendergraft, Robertson, & Shrader, 2004; van Boekhold, Faghri, & Li, 2014). If passenger processing at the screening checkpoint is frequently interrupted by raised alarms, a start-stop sequence will be initiated, and passenger lines will possibly move even slower while getting longer.

Evolution of TSA Screening Procedures

Since its inception, the TSA has introduced a medley of eclectic yet wide-ranging screening procedures as seen in Figure 1. Largely influenced by previous attacks and attempts on civil aviation, TSA screening procedures have been modified to withstand future attempts and potential reoccurrences (Peterson, 2016). The evolution of the TSA's screening procedure is summarized in Figure 1.

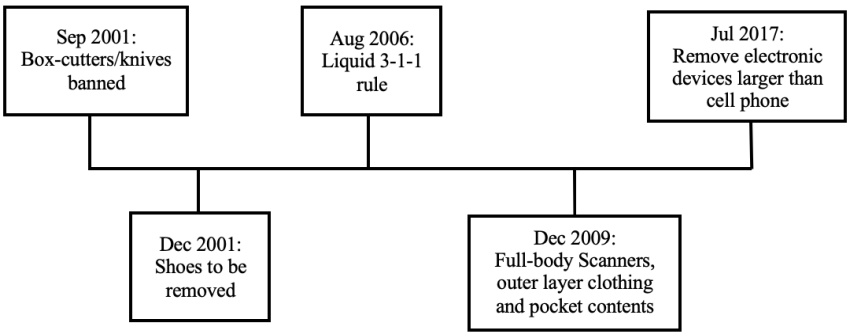

Figure 1. Timeline of TSA screening procedures.

Shortly after the September 11, 2001, hijacking by al-Qaeda terrorists, box-cutters were banned. Not long after, Richard Reid "The Shoe-Bomber," attempted to sneak and detonate a bomb in his shoe (Ehrett, 2011). Consequently, passengers remove their shoes for x-ray screening with the exception of some individuals such as those enrolled in TSA pre-check or above 75 years old (Blalock, Kadiyali, & Simon, 2007). In 2006, a plot to blow up an aircraft using liquid explosives stored in carry-on bags was uncovered. Inevitably, the liquid 3-1-1 rule was commissioned; 3-ounce (100ml) container limit inside 1-quart clear, plastic zip-lock, 1 per passenger (Deno, Diaz, Lliguicota, Norman, & González, 2014; Ehrett, 2011).

In 2009, Umar Farouk Abdulmutallab, "The Underwear Bomber," boarded an

aircraft with plastic explosives strapped to his underwear. Although it failed to detonate, it led to the introduction of the Full Body Scanner (FBS), where passengers now remove outer-layer clothing, belts, shoes, jewelry, and empty their pockets before proceeding to have a full-body image taken by the FBS to determine if they have carried any concealed weapons or explosives (Harawa, 2013; Stewart & Mueller, 2011). More recently, passengers are required to remove electronic devices larger than a cell phone (e.g., tablets and e-readers) from their carry-on, and undergo x-ray screening in the same manner that laptops currently do to reduce the clutter found in carry-on bags (Campbell, 2017).

Problem with TSA screening procedures. Introduced in direct response to previous threats or foiled attempts, TSA screening procedures were often modified. However, doing so also means that few passengers are likely to be able to keep abreast of all the most current screening procedures. Because of this reason, passengers in general, are probably less proficient at screening and naturally, more likely to not comply. When fewer passengers are screened at any one-time, long and slow-moving security lines are likely to emerge. Passengers are likely to be delayed, miss their connections, or at the very least, have to rush to their gates (Hattenschwiler et al., 2015; Lazar Babu, Batta, & Lin, 2006).

User Failure Creates More Stoppages and Secondary Searches

For regular scheduled flights, one in three passengers were found to have backtracked through metal detectors a second time, while every seventh to ninth passenger had their carry-on bags searched (Kirschenbaum, 2013). Searching carry-on bags can be problematic and time-consuming as screeners would have to stop the conveyor belt, identify the owner of the bag, and request for the passenger to proceed for further

inspection by another security officer. Here, considerable time and resources may be spent identifying suspicious items and possibly removing them from the bag (van Boekhold, Faghri, & Li, 2014). There are also times where carry-on bags may raise alarms that turn out to be harmless and inconsequential. This outcome often happens because screeners spot interference items that have to be removed before the bag can be re-screened and cleared (Sterchi & Schwaninger, 2015). Otherwise known as a false alarm, such instances can be time-consuming and can be particularly troublesome if security lines are already long (Department of Homeland Security, 2019).

The primary purpose of security screening should be to detect and remove items of unlawful interference (e.g., weapons and explosives), not to be overly stretched by the detection of benign interference items that should have been removed prior to security screening. Fewer interference items will not be subjected to additional screening if passengers took more responsibility.

Diminishing Passenger Tolerance

Security in itself is a trade-off and there is no perfect scenario where convenience meets extraordinary security or vice versa (Eldridge, 2018). When the TSA began securing airports in 2001, passengers accepted this trade-off and were willing to get to airports increasingly earlier, stand in long lines, and undergo extra security (Frederickson & LaPorte, 2002). At that time, it would have been hard to predict that long security lines would continue to this day. Passenger tolerance has slowly diminished as the memory of September 11 and previous terrorist attacks fade (Martin, 2011). Although threats are not as noticeably imminent as before, security lines seem to have gotten longer. Today, passengers are advised to arrive at most airports at least 3 hours before international flights, and no later than 2 hours for domestic ones, to have enough time for airport

security (O'Connor, 2018).

The hassle factor. In airport security literature, a far-reaching effect of the inconveniences associated with airport security is known as the *hassle factor*, where growing masses choose not to fly and turn to other modes of transportation (Ghobrial & Irvin, 2004; Ito & Lee, 2005; Seidenstat, 2004). The *hassle factor* became prominent during the TSA's infancy when long security lines started to emerge. Today there is evidence to suggest that the *hassle factor* continues to persist. For example, a recent 2016 survey found that during public holidays, about a fifth of respondents would rather travel by another mode of transport, or not travel at all than to be stuck in airport security (U.S Travel Association, 2016). The consequences of many travelers choosing not to fly or turning to other modes of transport can be costly.

During the 2016 summer period alone, the *hassle factor* was responsible for an approximate loss of $4.3 billion in potential travel spending (U.S Travel Association, 2016). There is also a rather new dimension of the hassle factor in the form of autonomous, driverless vehicles. Rice and Winter (2018) note that unlike air travel, driverless vehicles are not subjected to the same stresses and time spent waiting in airport security, or the restrictions on essentials such as traveling liquids.

The TSA's unsustainable security spending. In efforts to approach 100% security, the TSA has spent a considerable amount to mitigate long security lines, and to maintain airport security in its current form. For example, in 2016, the TSA requested $34 million from Congress to employ additional TSA officers and overtime workers, in order to alleviate congestion at various TSA checkpoints around the country (Jansen, 2016). At this rate of spending to contain congestion, security costs are likely to increase. In 2002, the funding to the TSA was only about $2.3 billion,

(Department of Transportation, 2002). However, over the last 5 years, the funding made available to the TSA was at an estimated $7 billion per year (GAO, 2017), a three-fold increase to the funding in 2002. It is worth noting that in 2002, the TSA was still securing airports around the nation whereas in the last 5 years, much of the TSA's security infrastructure should have already been well-established and would only require regular maintenance.

Additionally, the TSA was advised to explore alternatives to maintain the greatest risk mitigation value for every dollar spent, stressing the need for the Administration to be fiscally prudent (GAO, 2017). Every dollar spent on securing airports is a dollar that cannot be spent on securing other infrastructure (e.g., subways or bus stations). It would certainly be in the country's best interest to have security funds more equally distributed across other critical infrastructure.

Previous Studies Lack Understanding of User Failure

Focusing on the end user —the passenger— *user failure* differs with most research in the relevant literature on how to expedite the security screening process. A large focus has been on screening technology, screening procedures and screeners themselves, as evident in the following literature review.

Mediocre screener performance. Harris (2002) suggests that the disparity between expected (desired) and actual screener performance can be attributed to the fact that humans are simply not well suited to perform what is asked of screeners: visually searching for a target item among an array of heterogeneous, distractor items (Wolfe, Brunelli, Rubinstein & Horowitz, 2013). When complexities such as bag density, object superimposition, and orientation are thrown into the mix, a screener's detection ability and speed can be further diminished (Hofer & Schwaninger, 2005; Wetter, 2013). Many other

factors such as overloading and underloading screeners, task repetition, attention span, and monotony, can increase the number of screener errors and mistakes (Kraemer, Carayon, & Sanquist, 2009). These reasons highlight how susceptible screeners are to circumstances and factors beyond their control. One such factor that screeners cannot control is their ability to remain vigilant and focused on x-ray monitor displays over extended periods of time, otherwise known as vigilance decrement (Grier et al., 2003).

Vigilance decrement. A screener's job requires sustained attention that surpasses the average human capacity. Even more challenging, is the ability to maintain the required level of sustained attention, operational readiness, and responsiveness to pick out specific, rare-occurring targets such as explosives (Hubal, Mitroff, Cain, Scott, & DeWitt, 2010). These rare occurring targets can be separated by long intervals, which can cause a screener's supervisory ability to lose sensitivity, making the screener naturally less focused (Grier et al., 2003). When vigilance decrement occurs, screeners are more prone to errors, and are more likely to screen passengers at a slower rate than before.

It only takes 10 to 15 minutes of task engagement to substantially degrade the ability to maintain vigilance (Pavlas, Rosen, Fiore, & Salas, 2008). European regulations have been put in place to combat vigilance decrement by prohibiting its airport screeners from spending more than 20 continuous minutes reviewing x-ray images (Chavaillaz et al., 2019). Although implementing mandatory scheduled breaks may enable screeners to better focus on their tasks, it may not adequately alleviate the problem of long security lines. Nonetheless, vigilance decrement should be taken seriously, considering the central role it plays in human-machine operations and its ensuing success.

Leaving laptops in carry-on bags. Removing large electronic devices such as laptops from carry-on bags to be screened separately, can be seen as an inconvenience to

most. This procedure takes time and can slow down the screening process. Mendes, Schwaninger, Strebel and Michel (2012) investigated the possibility of leaving laptops in carry-on bags during screening. Because laptops are inherently dense, they interfere with the penetration of x-ray beams, and make it difficult for screeners to see items in front or behind the laptops. It would take screeners a longer time to inspect other carry-on items when laptops are left inside. Subsequently, Mendes et al. concluded that removing large electronic devices such as laptops from carry-on bags remained appropriate and necessary, despite its unfavorable impact on screening throughput. Although the idea of leaving large electronic devices in carry-on bags could simplify and expedite the screening process, this example illustrates that there are certain challenges with modifying current screening procedures without compromising security.

Expanding risk-based, trusted traveler programs. Wong and Brooks (2015) examined the possibility of revamping the one-size-fits-all approach that current security standards dictate because it is not feasible to subject most passengers to the same high standards of security. Pointing to the unfavorable effects that current security standards have had on security lines, Wong and Brooks proposed for the expansion of risk-based programs (also known as trusted traveler programs) such as TSA PreCheck, where passenger risk assessment is conducted using personal information such as demographics, historical background, and previous flight profiles.

With TSA PreCheck, eligible passengers are exempted from removing several interference items such as shoes, belts, even laptops, and liquids. Using a separate, expedited security line, TSA PreCheck allows more passengers to be screened at one time, eliminating the need for qualified passengers to undergo the same scrutiny as the rest of

the flying public (Nie et al., 2009). Introduced in 2011, TSA PreCheck has helped alleviate congestion at security checkpoints. However, security lines still remain long, implying that TSA PreCheck alone has probably not been enough to fix the problem. Wong and Brooks advocated the need to expand or introduce more similar risk-based programs to truly make an impactful difference. Examples of similar programs that already exist include Global Entry and NEXUS (Lowe, 2016).

Simpler screening procedures. According to de Barros and Tomber (2007), post September 11 screening throughput had drastically reduced due to the new and relatively complex security measures. de Barros and Tomber tested several ideas that would increase screening throughput using a simulation model of Seattle-Tacoma (Sea-Tac) International Airport. The most effectively tested idea was to simply reduce the number of carry-on items, by one item. Taking motivation from the simplicity of the idea, Sea-Tac began pursuing other simple yet practical ideas. One example was distributing large plastic bags for passengers to store and gather carry-on items to expedite the pre-screening divesting and post-screening gathering process. The study demonstrated that simpler, cost-effective measures could be undertaken to improve screening throughput and efficiency. The proposed idea enclosed in the present study takes motivation from the study by de Barros and Tomber in devising simple yet creative solutions to solve seemingly challenging, and complicated problems.

Queuing theory and screening throughput. Marin, Drury, Batta and Lin (2007) analyzed a less explored aspect of queuing theory: examining servers (screeners). Marin et al. investigated the prediction by Parkinson's Law where screeners would speed up their processing rate when confronted with longer security lines. This prediction had important implications because if it were true, it meant that a speed-accuracy trade-off was present.

In airport security, this trade-off involves the decision between correctly identifying prohibited items and that of quicker passenger processing. In favor of quicker passenger processing, screeners would focus more on speed and less so on accuracy. Although more passengers can be screened, it comes at the cost of more mistakes as less time is taken by the screener to make correct, accurate screening decisions (Knol, Sharpanskykh, & Janssen, 2019).

The speed-accuracy trade-off suggests that when security lines are long, screeners are more likely to pass a bag through as acceptable, even though they would have flagged the same bag if the line was not as long (Biggs, Cain, Clark, Darling, & Mitroff, 2013). Although the trade-off may help shorten security lines, the compromise between the ability to quickly screen passengers and that of screening them thoroughly and assiduously, is not in the best interest of safety. Consideration should be given to the consequences of less-thorough screening where more missed detections are tolerated in favor of quicker processing (Wetter, 2013). Marin et al. (2007) found that only one out of four tested item types experienced the speed-up effect predicted by Parkinson's Law. Screeners ensured that each item was thoroughly screened, fully aware that doing so would do little to alleviate the already long security lines and waiting times. The speed-up effect predicted by Parkinson's Law was not prominent enough and illustrated that Parkinson's Law is unlikely to help shorten airport security lines.

Greater Provision of Security Guidelines

Contrary to most of the literature review, van Boekhold, Faghri and Li (2014) recommends better educating the traveling public on how to prepare for security screening. van Boekhold et al. acknowledges the role of passengers in creating long security lines owing to their unfamiliarity with screening procedures. This notion stems from the

statistic that although screening guidelines can be found on internet sources such as airline websites, only 24.6% of travelers use it, and an even lower 9.1% of travelers use the TSA website to seek out screening information. The statistic suggests that although screening information can be conveniently found over the internet, utilization rates have been poor, and that perhaps more can be done to improve the utilization of such pertinent screening information.

One of the ways suggested by van Boekhold et al. (2014) to better educate the traveling public was to advocate for more effective use of security signage. van Boekhold et al. postulated that when passengers were better prepared for screening, they were less likely to be flagged by security personnel for non-compliance. Passengers more informed and familiar with screening procedures require less time to clear security, and could help expedite screening and shorten passenger lines.

Informed vs uninformed passengers. There are two types of passengers: informed and uninformed passengers. Informed passengers are well-versed with screening guidelines, and spend an average of 20-30 seconds to successfully clear security (Kirschenbaum, 2013). Uninformed passengers are more likely to not comply with screening guidelines albeit mostly unintentionally, and spend an average of 1-2 minutes to successfully clear security. Generally, informed passengers tend to, and are presumed to be frequent fliers, whereas uninformed passengers are usually non-frequent fliers and are more likely, international passengers. The difference in the time taken to successfully clear security by the two types of passengers is significant, because it supports the *user failure* sentiment that a lack of screening proficiency results in extra time needed to undergo security screening.

How User Failure Undermines Screener Performance

When *user failure* occurs, screeners encounter more interference items such as laptops and liquids that are left in carry-on bags instead of more dangerous, urgent threats such as weapons and explosives (Wolfe et al., 2013). More interference items can create an element of uncertainty that can compromise screener performance. Screeners already deal with an enormous amount of uncertainty from a wide array of dangerous, prohibited items that can pass through their checkpoint at any given time or day (Biggs & Mitroff, 2015). As such, a screener's job may be unnecessarily more challenging. It would be easier if the screener only had to focus on picking out dangerous and prohibited items, instead of combing for more benign interference items.

Mental representations. Before a screener identifies a target (prohibited or interference item), mental representations of the target must be formed beforehand, otherwise the screener does not know what he is looking out for. It is never that straightforward because screeners have to often simultaneously search for several targets (in carry-on bags) instead of just one (Menneer, Barrett, Phillips, Donnelly, & Cave, 2007). Because *user failure* results in more interference items being left in carry-on bags, screeners have to create even more mental representations to identify these targets. Given the pressure of achieving high passenger turnover, screeners are more likely to make more rash and careless decisions (Turcsany, Mouton, & Breckon, 2013).

User failure can lead to increased screener workload and pressure that can adversely affect their performance. In fact, evidence suggests that screeners are already performing at sub-optimal levels. In 2015, Homeland Security undercover agents were able to smuggle fake firearms and explosives through TSA screening checkpoints 67 out

of 70 tests (Lowe, 2016). This statistic demonstrates the effect of *user failure* on screener performance. More importantly, it underlines the need for countermeasures to protect screeners from the effects of *user failure*, giving them the best opportunity to do their job capably and without unnecessary complications (Graves et al., 2011; Michel, Hattenschwiler, Kuhn, Strebel, & Schwaninger, 2014).

Subsequent Search Misses (SSM). In professions such as radiology where multiple-target visual searches are central to the task at hand, the art of searching for one target among a set of distractors can result in the phenomenon known as Subsequent Search Miss (SSM). SSM is a type of error where the identification of one target leads to a higher likelihood of missing a second, subsequent target (Biggs, Adamo, Dowd, & Mitroff, 2015). This error occurs partly because the initially identified target is stored in the screener's working memory (WM) and hence, reduces the already limited amount of cognitive resources available to find another subsequent target (Cain, Biggs, Darling, & Mitroff, 2014). Biggs et al. (2015) proposes that a form of bias is developed where screeners are likely to find a subsequent target only if it is similar to the initial target found. This statement implies that screeners are less likely to find a second target if it is inconsistent with the first target found (Biggs & Mitroff, 2015).

SSM is undesirable because it suggests that a subsequent, dissimilar target is likely to be missed by screeners regardless if it is a dangerous or harmless target. *User failure* plays an important role in prompting SSM. For example, if a passenger packs a weapon in his bag and does not remove interference items (e.g., laptops or liquid containers), SSM suggests that if a screener finds the laptop or liquid container first, it is possible he will miss the weapon. Here, the individual escapes detection, and is able to pass through the checkpoint with the dangerous item (Biggs & Mitroff, 2015).

User Failure and Low Prevalence Targets

Prohibited items such as weapons and explosives are typical low prevalence targets. Such items are less conspicuous and can be difficult to detect during security screening. Prohibited items are often camouflaged among clothing or other bag contents. The prevalence of these items can be further reduced when distractors (i.e., interference items) are present (Wolfe et al., 2007). The more items there are in carry-on bags, the more disorganized and clustered the bag will be. *User failure* is one way that can increase the number of interference items in carry-on bags.

Reduced prevalence and increased missed targets. Because *user failure* can increase the number of interference items present in carry-on bags, the prevalence of dangerous and prohibited items is also reduced, and this effect can make them harder to find. In fact, Wolfe, Horowitz and Kenner (2005) captured the effect of reduced target prevalence on the ability to identify target items as illustrated in Table 1. They found that when target prevalence was lowered, participants were increasingly unable to identify and pick out the target items, also known as error rate in the study. In Table 1, there is an inverse relationship between target prevalence and error rate, where lower prevalence correlated with a higher error rate and vice versa. When more interference items were present, participants were less likely to identify target items.

Table 1

Correlation Between Target Prevalence and Error Rate

Target Prevalence	Error Rate (participant failing to identify the target)
50%	7%
10%	16%
1%	30%

Note. Inverse relationship between target prevalence and error rate. Adapted from Rare items often missed in visual searches, by Wolfe, J. M., Horowitz, T. S., & Kenner, N. M., 2005, *Cognitive psychology*, 435(7041), 439-440. Copyright 2005 by Nature.

Effect of missed target item on subsequent targets. When screeners fail to identify prohibited items, they can become less likely to flag subsequent prohibited items because their decision criterion has shifted to a more conservative stance, (Wolfe et al., 2007) where screeners prematurely abandon their searches quicker than before. More specifically, because there may be little justification to search as thoroughly for a target or prohibited item that has seemed unlikely to exist by virtue of numerous, previous inconsequential searches (Kunar, Rich, & Wolfe, 2010; Schwark, MacDonald, Sandry, & Dolgov, 2013; Wolfe, et al., 2005; Wolfe et al., 2007). A conservative stance can also result in fewer false alarms and secondary searches which can be beneficial to screening throughput as there are fewer interruptions. Fewer false alarms also mean that it is more likely that missed targets and prohibited items can pass through security checkpoints (Green & Swets, 1966; Schwark, Sandry, & Dolgov, 2013; Van Wert, Horowitz, & Wolfe, 2009; Wolfe et al., 2007).

Screeners may prematurely end their searches quicker than before because they deem prohibited items to be absent. Screeners may have failed to detect prohibited items

due to reduced target prevalence rather than because the items were indeed absent. Minimizing *user failure* might prevent prohibited items from being unnecessarily harder to find, and more importantly, prevent screeners from missing subsequent prohibited items.

User Failure and Signal Detection Theory (SDT)

Signal Detection Theory (SDT) is a particularly prominent aspect of airport security screening. In security screening, SDT suggests that screeners have to evaluate and make judgment calls to accurately detect relevant signals (McGuinness, 2004), while discounting irrelevant distractions or background noise. Distractions or background noise are non-signal events that do not require responses from screeners such as further inspection, removal, or confiscation of an item. A screener's judgment call can result in one of four possible outcomes as summarized in Table 2.

Benefits of fewer total signals. Signals relevant to screeners, can originate from both prohibited and interference items. However, signals from prohibited items can be considered more crucial and time-sensitive simply because the consequences of not detecting such signals can be far more severe. The focus should be on reducing signals from interference items by minimizing the number of interference items mistakenly left in carry-on bags. With fewer total signals, screeners can focus on more crucial signals from prohibited items. Furthermore, less time can be spent on re-screening, secondary searches and manual inspections.

Table 2

Signal Detection Theory Four Possible Outcomes

	Target Flagged	Target Not Flagged
Target Present	True positive (Correct detection)	False negative (Missed detection/target)
Target Absent	False positive (False detection/alarm)	True negative (Correct rejection)

Four outcomes of SDT. The four possible outcomes of SDT are summarized in Table 2 (Bruno & Abrahão, 2012; Lynn & Barrett, 2014). Generally, false positives and false negatives are undesirable because they create additional stoppages and may result in dangerous, prohibited items passing through security. Instead, the goal should be more true positives and true negatives where dangerous, prohibited items are caught in time and unnecessary stoppages are minimized (Lynn & Barrett, 2014; Nevin, 1969).

Receiver Operator Characteristic (ROC) curve. The ROC curve is imperative to SDT because it summarizes the four possible outcomes in a graph (Yonelinas & Parks, 2007). The ROC curve is a graphical representation of the trade-off between the measures of sensitivity and specificity (Martínez-Camblor, Bayón, & Pérez-Fernández, 2016, O'Mahony & Hautus, 2008). Figure 2 is an example of the ROC curve.

Sensitivity and specificity. In the medical field, sensitivity is the ability to correctly detect a disease when it is in fact present otherwise known as true positive. Specificity is the ability to correctly determine that a disease is not present when it is in fact absent, also known as true negative (Parikh et al., 2008; van Stralen et al., 2009). In security screening, sensitivity is accurately flagging a bag that contains a prohibited or interference item (true positive), whereas specificity is accurately and correctly allowing a bag that

does not contain a prohibited or interference item, to pass through without further inspection (true negative).

Optimal balance. Sensitivity and specificity possess an inverse relationship where an increase in either measure's value will see the corresponding measure value decrease. As such, the aim is to find an optimal balance between both measures by using the ROC curve to make a decision between a higher level of either sensitivity or specificity (Junge & Dettori, 2018; Kumar & Indrayan, 2011; Reitsma et al., 2005). Balancing sensitivity and specificity is often not straightforward. In an ideal scenario, high specificity entails that a negative result of "the target is not present" is truly negative, while high sensitivity entails that a positive result of "the target is present" is truly positive. This outcome rarely happens in real life as a negative result is typically accompanied by false negatives and a positive result is accompanied by false positives as denoted by the shaded areas in Figure 3, akin to a form of discrepancy (Junge & Dettori, 2018).

When specificity is higher, false negatives are more likely to be present, and when sensitivity is higher, false positives are also more likely to be present. A higher value of either specificity or sensitivity carries the consequences of either false negatives or false positives. It is important to find an optimal balance between sensitivity and specificity, and one where such discrepancies are minimized. In Figure 2, point C is an example of this optimal balance as denoted by the red lines where the results are fairly accurate, and void of errors as seen from the sensitivity score of 90 and specificity score of 10 that equals to a 100. In comparison, there is an obvious presence of errors in points A, B, D and E where the values of sensitivity and specificity do not add up to 100. Although point C is an example of a perfect balancing between specificity and sensitivity, it can be rare in

real life scenarios.

Trade-off. An optimal balance between sensitivity and specificity requires a trade-off that can be made using the ROC curve. Consideration must be given to the consequences of accepting either more false negatives or false positives. In Figure 3, a cut-off value is used to make the trade-off where a lower cut-off value (leaning more toward the left) entails accepting more false negatives while at the same time, accepting fewer true negatives and vice versa (Hoo, Candlish, & Teare, 2017).

Implication on airport operations. If *user failure* is known to be prevalent, airports should conduct a risk-benefit analysis to determine an acceptable cut-off level to balance specificity and sensitivity. If an airport wishes to speed up security lines and congestion caused by *user failure*, it could increase specificity and apply a higher cut-off value (leaning more to the right in Figure 3) where fewer false positives are picked up. This option may involve increasing the threshold of security equipment such as the WTMD (Knol, Sharpanskykh, & Janssen, 2019). By increasing specificity, sensitivity is lowered, meaning that fewer alarms are raised (including false alarms). The reduction of the number of stoppages and secondary searches should help expedite security screening.

However, the airport would also be accepting the risk of greater false negatives where there is a higher likelihood of prohibited items escaping detection. Although this example utilizes SDT and the ROC curve to illustrate how an airport can shorten security lines —adjusting its screening standards and accepting the ensuing trade-off— this paper will investigate if there is another way to shorten security lines using another form of security signage.

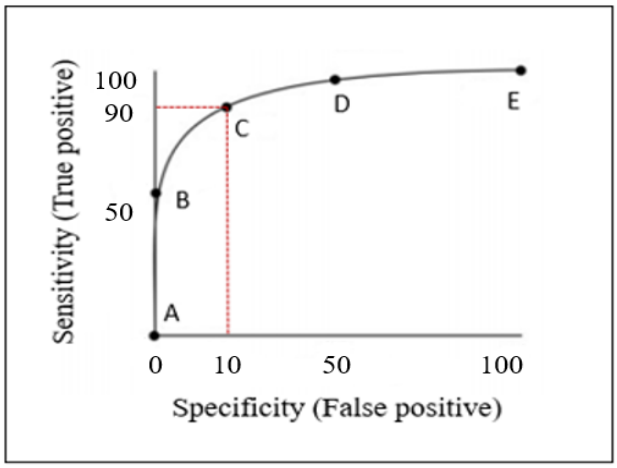

Figure 2. ROC curve. *Note.* An optimal balance has to be found between sensitivity and specificity. Figure 2 shows five cut-off points: A, B, C, D, and E. The most optimal trade-off is seen at point C where there is a relatively high rate of true positives that is accompanied by relatively low rates of false positives. Adapted from "ROC solid: Receiver operator characteristic (ROC) curves as a foundation for better diagnostic tests" by Junge, M. R. J., & Dettori, J. R., 2018, *Global Spine Journal*, 8, p. 427. Copyright 2018 by SAGE.

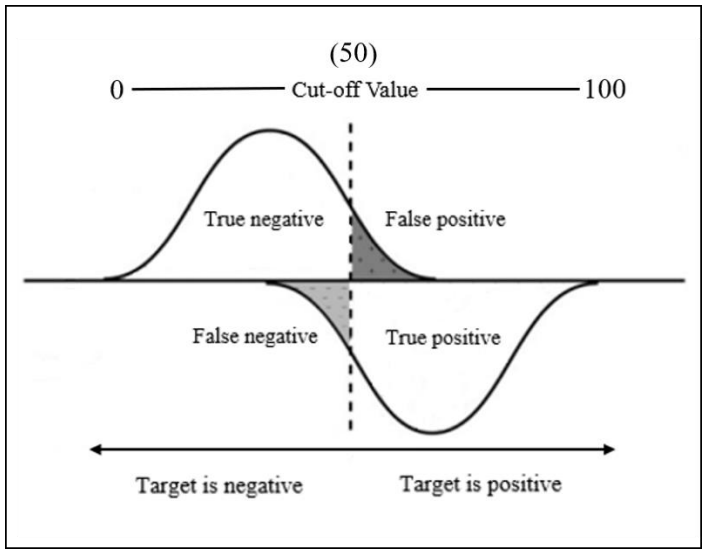

Figure 3. Cut-off value and the four-possible outcomes. *Note.* Lower cut-off value results in fewer false negatives, higher cut-off value results in fewer false positives. Adapted from "ROC solid: Receiver operator characteristic (ROC) curves as a foundation for better diagnostic tests" by Junge, M. R. J., & Dettori, J. R., 2018, *Global Spine Journal*, 8, p. 426. Copyright 2018 by SAGE.

Minimizing User Failure Through More Effective Security Signage

In an aircraft emergency, passengers who pay attention to crew safety briefings, watch the safety videos, or read the safety briefing cards, are more likely to survive (Chittaro, 2017; Lee, Wang, Hsu, & Jan, 2018). These passengers are better prepared for an emergency and are less likely to do things that hinder an evacuation such as climbing over seats, or removing bags from overhead bins (Tehrani & Molesworth, 2015).
For security screening, passengers that are familiar with security guidelines tend to be better prepared for security screening. In both aircraft emergencies and security screening, passenger preparation is key to procedural adherence.

Considering that informed passengers take 20-30 seconds to undergo security screening, and uninformed passengers required an average of 1-2 minutes (Kirschenbaum, 2013), it is fairly obvious that a more informed passenger who is well-versed with screening guidelines should contribute to faster moving lines. The extent to which passengers are well-versed and prepared for security screening would largely depend on the saliency of security signage. The saliency of the TSA's most visible form of signage —standing signposts— will be examined.

TSA security signposts (hereafter referred to as TSA signposts) are usually found near screening checkpoints as seen in Figure 4. However, there may be several shortcomings with TSA signposts that may explain why passengers continue to lack screening proficiency.

Figure 4. Example of TSA signposts being obstructed.

Figure 5. Example of small font and wording of a TSA signpost.

Figure 6. Example of difficulty in reading the contents of a TSA signpost

Short glances. Signposts can be easily and often obstructed by the movement of passengers and their bags, unintentionally blocking another passenger's line of sight (denoted with red circles in Figure 4). TSA signposts and their contents may not be clearly visible to passengers, particularly to those standing further away. Even when a passenger gets within viewing distance of a TSA signpost, the hurried and chaotic movement of people in the line may result in mere glances at best, or a complete failure to notice the signpost at worst. If a passenger finds that it is has become too challenging to read these signposts, he may choose to disregard it.

Viewing from a distance. Figure 5 illustrates the font size used in a regular TSA signpost. At times, a fair amount of screening information (sometimes not pertinent to the majority) is printed onto a single signpost. Doing so often shrinks the content's font and makes it necessary for passengers to physically get up close to read its contents. To

further illustrate, Figure 6 depicts the difficulty in reading the signpost from a distance and how passengers would have to leave their spot in the security line to physically approach the signpost to view it up close. Stepping aside and leaving one's spot (including personal belongings) in a long security line to read a signpost may not be desirable especially when traveling alone. Therefore, passengers are more likely to enter screening checkpoints with little understanding of screening procedures. To further understand why passengers do not fully utilize or benefit from TSA signposts, the concepts of voluntary attention, inattentional blindness, and selective attention are introduced.

Voluntary attention. Voluntary attention suggests that when a stimulus relevant to a desired goal is employed, the stimulus is able to better capture and draw the attention of its intended respondent (Huang et al., 2015). TSA signposts should in fact, be able to better capture the attention of passengers standing in security lines as it provides information to help passengers clear screening quickly and without incident. The desired effects of voluntary attention may not be as prominent as expected because of inattentional blindness and selective attention.

Inattentional blindness. When fixated on a demanding task, passengers may not see clearly visible objects that would have otherwise not have been missed (Beanland & Pammer, 2012). When standing in security lines, passengers may find themselves being hurried while engaged in tasks such as preparing identification, moving along the line with children, or having to do so with bags in one or both hands. Here, these tasks can quickly become demanding and frantic. Passengers may be temporarily narrow focused on the task at hand, blinding them from salient objects such as TSA signposts (Drew, Võ, & Wolfe, 2013). This example demonstrates how inattentional blindness can inadvertently

offset the desired effects of voluntary attention, leaving passengers no more prepared for screening than before being exposed to security signage.

Selective attention. Selective attention is the mechanism that determines where an individual directs his attention and how he selects the information most relevant to his current state (Giesbrecht, Sy, Bundesen, & Kyllingsbaek, 2014). Selective attention can have an adverse impact on voluntary attention, particularly when passengers are distracted by multiple sources of information (stimuli or salient objects) that actively compete to capture passenger attention (Chelazzi, Perlato, Santandrea, & Della Libera, 2013). This effect is especially prominent in dynamic environments (e.g., security checkpoints) where there is too much information originating from various stimuli and salient objects, making it difficult for one particular source of information to successfully obtain selective attention (Downing, 2000).

At security checkpoints, public conversations, speaker announcements, and televised monitors that display flight information can be considered as sources of information that compete with TSA signposts for selective attention. In this scenario, if a passenger is engaged in a conversation, he or she is less likely to notice the TSA signposts or the other sources of information since his attention has already been captured by the other individual party to the conversation. For this reason, selective attention may explain why passengers remain unprepared and unaware of screening procedures, despite the recurring presence of security signage at screening checkpoints.

Low Utilization of the Internet

Although security screening guidelines are readily available over the internet, van Boekhold et al. (2014) found that a relatively low percentage of passengers used the

internet, particularly TSA or airline websites, to source out such information. In today's digital age, this statistic raises several concerns. The first points to how passengers have not turned to the internet despite the convenience of being able to use their smartphones or other electronic device to access screening information.

Second, passengers may erroneously believe that they are fully aware or familiar with screening procedures. Passengers may not feel the need to gather more information or verify if they are correct; a concern similar to passengers who are inattentive during pre-flight safety briefings (Molesworth, Seneviratne, & Wilcock, 2019). Although these passengers may feel that they possess high levels of screening proficiency, they may still make the occasional screening mistake that contribute to delays at the checkpoint. It is important that more is done to encourage passengers to review screening information before they proceed to security checkpoints.

Justifying the Need for More Effective Signage

The present study suggests that passengers should be better prepared for security screening. Figures 4, 5 and 6 illustrate how passengers are still relatively unprepared for screening despite the presence of TSA signposts. The internet has not yielded the desired utilization rates among passengers (van Boekhold et al., 2014).

Added visibility and accessibility. Screening instructions could be made more immediately visible and easily accessible to passengers. The benefits of having more convenient screening instructions can be explained by Wickens et al. (2004) who notes that humans generally prefer to scan over shorter distances and favor minimal head movements when choosing a source of information to focus on.

Using driving as an example, Wickens et al. (2004) explains that because it can be

more inconvenient and physically demanding to check blind spots, fatigued drivers are less likely to do so when changing lanes. This behavior is attributed to the additional effort required to turn their heads and properly check their blind spots. In parallel, the same can be said about TSA signposts because it can require a considerate amount of effort to find a TSA signpost or get close enough to read it particularly when already exhausted from pre-flight preparation (i.e., getting to the airport, check-in). Passengers may be less inclined to look for TSA signposts in the same manner that fatigued drivers do not check their blind spots.

More time for preparation. Screening information could also be provided to passengers ahead of time, particularly before they reach security checkpoints. If passengers have more time to review screening information before security screening, they can be less likely to make mistakes as they are more familiar with what is expected of them. On average, they should take a shorter time to be successfully screened. Because TSA signposts are observed to be found near screening checkpoints, passengers may only read these signposts when they enter screening checkpoints or when they are already standing in line. Consequently, passengers are likely to be less prepared for screening.

Attentional refreshing. Lapses in memory are common and frequent occurrences that happen because of the natural temporal decay of information from the WM, also known as the short-term memory. Limited in its capacity, the WM temporarily stores information until it is ready to be used (Wickens, Lee, Liu, & Becker, 2004). In context, non-frequent travelers (presumed to be a large majority of passengers) are more likely to have lengthier breaks between their travel and for this reason, will probably forget certain screening procedures. These passengers are more likely to make mistakes during

screening.

However, this temporal decay of information can be counteracted if the stored information and its memory traces are periodically reactivated in a process known as attentional refreshing (Vergauwe & Langerock, 2017). Attentional refreshing not only allows stored information to be prolonged but also strengthens the ability to activate it. There is greater immediate recollection and retrieval of stored information (Camos et al., 2018). A stimulus to display screening information could incorporate the use of attentional refreshing to help passengers better remember screening guidelines.

Benefits of Using Symbols for Screening Instructions

Symbols could be used to represent screening information. The main benefit of using symbols stem from the knowledge that symbols (including pictures) can be better at drawing and attracting attention as compared to written or orally communicated information. As word replacements, symbols are effective at stimulating better reading and allows for a large amount of information to be replaced by a symbol or picture (Brookshire, Scharff & Moses, 2002).

Lower English literacy and deaf passengers. The ability to transcend language barriers help position the use of symbols and pictures as an effective means of providing universal and easily understood information to most passengers, even if they are of lower English literacy, or from an area where English is not the native language (Kripalani et al., 2007; Shen, Xue, & Wang, 2018). Pictures and symbols can also be equally beneficial to deaf passengers. With sign language as their primary mode of communication, it is common that deaf passengers only command a third or fourth grade level of reading which can make English instructions challenging. Symbols may be familiar and simple enough

for these individuals to understand. The use of symbols may help mitigate the costly training and hiring of full-time sign language interpreters that are occasionally deployed at checkpoints to guide deaf passengers through screening procedures (Lancaster et al., 2003).

Picture superiority effect. Katz et al. (2006) explained that humans possess a cognitive inclination toward pictorial instructions rather than those only represented in words, as explained by the phenomenon known as the "picture superiority effect". More specifically, it is the ability to better remember instructions illustrated as symbols or pictures compared to when represented in words (Paivio, 1969; Paivio, & Csapo, 1973). The preference for pictures over words has been frequently explained by the dual-coding theory where, very simply put, words are coded once by the verbal-processing subsystem whereas pictures are coded twice by the verbal and non-verbal processing subsystems. This dual coding of pictures increases the magnitude and depth of the encoding, prompting better recollection and recall (Crutcher & Beer, 2011; Curran, & Doyle, 2011; Lwin, Morrin, & Krishna, 2010; Paivio, 1991; Whitehouse, Maybery, & Durkin, 2006).

Application in the medical field. In the medical field, low health literacy was found to be a large factor for non-adherence to medical instructions. Non-adherence was primarily due to misinterpretation and the inability to understand instruction labels. To improve the understanding and adherence of prescription medication among lower health literacy patients, Kripalani et al. (2007) experimented with pictorially illustrated instructions. It was found that participants not only felt that pictorial instructions were easy to comprehend but that participants were also receptive to its continued use. Given the findings by Kripalani et al., it is hoped that the benefits and receptiveness toward

pictorial instructions seen in the medical field may be transferred to security screening.

Maintaining symbol simplicity and familiarity. Shen, Xue and Wang (2018) found that when more familiar and simple symbols were used, participants were better able to recall the semantic information attached to each symbol, as compared to when more unfamiliar, abstract symbols were used. This sentiment of avoiding abstract symbols was further echoed by Houts,Doak, Doak and Loscalzo (2006). In fact, it was concluded that pictograms or symbols used in safety briefing cards should also be simple and unambiguous, designing it with the novice passenger in mind (Corbett, McLean, & Cosper, 2008).

English Texts to Accompany Symbols

To help guide interpretation and minimize misunderstanding, English texts can be used to accompany symbols. At times, accompanied English texts are important because pictorial instructions may be too complex for some users, and can lead to misinterpretation (Katz, Kripalani, & Weiss, 2006). Houts et al. (2006) demonstrated that when accompanied written texts were used, there were signs of increased understanding and adherence of instructions among participants. Houts et al. also advised that the accompanying text should be as simple and concise as possible in order to be helpful and meaningful, particularly to those of lower English literacy. Otherwise, the texts may confound the intended meaning of the symbol and be of little to no use to its users.

English Texts Only, Symbols Only or Both

Leib, Dillman, Petrin and Young (2012) analyzed if passengers of various cultural backgrounds (Chinese and American) would interpret airport terminal signage differently from its intended meaning when three forms of signage were used: English texts only,

symbols only or symbols with English texts. The study attempted to investigate which form of signage was most effective to a culturally diverse audience. Leib et al. (2012) concluded that both American and Chinese participants not only preferred the symbol-text combination but also made fewer errors as compared to using symbols only. Passengers of different cultural backgrounds albeit only two, preferred the symbol-text combination. In fact, the passengers performed better when the symbol-text combination was used compared to when the symbols or texts were used in solitary. Following the promising response to the symbol-text combination, both symbols and accompanied English texts could be used to display screening information in the hopes of achieving similar positive outcomes.

Summary of the Relevant Literature

User failure was first examined in greater detail, underlining how passengers contribute to long passenger lines. Following *user failure*, concerns brought about by the hassle factor, the threat of driverless vehicles and the TSA's security budget were examined. Subsequently, the rest of the literature review revealed an eclectic mix of studies that proposed solutions to improve the screening process or airport security as a whole.

Chapter III

Methodology

The Modified Boarding Pass

As the proposed security signage should be both easily accessible and visible, the present study proposes the use of a modified boarding pass with printed screening instructions on its underside (Figure 7 and Appendix B3). These printed screening instructions consist of symbols and accompanied English texts that represent interference items as well as other basic screening instructions. The idea of using a combination of symbols, pictures, and texts is similar to that of safety briefing cards where pictorially depicted instructions are used to enhance comprehension, and provide better conveyance of information (Corbett, McLean, & Cosper, 2008). Owing to the benefits of the picture superiority effect and dual-coding theory where there are known benefits of better recall and attention stimulation, symbols were used to pictorially illustrate interference items. English texts were also used to accompany the symbols because they can guide interpretation.

Configuring to each airport. Airports occasionally vary about what constitutes an interference item. For example, some airports do not require passengers to remove their shoes during security screening (Popken, 2013). To mitigate any confusion, the modified boarding pass would allow airports and airlines to configure printed instructions to reflect their respective screening procedures. This configuration ensures that passengers receiving their boarding pass in a one airport will be provided with screening instructions that accurately reflects the screening procedures of that particular airport.

Configuring to each passenger. The sample modified boarding pass in Figure 7

applies primarily to the large majority of the traveling public, not particularly to groups such as TSA PreCheck, passengers over 75 years old, or those traveling with children. However, airlines may configure and print screening instructions specifically tailored to each individual passenger. For instance, passengers under TSA PreCheck will receive boarding passes notifying them that they do not need to remove their shoes, laptops, and liquids from their carry-on bags (Song & Zhuang, 2018). This possibility could minimize the likelihood of TSA PreCheck passengers unknowingly removing their shoes, laptops or liquids and thus, ensuring that such passengers are processed more quickly. Figure 8 is an example of the modified boarding pass designed for TSA PreCheck passengers.

By allowing these passengers to correctly prepare for screening beforehand, there is less need to seek guidance from security personnel. Fewer and shorter interactions with security personnel may reduce the average time spent screening each passenger. It should be noted that this aspect of the modified boarding pass will not be analyzed nor tested in the scope of the present study.

Figure 7. Sample modified boarding pass.

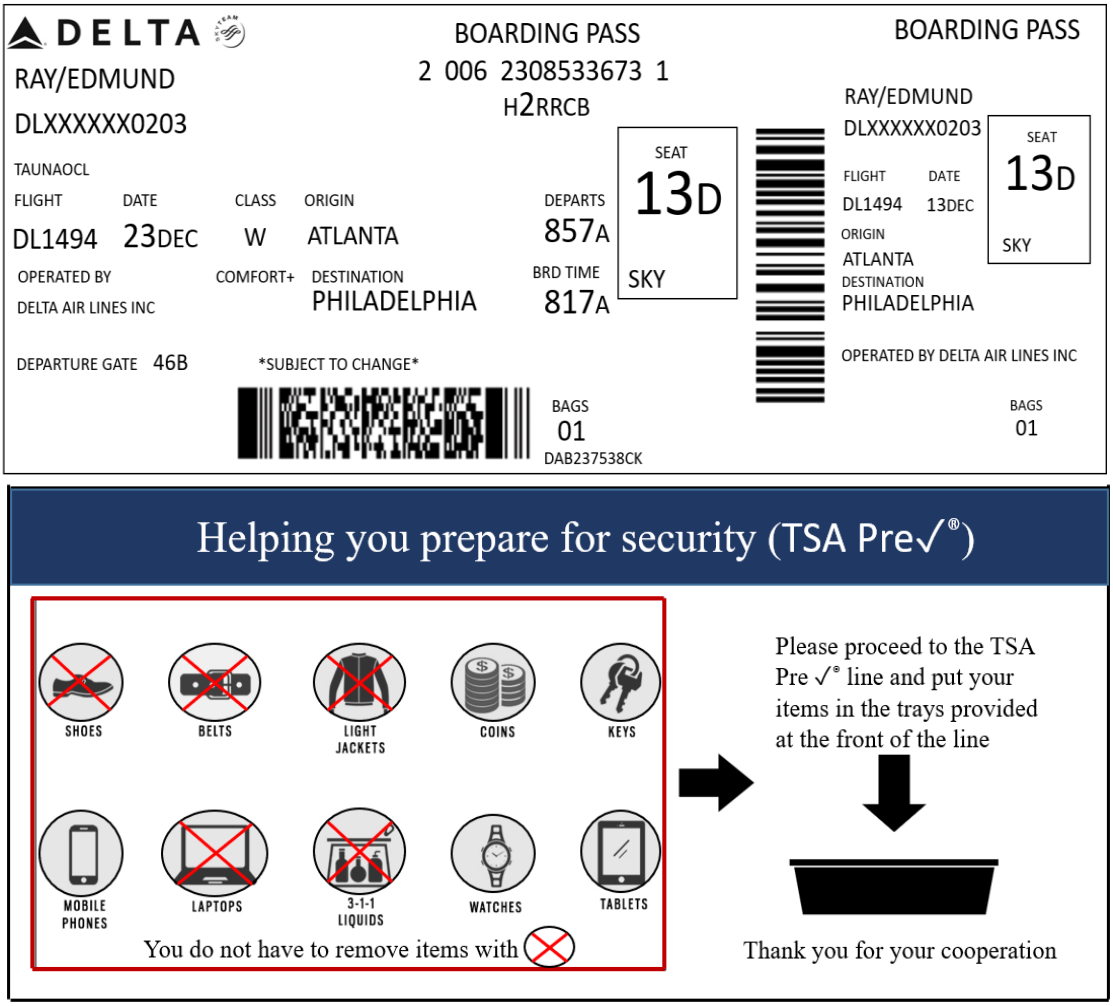

Figure 8. Sample modified boarding pass for TSA PreCheck passengers.

Figure 9. Sample regular, non-modified boarding pass

Research Approach

This study is a two-part examination into the effects and feasibility of using the modified boarding pass to provide screening information to passengers. Research study 1 focuses on the ability to recall interference items when three types of stimuli are presented to participants in a simulated environment. Research study 2 captures passenger responses at a domestic airport, pertaining to their receptiveness toward the modified boarding pass.

Study 1 (Recall Evaluation)

Study 1 analyzed whether there were differences in the ability to recall 10 interference items when three types of stimuli were used to provide screening information to participants. The results from this study will provide insight into the differences that exist between different types of security signage, particularly how well-informed

passengers are of screening information. Three sets of participants underwent a recall evaluation after being exposed to their respective stimuli. The researcher manipulated the stimuli to create the three scenarios and test the effects on participant recall. The range of interference items on each stimulus remained the same to ensure consistency.

- Group 1 served as the experimental control. Participants were provided regular, non-modified boarding passes and two standing signposts
- Group 2 was provided with modified boarding passes only
- Group 3 was provided with both modified boarding passes and two standing signposts

The dependent variable (DV) for this experiment was the number of interference items recalled by participants in each group in response to the question "List the items that passengers are required to be remove prior to security screening from their person and their carry-on bags (TSA Pre-Check is excluded)." The independent variables (IV) for this experiment were the three types of stimuli mentioned above.

Hypotheses.

$H_0$1: There will be no significant difference in recalling interference items between Group 1 and Group 2.

$H_0$2: There will be no significant difference in recalling interference items between Group 3 and Group 1.

$H_0$3: There will be no significant difference in recalling interference items between Group 3 and Group 2.

Sample. A total of 48 participants were recruited for this study – 16 participants for each group. The criteria for participation included participants that are at least 18 years old and enrolled at ERAU. Convenience sampling was employed and participation was

voluntary; each participant had received an email with an invitation to participate in a simulated security screening exercise. Interested participants contacted the researcher to schedule an available date for participation.

Design and Procedures. Study 1 was a between-subjects design that comprised of three different scenarios where participants were asked to recall as many of the 10 interference items that were presented on their respective stimuli. The groups were exposed to either (a) non-modified boarding pass with two standing signposts, (b) the modified boarding pass only, or (c) both the modified boarding pass and two standing signposts. A post-study survey was handed out to the participants upon the completion of the recall evaluation.

The participants in each group gathered at a conference room at a hallway in one of the university buildings. Each group had a separate, dedicated meeting date and time. Upon the researcher's arrival, participants were given a consent form to acknowledge and confirm their participation in the study. Afterward, the researcher gave a short briefing about the study. Here, participants were told again that they would be participating in a simulated security screening exercise.

The boarding passes were handed out in the conference room. Participants in Group 1 were given individualized, non-modified boarding passes that resembled regular boarding passes whereas participants in Groups 2 and 3 were given individual modified boarding passes. All three groups were instructed to keep their boarding passes with them until they entered the test room where they returned it to the researcher.

Instructions. Participants were informed that the corridor along the lounge area was part of the study and that the test room was located at the end of the corridor. In the conference room, participants were told that once the briefing was over, they would line up

along the corridor before being allowed into the test room. Participants spent 2 minutes lining up outside the test room. Afterward, they would be allowed into the room one at a time, with 10 second intervals between each participant. For Groups 1 and 3, the researcher pointed out the two standing signposts outside the test room. After being allowed into the test room, participants returned their boarding passes and were issued a test paper instructing them to recall the items displayed on their respective stimuli. At the end of the evaluation, participants were given a post-study survey and were allowed to leave upon completion of the survey. An important aspect of this study was the employment of deception. Effort was made to stimulate mundane realism by notifying participants that they would be participating in a simulated screening exercise, having to bring along a bag for simulated screening, and they were provided individualized boarding passes. There was no mention of a recall evaluation taking place in the test room during the briefing. An explanation to reveal the reason for the recall evaluation instead of a simulated screening exercise was not provided at the time of the study. The researcher emailed all the participants to inform them of the deception and reveal the true purpose of the study once all the data had been collected.

Materials. The study required the use of an informed consent form, two standing signposts, two different sets of boarding passes, a test paper, and a post evaluation survey.

Informed consent form. The informed consent form explained to the participants the conditions of the study such as the expected time required for the evaluation, reminding participants that they were not obligated to complete the evaluation, and that they could abandon the experiment at any time, without any repercussions. The consent form can be found in Appendix A.

Standing signposts. The two standing signposts were meant to mimic those

typically employed by the TSA, to remind passengers to remove interference items while they stood in line at security checkpoints. The two standing signposts were evenly separated along the corridor of the test room. The sample standing signpost can be found in Appendix B1.

Group 1 boarding pass. The regular, non-modified boarding pass contained the names of each participant as well as other made-up flight information. The underside of the boarding pass was intentionally left blank to replicate a regular boarding pass. The Group 1 boarding pass can be found in Figure 9 and Appendix B2.

Group 2 and 3 modified boarding passes. The modified boarding pass contained the names of each participant, other made-up flight details, and had screening information printed on the underside. The screening information was the same as seen on the standing signposts outside the classroom. The modified boarding pass can be found in Figure 7 and Appendix B3.

Test paper. The question on all three test papers were the same, "List the items that passengers are required to remove prior to security screening from your person and their carry-on bags (TSA Pre-Check is excluded). However, there were different hints for each group as different stimuli were used. For example, the hint on the test paper for Group 1 included the sentence, "The items were listed on the standing signposts outside the classroom". The other two groups had similar hints according to their provided stimuli. The three test papers are found in Appendix C.

Post-evaluation survey. The post-evaluation survey contained a short demographic questionnaire where participants were asked to note their gender, ethnicity, and age. The researcher used this information to define the population sample. The survey also contained various questions regarding the perceived effectiveness of their respective

stimuli. The surveys for Groups 1 and 2 contained a total of five questions: four were yes or no questions, and one was on a scale. The survey for Group 3 had a total of 11 questions: eight were yes or no questions, and the remaining three were on a scale. The three surveys are found in Appendix D.

Data Collection. The data for the recall evaluation were collected via a pen and test paper. Afterward, the data was entered into SPSS for analysis. The data for the post-evaluation survey were collected via a pen and paper survey, and entered into Microsoft Excel for analysis.

Study 2 (Airport Survey)

Study 2 involved gathering passenger responses and opinions at Daytona International Airport (DAB) when presented with the modified boarding pass (Figure 7). A survey with eight questions: seven scale item questions on a scale, and one open-ended question was used. A copy of the survey can be found in Appendix F.

Sample. The researcher gathered a sample of 150 respondents. The sample comprised of respondents that were recruited by means of convenience sampling at DAB. The researcher obtained IRB approval as well as approval from the DAB authority to conduct the survey and to approach passengers in the following designated areas: (a) Baggage claim lobby, (b) Rental car counters, (c) Ticket lobby, (d) Entry lobby, (e) Small café at level 2, and the (f) Grand lobby. It was requested by the airport that the researcher set-up a workstation —with a school emblem —to clearly identify that the survey was part of an official Embry-Riddle Aeronautical University (ERAU) research study. Over the course of two days, the researcher obtained the 150 responses needed. The criteria for participation include respondents will be at least 18 years old and have flown within the U.S at least once in the last six months. The demographic data

collected included age, gender, and the airline flown the most often by the passenger.

Design and procedures. The researcher approached passengers within the designated areas to request their participation in the survey. The researcher handed out the survey and instructed the passengers to answer the first four questions and to let him know when they were done. Afterward, the passengers were shown a sample of the modified boarding pass to review and help them answer Questions 5 and 6 which directly pertain to the modified boarding pass. Upon completing the survey, the researcher placed each survey into a sealed opaque box to ensure confidentiality and anonymity.

Materials. An informed consent form, paper survey, and five sample modified boarding passes were used for this study.

Informed consent form. Each respondent was given an informed consent form to review and to pen their acknowledgement before commencing with the survey. The consent form explained the purpose of the survey, the expected time required for the evaluation, and reminded respondents that they were not obligated to complete the survey, and could abandon it at any time, without any repercussions. A copy of the consent form can be found in Appendix E.

Survey. The survey contained a short demographic section where respondents were asked to note their age and gender. The researcher used this information to define the population sample. Clipboards and pens were provided. The survey can be found in Appendix F.

Modified boarding pass. The sample modified boarding pass contained made-up flight details, and had printed screening information on its underside. A total of five samples were printed and used for the survey. A copy of the modified boarding pass is found in Figure 7 and Appendix B3.

Data Collection. The data was collected via a pen and paper survey. Following the data collection, the data was entered into Microsoft Excel for analysis.

Instrument validity and reliability. The survey questions were specifically designed to elicit responses that would reveal passenger sentiment toward their experiences with airport security and their receptiveness toward the modified boarding pass. The questions were carefully worded and reviewed, undergoing several iterations by experts in the field. Cronbach's alpha was calculated as a measure of reliability.

Chapter IV

Results

Study 1 (Recall Evaluation)

A total of 48 participants from ERAU participated in the recall evaluation and were split into three groups of 16 participants each. There were 10 females and 38 males. The average age was 26 and the range was from 20 to 51.

Sample. Participants were asked to provide basic demographic information to define the sample. The three demographic questions were: age, gender, and ethnicity. Additionally, participants were not obligated to answer the demographic section. Although all 48 participants provided their age and gender, only three did not reveal their ethnicity. The demographic data are summarized in the figure below.

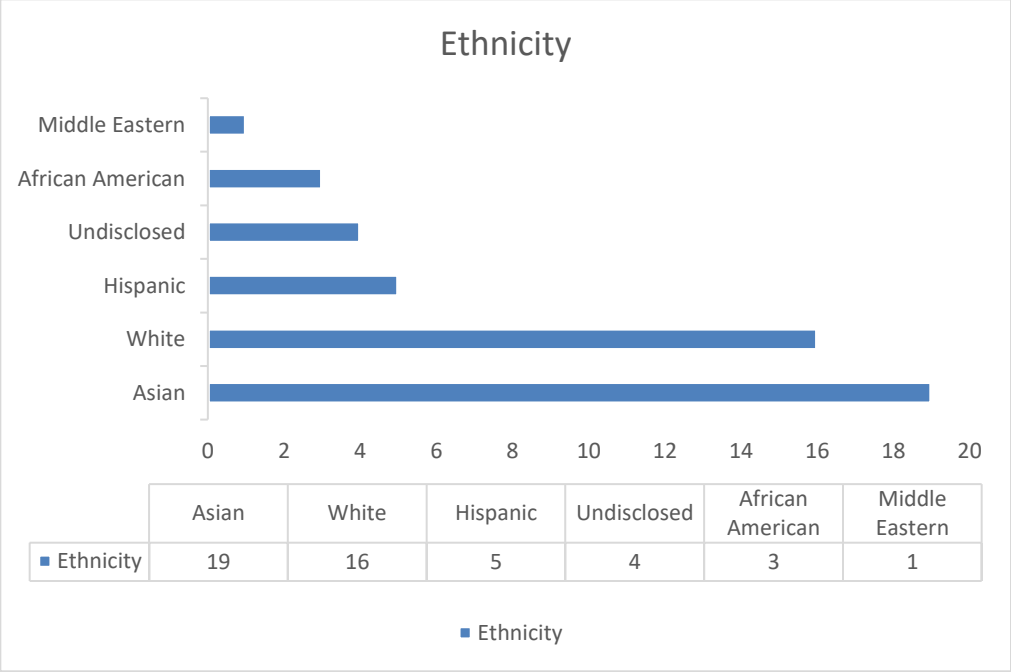

Figure 10. Ethnicity breakdown

The Asian and White population made up the majority of the sample whereas the rest included Middle Eastern, African American, Hispanic, and those that did not disclose their ethnicity.

Recall evaluation. Each group of participants were provided one of three stimuli to help them recall as many of the 10 interference items as possible. The lowest score possible was 0 and the highest was 10. The results of each group are summarized below in the Table 3.

Table 3

Recall evaluation results

	Valid	Mean	Median	Mode	SD	Min	Max
Group 1	16	4.06	4	4	2.32	0	8
Group 2	16	4.38	4.5	4	2.39	0	8
Group 3	16	6.44	6	6	1.50	4	9

One-way between-subjects ANOVA. A one-way between-subjects ANOVA was conducted to compare the mean of the recalled items between the three groups. The results showed that the one-way between-subjects ANOVA was significant, $F(2, 45) = 5.977$, $p = .005$, $\eta^2 = 0.21$. Levene's test for homogeneity of variance was not significant ($p = .353$). The post-hoc test, Tukey HSD, indicated that the mean for Group 3 ($M = 6.44$, $SD = 1.50$) was significantly better than Group 1 ($M = 4.06$, $SD = 2.32$) and Group 2 ($M = 4.38$, $SD = 2.39$). However, there were no significant post hoc tests between Groups 1 and 2.

Hypotheses testing. As per the results, H1 was retained whereas H2 and H3 were rejected.

$H_0$1: There will be no significant difference in recalling interference items between Group 1 (regular, non-modified boarding pass and two standing signposts) and Group 2 (modified boarding pass only).

$H_0$2: There will be no significant difference in recalling interference items between Group 3 (modified boarding pass and two standing signposts) and Group 1 (regular, non-modified boarding pass).

$H_0$3: There will be no significant difference in recalling interference items between Group 3 (modified boarding pass and two standing signposts) and Group 2 (modified boarding pass only).

Group 1 survey results. There was a total of five questions, four of which were yes or no questions, and one question that was measured against a scale ranging from 1 to 5, where 1 represented the lowest score (Not useful) and 5 represented the highest (Very useful). The results from each of the five questions are provided below.

Table 4

Group 1 Question 1

Did you notice the TSA signage post outside the test room?	
Yes	No
16	0

Note. For this question, if participants noted no, they would skip to question 5. Since all 16 participants answered yes, none of them left questions 2, 3 and 4 unanswered.

Table 5

Group 1 Question 2

Did you read the contents of the TSA signage post?	
Yes	No
10	6

Table 6

Group 1 Question 3

Did you have sufficient time to read the contents?	
Yes	No
12	4

Table 7

Group 1 Question 4

Was the TSA signage post helpful in recalling the items to remove before security screening?	
Yes	No
10	6

Table 8

Group 1 Question 5

In your opinion, how useful are TSA signposts at airports during security screening?		
N	Mean	Std. Deviation
16	3.38	1.20

Note. This question was measured on a scale (1-5). The lowest score gathered was 1, and the highest was 5.

Group 2 survey results. There was a total of five questions in this survey, four of which were yes or no questions, and one that was measured against a scale similar to that used in Group 1. The results are provided below.

Table 9

Group 2 Question 1

Did you notice the TSA information on the underside of the boarding pass?	
Yes	No
11	5

Note. For this question, if participants noted no, they would skip to question 5. Since all 5 participants answered no, there will be only 11 responses to questions 2, 3 and 4.

Table 10

Group 2 Question 2

Did you read the contents on the underside of the boarding pass?		
Yes	No	Invalid
6	5	5

Table 11

Group 2 Question 3

Did you have sufficient time to read the contents?		
Yes	No	Invalid
9	2	5

Table 12

Group 2 Question 4

Was the underside of the boarding pass helpful in recalling the items to remove before security screening?		
Yes	No	Invalid
9	2	5

Table 13

Group 2 Question 5

In your opinion, how useful can the boarding pass you received, be during security screening if used at airports?		
N	Mean	Std. Deviation
16	3.31	1.19

Note. This question was measured on a scale (1-5). The lowest score gathered was 1, and the highest was 5.

Group 3 survey results. There was a total of 11 questions in the survey, eight of which were yes or no questions, and three of them were measured against a scale used in Groups 1 and 2. The results are provided below.

Table 14

Group 3 Question 1

Did you notice the information on the TSA signage posts?	
Yes	No
15	1

Table 15

Group 3 Question 2

Did you notice the information on the underside of the boarding pass?	
Yes	No
14	2

Table 16

Group 3 Question 3

Did you read the contents of the TSA signage posts?	
Yes	No
10	6

Table 17

Group 3 Question 4

Did you read the contents on the underside of the boarding pass?	
Yes	No
11	5

Table 18

Group 3 Question 5

Did you have sufficient time to read the contents of the TSA signage posts?	
Yes	No
15	1

Table 19

Group 3 Question 6

Did you have sufficient time to read the contents on the underside of the boarding pass?	
Yes	No
16	0

Table 20

Group 3 Question 7

Was the TSA signage posts helpful in recalling the items to remove before security screening?	
Yes	No
11	5

Table 21

Group 3 Question 8

Was the underside of the boarding pass helpful in recalling the items to remove before security screening?	
Yes	No
13	3

Table 22

Group 3 Question 9

In your opinion, how useful are TSA signposts at airports during security screening?		
N	Mean	Std. Deviation
16	3.75	1.29

Note. This question was measured on a scale (1-5). The lowest score gathered was 1, and the highest was 5.

Table 23

Group 3 Question 10

In your opinion, how useful can the boarding pass you received, be during security screening if used at airports?		
N	Mean	Std. Deviation
16	4.06	1.18

Note. This question was measured on a scale (1-5). The lowest score gathered was 1, and the highest was 5.

Table 24

Group 3 Question 11

In your opinion, how useful would the use of both TSA signposts and the boarding pass you received, be during security screening if used at airports?		
N	Mean	Std. Deviation
16	4.44	0.81

Note. This question was measured on a scale (1-5). The lowest score gathered was 2, and the highest was 5.

Cross-comparing results. As certain questions were repeated, some results across the three surveys can be compared with each other to measure consistency. Group 1 question 5 and Group 3 question 9 both measured the perceived usefulness of the standing signposts. Group 2 question 5 can be compared against Group 3 question 10 which measured the perceived usefulness of the modified boarding pass. A combined average was calculated to determine the general consensus among the participants involved. The results are as follows.

Table 25

In Your Opinion, How Useful Are TSA Signposts at Airports During Security Screening?

	Valid	Mean	Std. Deviation
Group 1	16	3.39	1.20
Group 3	16	3.75	1.29
Combined	16	3.57	1.24

Table 26

In Your Opinion, How Useful Can The Boarding Pass You Received, Be During Security Screening If Used at Airports?

	Valid	Mean	Std. Deviation
Group 2	16	3.31	1.19
Group 3	16	4.06	1.18
Combined	16	3.69	1.23

Consistency. In Table 25, the results from Groups 1 (M = 3.39, SD = 1.20) and 3 (M = 3.75, SD = 1.29) are relatively consistent as the mean does not vary substantially. However, as seen in Table 26, the results from Groups 2 (M = 3.31, SD = 1.19) and 3 (M = 4.06, SD = 1.18) do vary quite a bit. The perceived usefulness of the standing signposts is considered consistent whereas the perceived usefulness of the modified boarding pass is relatively inconsistent. The combined averages for both the standing signposts only and the modified boarding pass only questions were calculated for easier analysis.

Study 2 (Airport Survey)

A total of 150 passengers responded to the airport survey conducted at DAB. There was a fairly equal representation of gender with 73 females and 77 males. The average age is 50, and the range was from 19 to 81. Additionally, the respondents answered all the questions. Cronbach's alpha for the survey questions was .52. There were a total of 160 responses to question 7 as some respondents noted down more than one answer. As the only non-scale question, the results of question 7 will be discussed first.

Question 7. Participants were asked to note the airline that they flew with the most often. With a 62.5% share, the majority indicated that they flew with Delta the most often. The next highest was American with 23.8%, followed by Southwest (7.5%), United (3.8%), and Others (Air France, Allegiant, Alaska, and JetBlue) with 2.5%. The breakdown is summarized as a pie chart and can be found in Figure 11.

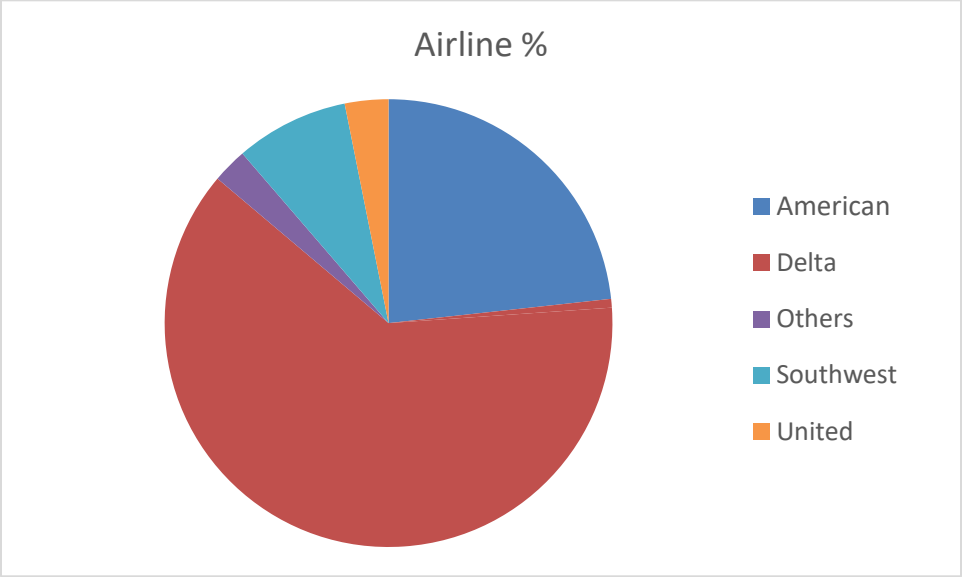

Figure 11. Airline flown the most often.

Descriptive Statistics

A scale ranging from 1 to 10 was used for the survey with 1 representing the lowest score (e.g., Never, Not At All) and 10 being the highest score possible (e.g., Always, Definitely). The mean score of each question was calculated to gain a preliminary understanding of the respondents' answers. Table 27 summarizes the results from the survey, while Table 28 contains a detailed breakdown (number and percentage of the sample) of each score, for each question. The researcher omitted Question 8 from this analysis because the question was requested by DAB for their own in-house assessment and does not pertain directly to the objectives of this paper.

Table 27

Descriptive Statistics for Airport Survey

	Valid	Missing	Mean	Median	Mode	SD	Min	Max
Qn 1	150	0	8.67	10	10	2.13	1	10
Qn 2	150	0	6.09	7	8	2.79	2	10
Qn 3	150	0	3.64	3	2	2.49	1	10
Qn 4	150	0	6.47	7	10	3.06	1	10
Qn 5	150	0	8.60	10	10	2.10	1	10
Qn 6	150	0	8.43	9	10	2.07	1	10

Table 28

Detailed Scoring for Airport Survey

Scores	1	2	3	4	5	6	7	8	9	10	*n*
Qn 1	4	3	0	2	3	6	11	15	26	80	150
	2.7%	2%	0%	1.3%	2%	4%	7.3%	10%	17.3%	53.3%	100%
Qn 2	12	9	12	12	18	8	19	29	13	18	150
	8%	6%	8%	8%	12%	5.3%	12.7%	19.3%	8.7%	12%	100%
Qn 3	30	40	21	13	9	7	13	12	3	2	150
	20%	26.7%	14%	8.7%	6%	4.7%	8.7%	8%	2%	1.3%	100%
Qn 4	16	5	11	8	17	12	16	14	12	39	150
	10.7%	3.3%	7.3%	5.3%	11.3%	8%	10.7%	9.3%	8%	26%	100%
Qn 5	2	4	2	1	4	6	11	20	23	77	150
	1.3%	2.7%	1.3%	0.7%	2.7%	4%	7.3%	13.3%	15.3%	51.3%	100%
Qn 6	1	2	3	2	8	12	13	10	31	68	150
	0.7%	1.3%	2%	1.3%	5.3%	8%	8.7%	6.7%	20.7%	45.3%	100%

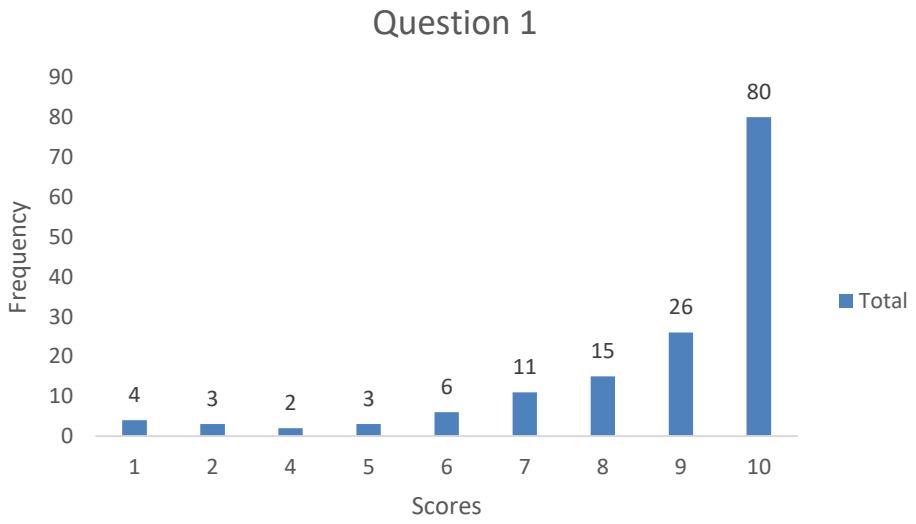

Figure 12. Are you aware of all the personal possessions that are needed to be removed in preparation for TSA screening?

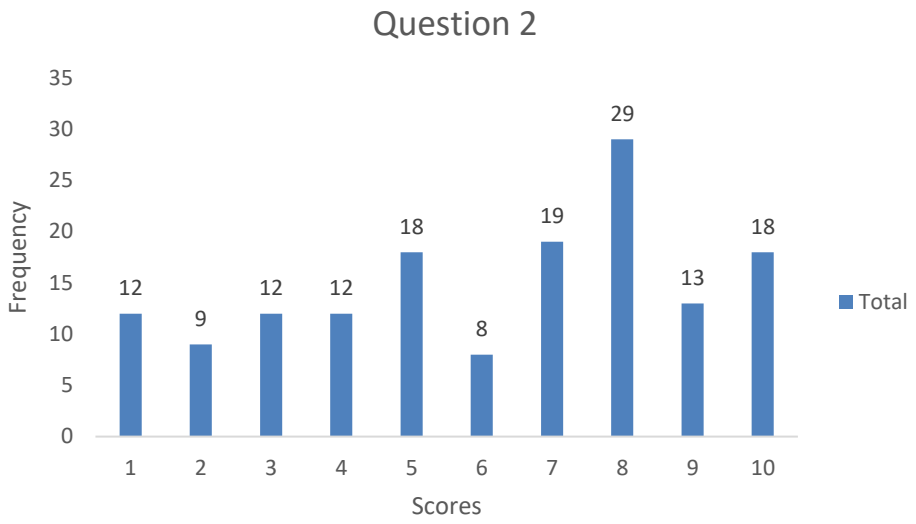

Figure 13. At times, are you frustrated by other passengers who did not know of all the items to remove for screening?

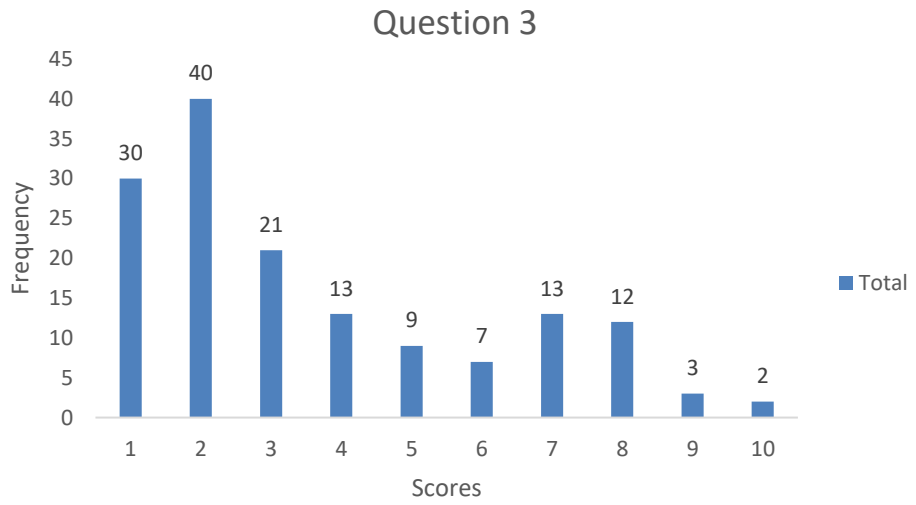

Figure 14. Have you forgotten to remove an item during screening that you know you should have removed?

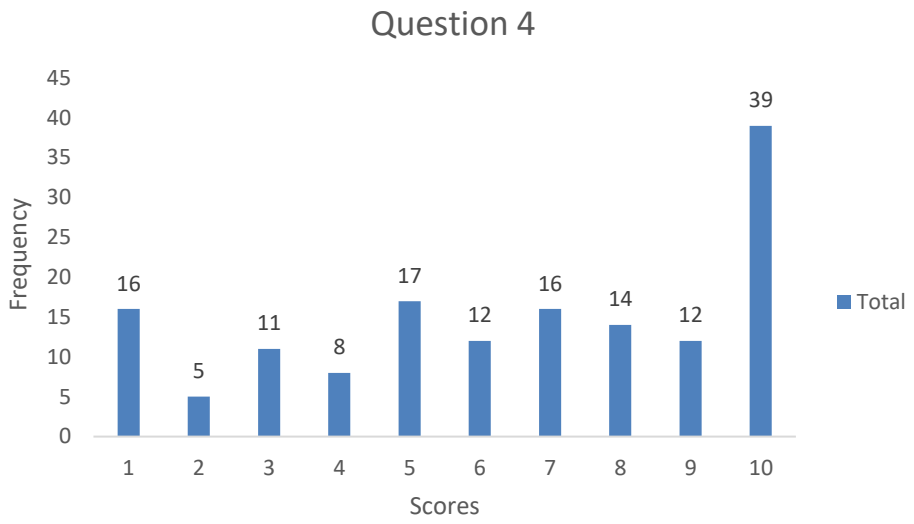

Figure 15. Do you believe security screening should be made more convenient for passengers?

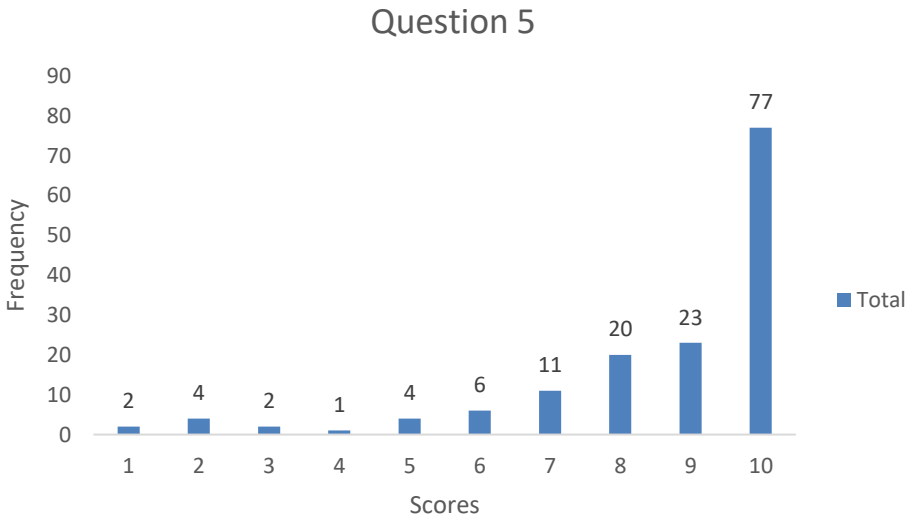

Figure 16. TSA screening protocol can differ between airports. This sample boarding pass can help notify you of these changes. Would this information on the sample boarding pass be useful to you in preparing for screening?

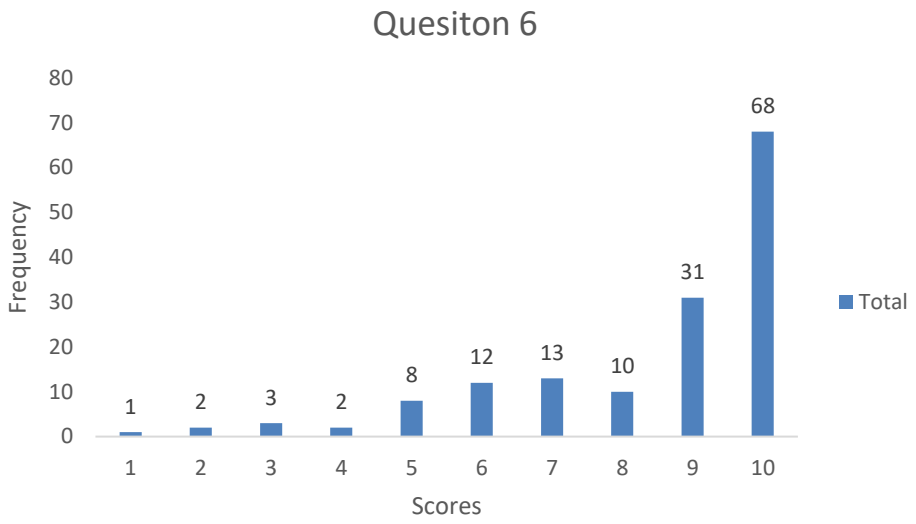

Figure 17. Do you think the sample boarding pass can be more useful for passengers compared to current TSA methods (such as signposts and announcements).

Chapter V

Discussion, Conclusions, and Recommendations

Discussions for Study 1

Recall evaluation. The purpose of Study 1 was to determine if there were differences in the ability to correctly recall the 10 interference items that were displayed on the three types of stimuli used.

1. Regular, non-modified boarding pass and two standing signposts only (Group 1)
2. Modified boarding pass only (Group 2)
3. Modified boarding pass and two standing signposts (Group 3)

Comparing TSA signposts only and modified boarding pass only. The results showed that there were no significant differences in the number of interference items recalled between these groups. Interestingly, the modified boarding pass did not help participants better remember the 10 items when presented alone. Participants in Group 1 did nearly as well as Group 2 despite having less exposure time to their stimuli (standing signposts). There could be four reasons for this result. First, five participants in Group 2 did not realize that there were screening instructions on the back of the modified boarding pass despite being informed in the pre-study briefing. A plausible explanation could be that participants missed out on this particular instruction during the briefing. Another five participants did not read the contents on the underside of the boarding pass although they knew that it contained screening information.

In comparison, all 16 participants in Group 1 noticed the standing signposts, and only six did not read it. Overall, 10 out of 16 participants in Group 2 did not read the

underside of their boarding passes. Significantly, 25% more participants in Group 2 underwent the recall evaluation with no knowledge of the 10 interference items and would have likely guessed their answers, perhaps explaining why they did not do much better than Group 1.

Second, in Group 2, several participants were engaged in conversation throughout the course of the study, particularly when standing in line outside the test room. These individuals were probably distracted and less likely to focus on the modified boarding pass, or the standing signposts while in line. This observation may explain why many participants in Group 2 did not read or refer to their modified boarding pass during the study.

Third, there was a difference in exposure time to the respective stimuli. Participants in Group 2 were given the modified boarding pass in the conference room several minutes before lining up outside the test room. Although the participants had more time with the modified boarding pass, they did not necessarily refer to it again outside of the conference room. A longer time would have elapsed between their exposure to the modified boarding pass and the recall evaluation, where they may have then forgotten some of the items. Participants in Group 1 had a shorter time (roughly two minutes) between their exposure to the standing signposts and their recall evaluation. Their memory of the interference items may have been more recent and fresher, perhaps slightly offsetting the limited time they had to review the standing signposts outside the test room.

Finally, the design of the study may have deflated the potential effects of the modified boarding pass in Group 2. Unlike being in an airport environment where

passengers refer to their boarding passes multiple times for information such as gate numbers, participants in this study did not need to use or refer to their modified boarding passes after receiving it in the conference room. Instead, they were led directly to the test room. If participants were afforded more time, more of them may have noticed the information on the back of the modified boarding pass and the results may have been different.

Comparing standing signposts only with standing signposts and modified boarding pass. There was a significant difference between the combination of the standing signposts and the modified boarding pass group and the standing signposts only group.

Comparing modified boarding pass only with standing signposts and modified boarding pass. There was a significant difference between the combination of the standing signposts and the modified boarding pass group and the modified boarding pass only group.

The natural conclusion points to an increase in participant recall when the two types of stimuli were used together. Six participants in Group 1 and six in Group 3 reported that they did not read the standing signposts, whereas 10 participants in Group 2 and five in Group 3 did not read the underside of the modified boarding pass. Group 3 did significantly better than Groups 1 and 2 despite an almost equal number of participants not reviewing their respective stimuli. In Group 3, although participants may not have read the standing signposts, they may have read the modified boarding pass instead and vice versa. This observation would align well with the theory of selective attention where individuals tend to only focus on one particular source of attention. With

more stimuli present, it would have also been less likely that the participants did not see the 10 interference items at all. Participants in Groups 1 and 2 may have not seen any of the 10 items as they had overlooked their respective stimuli, perhaps explaining their relatively low scores on the recall evaluation.

Post-evaluation survey. The purpose of the post-evaluation survey was to ascertain participant opinion on the respective stimuli that they were provided. The survey asked participants how useful they would find their respective stimuli if it were used during security screening at airports. As mentioned in the results, certain questions were repeated and were subsequently compared against each other to measure consistency. The combined averages for the standing signposts only and modified boarding pass only, were calculated. The results found that the standing signposts scored the lowest on perceived usefulness during security screening.

Although participants found the modified boarding pass to be slightly more useful than the standing signposts, the difference was marginal at best. The difference in mean score was only 0.12. It is rational to conclude that when used alone, participants generally feel that the modified boarding pass and the standing signposts were somewhat, equally useful. There was evidence of inconsistency between the groups that measured the perceived usefulness of the modified boarding pass. Out of the three types of stimuli, the combination of the modified boarding pass and the TSA signposts was perceived to be most useful, if implemented at airports.

Discussions for Study 2

The purpose of Study 2 was to assess passenger receptiveness toward the idea of using the modified boarding pass as an alternative, supplementary form of security signage to help them better prepare for security screening. An overall positive response would indicate if the modified boarding pass was perceived to be useful, and if passengers would use it if it became an option to them in the future. Answers to the other questions would also provide additional insight into passenger sentiment toward the current security screening experience and perhaps, reveal other passenger-related concerns.

Question 1 (*M* = 8.67, *SD* = 2.13). Approximately 80.6% of the respondents scored 8 and above on the scale, suggesting that a large majority were confidently aware of the personal possessions that had to be removed prior to screening (hereafter referred to as removal of interference items).

Sampling limitation. The result points to a sampling limitation that may be a direct result of the researcher employing convenience sampling. It is not possible to be certain of the diversity and demographic make-up of the passengers surveyed. With an overwhelming majority of passengers scoring highly for Question 1, it is assumed that the majority of the passengers could have been either American travelers or frequent fliers, owing to their strong familiarity with screening procedures.

With the large majority scoring highly for Question 1, it is also possible that an element of social desirability bias may have been present. Social desirability bias is a form of socially motivated misreporting where individuals tend to inflate their responses to impress and try to cultivate a positive self-image to others (Krumpal, 2013). It would

have been possible that the respondents may have over-estimated their knowledge of screening procedures to avoid humiliation or embarrassment in front of the researcher, given that there was also no way to validate the accuracy of their response.

Question 2 (*M* = 6.09, *SD* = 2.79). Over half of the respondents (58%) indicated that they were occasionally frustrated by other passengers who were unfamiliar with interference items that needed to be removed during security screening. The rest (42%) were either more tolerant or were not bothered by other passengers and their unfamiliarity with screening procedures. The group that was more tolerant and not bothered by other passengers could have been affected by social desirability as well, one involving ethical behavior. This aspect of social desirability bias involves the perception of ethical behavior where an individual may inflate or deflate a response to a desirable or undesirable action or feeling (Chung & Monroe, 2003).

The respondents may have deflated their response to be perceived as less judgmental by downplaying their level of frustration with others who take a longer time to undergo screening. Respondents who scored low tended to hesitate (perhaps re-evaluating their initially harsh response), while respondents that scored high were more likely to try and verbally justify giving higher scores (perhaps to rationalize for their more judgmental opinion). The researcher finds that both actions corresponded with the explanation of social desirability bias by Chung and Monroe (2003) where it was evident that individuals were inclined to appear more socially and ethically acceptable in front of others.

Question 3 (*M* = 3.64, *SD* = 2.49). Approximately 75% of respondents rarely forgot to remove an item during security screening that they knew they should have

removed (hereafter referred to as failure to remove an interference item). The remaining respondents occasionally failed to remove an interference item(s) during security screening. The results from Question 3 coincide and support Question 1 where the majority of travelers claimed to be confidently aware of interference items that have to be removed during security screening. A large majority of travelers indicated in Question 3 that they rarely failed to remove an interference item during security screening.

Although the results of Questions 1 and 3 are promising —passengers more aware of interference items are less likely to fail to remove them during screening— it would not be appropriate to assert that the greater population is indeed proficient and fully aware of screening procedures. The reason is partly because the researcher cannot be certain that non-American travelers and non-frequent fliers were sufficiently represented in the sample. *User failure* should not be discounted without obtaining a more representative sample, particularly one that confidently exhibits equal representation of non-Americans travelers and non-frequent fliers.

Question 4 (*M* = 6.47, *SD* = 3.06). Slightly more than a third (35.3%) of respondents were strong believers that security screening should be made more convenient. About a fifth (21.3%) of respondents were relatively satisfied with the current state of security screening, and do not believe that it should be made more convenient. The remaining respondents (43.4%) had a more neutral stance or were undecided. Many respondents attributed their neutrality to their lack of traveling through major airports. Most of them indicated that because they frequently traveled through DAB —a small regional airport that almost never encounters long security lines or congestion— they could not meaningfully answer the question based on experience.

Many passengers were conflicted when answering this question as many felt that more convenient security screening would directly correspond to more lenient security standards. At the same time, however, many of them were concerned with the prospect of security lines getting increasingly longer, and air travel becoming more inconvenient. As a result, a large number of passengers took up a more neutral position on the question.

Question 5 (*M* = 8.60, *SD* = 2.10). About 79% of respondents strongly felt that the modified boarding pass would enable them to better prepare for security screening, considering that airports often have differing screening procedures and guidelines. The researcher also recalled that numerous respondents were confused by different screening standards between domestic airports.

An example frequently brought up, was the removal of shoes for security screening in one local airport, but not having to do so in another. Respondents disclosed that they took off their shoes anyway, regardless of whether they were not required to. Despite requiring more time to remove their shoes and having to put them back on again, respondents felt that doing so was easier than figuring out the airport's stance on shoe removal, let alone being called back by TSA officers for not removing their shoes. When passengers feel and act this way, airports are unlikely to observe the time-saving benefits of allowing passengers to keep their shoes on to expedite screening.

Question 6 (*M* = 8.43, *SD* = 2.07). Approximately 72% of respondents strongly felt the modified boarding pass would be more useful at providing screening information than current TSA methods (e.g., signposts and security announcements). Respondents offered the researcher additional insight into several shortcomings with security signposts and announcements. Rather unsurprisingly, numerous respondents mentioned that they

struggled to read the signposts without obstructing the movement of other passengers in security lines, often choosing to sacrifice reading the signposts than to interfere with the movement of people, particularly during peak periods. Others admitted to not paying attention to security announcements, partly because they were engaged in other activities (e.g., listening to music, using their mobile phones, engaged in conversation) or that they simply could not hear the announcements clearly due to the background noise from the vast number of people in line.

Conclusions for Study 1

Underwhelming effect of the modified boarding pass. The results of the recall evaluation suggested that the modified boarding pass was not significantly better than the standing signposts at stimulating recall. However, the utilization rate of the modified boarding pass was rather underwhelming. More than half of the participants did not use the modified boarding pass to answer the recall evaluation. It would not be appropriate to conclude that the modified boarding pass is not better than standing signposts in stimulating recall.

Sampling limitation. Participants particularly in Groups 2, were engaged in conversation throughout the study. This observation was interpreted as the reason for more participants not noticing or reviewing their stimuli. Naturally, these individuals were less likely to recall as many of the 10 items. This outcome may be attributed to the use of convenience sampling, where participants were found to have been classmates or friends, and offered to participate together on the same day. This factor could present itself as a confounding variable to the saliency of both the modified boarding pass, the two standing signposts, as well as the number of items recalled.

More stimuli, better recall. When both the standing signposts and the modified

boarding pass were used, participants were significantly better at recalling the 10 items. Using the standing signposts and the modified boarding pass together, could potentially help passengers better remember pertinent items that are to be removed prior to security screening. The result could also mean that fewer passengers are flagged for leaving interference items on their person, or in their carry-on bags during screening. Fewer passengers would have to backtrack or undergo secondary bag inspections.

Conclusions for Study 2

Higher awareness, fewer mistakes. The results from Questions 1 and 3 show signs of promise where passengers that are more aware of interference items are less likely to make user-failure related mistakes such as forgetting, or failing to remove interference items from their person or carry-on. The result also implies that a better-informed passenger is more prepared for security screening and is less likely to make mistakes, or create time-consuming stoppages at screening checkpoints.

Not to overlook user failure yet. Owing to the high levels of awareness (of interference items) and few mistakes made during screening (forgetting interference items), the researcher concludes that the majority of respondents are likely to be American travelers and/or frequent fliers. Although the results suggest that *user failure* is not as prevalent, it cannot be certain that *user failure* does not exist. A subsequent study could include provisions to ensure that the sample is not only more diverse but provides a greater representation of non-American and non-frequent travelers.

Shortcomings. Other important discoveries from the survey include further evidence that passengers struggle with screening procedures that differ between domestic airports. When screening procedures differ, the saliency of security signage is important in ensuring that passengers are aware of what is expected of them. Otherwise,

user failure will be increasingly common. The passenger sentiment gathered exposes several shortcomings of current security signage, as put forth by the researcher. Some of the assumptions and observations made in the study prior to the survey were validated by passenger sentiment and feedback.

Passenger sentiment. The data revealed that roughly 3/4 of all respondents had a positive impression and attitude toward the modified boarding pass. The majority understood its purpose and the value it could add to their own future security screening experience. Passengers were also impressed by the simplicity of the sample modified boarding pass and their feedback gave the researcher ample confidence that they would benefit from it.

Recommendations for Study 1

Instruction to participants. A common theme among the three experimental groups was that roughly a third of the participants did not review their respective stimuli, regardless of which group they were in. Results of the recall evaluation would have possibly been deflated. Hence, a future similar study could be conducted where instructions to participants are clearer and unambiguous. Such a study could yield greater differences between the standing signposts only group, and the modified boarding pass only group.

Random sampling. The recall evaluation results from Group 2 may not accurately represent the saliency of the modified boarding pass because a considerable number of participants were busily engaged in conversation instead of paying attention to their surroundings and their stimuli. The number of items recalled were most likely, guesses at best. It would be challenging to ascertain the true effects of the modified boarding pass without a subsequent study comprising of a more diverse and randomized

sample. A greater attempt at randomization where participants do not know each other prior to the study, may limit participant interaction, increase attention to the stimuli, and provide more definitive results.

More exposure time to stimuli. A drawback with the design of the study was an inadequate amount of exposure time to either of the three stimuli. Many participants in each of the three groups did not review the contents of their respective stimuli. A subsequent study could provide participants more time with their stimuli so that they may properly review it, or at the very least, notice it.

Recommendations for Study 2

Revised sample. The survey was limited in its analysis because the researcher assumes that the large majority of respondents were American travelers and/or frequent fliers. The implication is the inability to assess the extent of *user failure* where the main passenger profile is primarily international, non-American travelers or non-frequent fliers. It is recommended that a subsequent survey specifically targeting international, non-American travelers or non-frequent fliers is conducted to provide essential data about their level of preparedness for security screening and their frequency of making user-failure related mistakes. If the findings indicate low levels of preparedness for security screening, and high frequencies of user-failure related mistakes, there would be compelling evidence that *user failure* exists.

Security signage. Passenger feedback from the survey was particularly insightful and constructive to the researcher. Their feedback validated the saliency shortcomings of TSA signposts, mentioned in the paper. It is recommended that there is prompt revision and re-examination into the saliency of current security signage. Other alternative stimulus such as the modified boarding pass, or other creative solutions could be

considered, with the main objective of better-informing, and better-preparing passengers for security screening.

In an effort to maximize the effectiveness of the modified boarding pass, an improvement that can be considered would be to include a Uniform Resource Locator (URL) or QR code (sort of matrix barcode), that allows passengers to be effortlessly directed to a TSA website, or one with useful security screening information, using their smartphones. This option would offer passengers access to an even wider range of security-related information over the internet.

Closing Statement

The present study found that due to some experimental design shortcomings, the true effects of the modified boarding pass may not have been entirely captured in the recall evaluation. A subsequent, improved study could address this shortcoming and gather more definitive results. However, the positive results gathered when the modified boarding pass was supplemented with security signposts is encouraging. The majority of the flying public were receptive toward potentially using the modified boarding pass to prepare for security screening. These findings strongly suggest that the concept of the modified boarding pass may add value as an alternative or supplementary form of security signage for passenger screening and hence, consideration could be given toward a trial or preliminary testing of the idea at an airport. Finally, it is hoped that this paper serves as a pioneering groundwork for greater recognition and examination into *user failure*.

References

Alards-Tomalin, D., Ansons, T. L., Reich, T. C., Sakamoto, Y., Davie, R., Leboe-McGowan, J. P., & Leboe-McGowan, L. C. (2014). Airport security measures and their influence on enplanement intentions: Responses from leisure travelers attending a Canadian University. *Journal of Air Transport Management*, 60-68.

Beanland, V., & Pammer, K. (2012). Minds on the blink: The relationship between inattentional blindness and attentional blink. *Attention, Perception, & Psychophysics*, *74*(2), 322-330. doi:10.3758/s13414-011-0241-4

Biggs, A. T., Cain, M. S., Clark, K., Darling, E. F., & Mitroff, S. R. (2013). Assessing visual search performance differences between transportation security administration officers and nonprofessional visual searchers. *Visual Cognition, 21*, 330-352. doi:10.1080/13506285.2013.790329

Biggs, A. T., & Mitroff, S. R. (2015). Improving the efficacy of security screening tasks: A review of visual search challenges and ways to mitigate their adverse effects. *Applied Cognitive Psychology*, *29*, 142-148. doi:10.1002/acp.3083

Biggs, A. T., Adamo, S. H., Dowd, E. W., & Mitroff, S. R. (2015). Examining perceptual and conceptual set biases in multiple-target visual search. *Attention, Perception, & Psychophysics, 77*, 844-855. doi:10.3758/s13414-014-0822-0

Blalock, G., Kadiyali, V., & Simon, D. H. (2009). Driving fatalities after 9/11: A hidden cost of terrorism. *Applied Economics*, *41*, 1717-1729. doi: 10.1080/00036840601069757

Brookshire, J., Scharff, L. F., & Moses, L. E. (2002). The influence of illustrations on children's book preferences and comprehension. *Reading Psychology*, *23*, 323-339. doi:10.1080/713775287

Bruno, T., & Abrahão, J. (2012). False alarms and incorrect rejections in an information security center: Correlation with the frequency of incidents. *Work (Reading, Mass.), 41 Suppl 1*, 2902.

Cain, M. S., Biggs, A. T., Darling, E. F., & Mitroff, S. R. (2014). A little bit of history repeating: Splitting up multiple-target visual searches decreases second target miss errors. *Journal of Experimental Psychology. Applied, 20*(2), 112-125. doi:10.1037/xap0000014

Camos, V., Johnson, M., Loaiza, V., Portrat, S., Souza, A., & Vergauwe, E. (2018). What is attentional refreshing in working memory?: What is attentional refreshing? *Annals of the New York Academy of Sciences*, *1424*(1), 19-32. doi:10.1111/nyas.13616

Campbell, C. (2017). *New TSA rules on carry-on luggage coming to BWI Marshall Airport*. Baltimore: Tribune Interactive, LLC. Retrieved from https://search-proquest-com.ezproxy.liproxy.db.erau.edu/docview/1952053100?pq-origsite=summon

Chavaillaz, A., Schwaninger, A., Michel, S., & Sauer, J. (2019). Work design for airport security officers: Effects of rest break schedules and adaptable automation. *Applied Ergonomics, 79*, 66-75. doi:10.1016/j.apergo.2019.04.004

Chelazzi, L., Perlato, A., Santandrea, E., & Della Libera, C. (2013). Rewards teach visual selective attention. *Vision Research, 85,* 58-72. doi:10.1016/j.visres.2012.12.005

Chittaro, L. (2017). A comparative study of aviation safety briefing media: Card, video, and video with interactive controls. *Transportation Research Part C, 85,* 415-428. doi:10.1016/j.trc.2017.10.007

Chung, J., & Monroe, G. S. (2003). Exploring social desirability bias. *Journal of Business Ethics, 44*(4), 291-302. doi:10.1023/A:1023648703356

Corbett, C. L., McLean, G. A., & Cosper, D. K. (2008). *Federal Aviation Administration Oklahoma City OK Civil Aerospace Medical Inst. Effective presentation media for passenger safety I: Comprehension of briefing card pictorials and pictograms.* Retrieved from https://www.faa.gov/data_research/research/med_human-facs/oamtechreports/2000s/media/200820.pdf

Crutcher, R. J., & Beer, J. M. (2011). An auditory analog of the picture superiority effect. *Memory & Cognition, 39*(1), 63-74. doi:10.3758/s13421-010-0015-6

Curran, T., & Doyle, J. (2011). Picture superiority doubly dissociates the ERP correlates of recollection and familiarity. *Journal of Cognitive Neuroscience, 23*, 1247-1262. doi:10.1162/jocn.2010.21464

de Barros, A. G., & Tomber, D. D. (2007). Quantitative analysis of passenger and baggage security screening at airports. *Journal of Advanced Transportation, 41*, 171-193. doi: 10.1002/atr.5670410204

Deno, F., Diaz, C., Lliguicota, C., Norman, D., & González, R. (2014). TSA Screening Procedures: A Threat to Privacy. *International Journal of Arts & Sciences, 7*(3), 37. Retrieved from https://slidex.tips/download/tsa-screening-procedures-a-threat-to-privacy

Department of Homeland Security. (2019). Apex screening at speed. Retrieved from https://www.dhs.gov/science-and-technology/apex-screening-speed

Department of Transportation. (2002). *Challenges facing TSA in implementing the Aviation and Transportation Security Act.* (CC-2002-088). Retrieved from https://www.oig.dot.gov/sites/default/files/cc2002088.pdf

Downing, P. E. (2000). Interactions between visual working memory and selective attention. *Psychological Science, 11*(6), 467-473. doi:10.1111/1467-9280.00290

Drew, T., Võ, M. L, & Wolfe, J. M. (2013). The invisible gorilla strikes again: Sustained inattentional blindness in expert observers. *Psychological Science, 24*(9), 1848-1853. doi:10.1177/0956797613479386

Ehrett, J. (2011). Airport Security Airport Security. *MIDSEASON*, 11-16. Retrieved from https://www.trainingminds.org/wp-content/uploads/2012/08/2010-Gold-Book-Midseason.pdf#page=11

Eldridge, M. (2018). Security is always a trade-off. Retrieved from https://markeldo.com/Security-is-always-a-trade-off/

Frederickson, H. G., & LaPorte, T. R. (2002). Airport security, high reliability, and the problem of rationality. Public Administration Review, 62(s1), 33-43. doi:10.1111/1540-6210.62.s1.7

Government Accountability Office. (2017). *Aviation security: Actions needed to systematically evaluate cost and effectiveness across security countermeasures.* (GAO-17-794). Retrieved from https://www.gao.gov/assets/690/687059.pdf

Ghobrial, A., & Irvin, W. A. (2004). Combating air terrorism: Some implications to the aviation industry. *Journal of Air Transportation, 9*(3). Retrieved from: http://webhome.auburn.edu/~johnsrd/4160/Readings/Combating%20Air%20Terrorism.pdf

Giesbrecht, B., Sy, J., Bundesen, C., & Kyllingsbaek, S. (2014). A new perspective on the perceptual selectivity of attention under load: Selective attention under load. *Annals of the New York Academy of Sciences*, *1316*(1), 71-86. doi:10.1111/nyas.12404

Graves, I., Butavicius, M., MacLeod, V., Heyer, R., Parsons, K., Kuester, N., ... & Johnson, R. (2011). The role of the human operator in image-based airport security technologies. *In Innovations in defense support systems-2* (pp. 147-181). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-17764-4_5

Green, D. M., & Swets, J. A. (1966). *Signal detection theory and psychophysics.* New York, NY: Wiley. Retrieved from http://voyager.db.erau.edu:7008/vwebv/holdingsInfo?searchId=1&recCount=50&recPointer=488&bibId=39089

Grier, R. A., Warm, J. S., Dember, W. N., Matthews, G., Galinsky, T. L., Szalma, J. L., & Parasuraman, R. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. Human Factors: *The Journal of the Human Factors and Ergonomics Society, 45*, 349-359. doi:10.1518/hfes.45.3.349.27253

Halsey, A. (2016). TSA scrambling resources to deal with long line of travelers. *Washington Post.* Retrieved from https://www.washingtonpost.com/local/traffi-candcommuting/tsa-scrambling-resources-to-deal-with-long-lines-at-air-ports/2016/05/29/69a68924-2409-11e6-aa84-42391ba52c91_story.html

Harawa, D. S. (2013). The Post-TSA Airport: A Constitution Free Zone. *Pepperdine Law Review*, *41*, 1. Retrieved from https://digitalcommons.pepperdine.edu/cgi/view-content.cgi?article=2327&context=plr

Harris, D. H. (2002). How to really improve airport security. Ergonomics in Design*: The Quarterly of Human Factors Applications, 10*, 17-22. doi:10.1177/106480460201000104

Hattenschwiler, N., Michel, S., Kuhn, M., Ritzmann, S., & Schwaninger, A. (2015). *A first exploratory study on the relevance of everyday object knowledge and training for increasing efficiency in airport security X-ray screening.* Paper presented at the 2015 International Carnahan Conference on Security Technology (ICCST) (pp. 25-30). Taipei, Taiwan. doi:10.1109/CCST.2015.7389652

Hofer, F., & Schwaninger, A. (2005). Using threat image projection data for assessing individual screener performance. *WIT Transactions on the Built Environment*, *82*, 417-426. doi: 10.2495/SAFE050411

Hoo, Z. H., Candlish, J., & Teare, D. (2017). What is a ROC curve? *Emergency Medicine Journal, 34*, 357-359. doi:10.1136/emermed-2017-206735

Houts, P. S., Doak, C. C., Doak, L. G., & Loscalzo, M. J. (2006). The role of pictures in improving health communication: A review of research on attention, comprehension, recall, and adherence. *Patient Education and Counseling, 61*, 173-190. doi:10.1016/j.pec.2005.05.004

Huang, T., Yeh, S., Yang, Y., Liao, H., Tsai, Y., Chang, P., & Chen, H. H. (2015). Method and experiments of subliminal cueing for real-world images. *Multimedia Tools and Applications, 74*(22), 10111-10135. doi:10.1007/s11042-015-2804-1

Hubal, R., Mitroff, S. R., Cain, M. S., Scott, B., & DeWitt, R. (2010). *Simulating a vigilance task: Extensible technology for baggage security assessment and training*. Paper presented at the 2010 International Conference on Technologies for Homeland Security (HST) (pp. 543-548). Waltham, MA. IEEE. doi:10.1109/THS.2010.5654982

Ito, H., & Lee, D. (2005). Assessing the impact of the September 11 terrorist attacks on US airline demand. *Journal of Economics and Business*, *57*, 75-95. doi:10.1016/j.jeconbus.2004.06.003

Jansen, B. (2016, May 11). Congress approves TSA request for screeners to meet summer crush. *USA Today.* Retrieved from https://www.usatoday.com/story/news/2016/05/11/white-house-urges-congress-allow-tsa-hiring-ot/84238540/

Jet, J. (2018, March 30). How to skip airport security lines. *Forbes.* Retrieved from https://www.forbes.com/sites/johnnyjet/2018/03/30/how-to-skip-airport-security-lines/#47b485e15d83

Junge, M. R. J., & Dettori, J. R. (2018). ROC solid: Receiver operator characteristic (ROC) curves as a foundation for better diagnostic tests. *Global Spine Journal, 8*(4), 424-429. doi:10.1177/2192568218778294

Katz, M. G., Kripalani, S., & Weiss, B. D. (2006). Use of pictorial aids in medication instructions: A review of the literature. *American Journal of Health-System Pharmacy, 63,* 2391-2397. doi:10.2146/ajhp060162

Kirschenbaum, A. A. (2013). The cost of airport security: The passenger dilemma. *Journal of Air Transport Management, 30,* 39-45. doi:10.1016/j.jairtraman.2013.05.002

Knol, A., Sharpanskykh, A., & Janssen, S. (2019). Analyzing airport security checkpoint performance using cognitive agent models. *Journal of Air Transport Management, 75,* 39-46. doi:10.1016/j.jairtraman.2018.11.003

Kraemer, S., Carayon, P., & Sanquist, T. F. (2009). Human and organizational factors in security screening and inspection systems: *Conceptual framework and key research needs. Cognition, Technology & Work, 11,* 29-41. doi:10.1007/s10111-008-0121-4

Kripalani, S., Robertson, R., Love-Ghaffari, M. H., Henderson, L. E., Praska, J., Strawder, A., & Jacobson, T. A. (2007). Development of an illustrated medication schedule as a low-literacy patient education tool. *Patient education and counselling, 66,* 368-377. doi:10.1016/j.pec.2007.01.020

Krumpal, I. (2013). Determinants of social desirability bias in sensitive surveys: A literature review. *Quality & Quantity, 47*(4), 2025-2047. doi:10.1007/s11135-011-9640-9

Kumar, R., & Indrayan, A. (2011). Receiver operating characteristic (ROC) curve for medical researchers. *Indian Pediatrics, 48,* 277-287. doi:10.1007/s13312-011-0055-4

Kunar, M. A., Rich, A. N., & Wolfe, J. M. (2010). Spatial and temporal separation fails to counteract the effects of low prevalence in visual search. *Visual Cognition, 18,* 881-897. doi:10.1080/13506280903361988

Lancaster, G., Alkoby, K., Campen, J., Carter, R., Davidson, M. J., Ethridge, D., & Loeding, B. (2003). *Voice activated display of American Sign Language for airport security.* Technology and Persons with Disabilities Conference 2003. California State University at Northridge, Los Angeles, CA. Retrieved from https://scholarworks.bgsu.edu/cgi/viewcontent.cgi?article=1009&context=vcte_pub

Lastoe, S. (2019). TSA to launch 3-D tech that will make going through security a walk in the park. *CNN Travel*. Retrieved from https://www.cnn.com/travel/article/new-tsa-screening-technology/index.html

Lazar Babu, V. L., Batta, R., & Lin, L. (2006). Passenger grouping under constant threat probability in an airport security system. *European Journal of Operational Research, 168,* 633-644. doi:10.1016/j.ejor.2004.06.007

Lee, C., Wang, S. W., Hsu, M. K., & Jan, S. (2018). Air passenger's perception toward pre-flight safety briefing videos: Does it matter? *Journal of Air Transport Management, 72*, 20-31. doi:10.1016/j.jairtraman.2018.07.004

Leib, S., Dillman, B., Petrin, D., & Young, J. P. (2012). A comparison of the effect of variations to U.S. airport terminal signage on the successful wayfinding of Chinese and American cultural groups. *Journal of Aviation Technology and Engineering, 1*, 79-89. doi: 10.5703/1288284314661

Lowe, K. A. (2016). Safety in the Sky: Will reforming and restructuring the TSA improve our security or merrily infringe on our rights? *Journal of Air Law and Commerce,* 81, 291.Retrieved from https://scholar.smu.edu/cgi/viewcontent.cgi?referer=https://scholar.google.com/&httpsredir=1&article=1002&context=jalc

Lwin, M. O., Morrin, M., & Krishna, A. (2010). Exploring the superadditive effects of scent and pictures on verbal recall: An extension of dual coding theory. *Journal of Consumer Psychology, 20,* 317-326. doi:10.1016/j.jcps.2010.04.001

Lynn, S. K., & Barrett, L. F. (2014). "Utilizing" signal detection theory. *Psychological Science, 25*, 1663-1673. doi:10.1177/0956797614541991

Marin, C. V., Drury, C. G., Batta, R., & Lin, L. (2007, October). Human factors contributes to queuing theory: Parkinson's law and security screening. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 51, No. 10, pp. 602-606). Sage CA: Los Angeles, CA: SAGE Publications.

Marsh, R. & Patterson, T. (2016). U.S. air traveler patience with TSA at 'breaking point'. *Business Traveler.* Retrieved from https://www.cnn.com/travel/article/airport-frustration-tsa-passenger-screening-lines/index.html

Martin, H. (2011). 10 years after 9/11, the airline industry is looking up. *Los Angeles Times.* Retrieved from https://www.latimes.com/nation/la-xpm-2011-sep-10-la-fi-911-cover-sept11-airlines-20110911-story.html

Martínez-Camblor, P., Bayón, G. F., & Pérez-Fernández, S. (2016). Cumulative/dynamic ROC curve estimation. *Journal of Statistical Computation and Simulation, 86,* 3582-3594. doi:10.1080/00949655.2016.1175442

McGuinness, B. (2004). *Quantitative analysis of situational awareness (QUASA): Applying signal detection theory to true/false probes and self-ratings*. BAE Systems. Bristol, United Kingdom. Advanced Technology Centre. Retrieved from https://apps.dtic.mil/dtic/tr/fulltext/u2/a465817.pdf

Mendes, M., Schwaninger, A., Strebel, N., & Michel, S. (2012). *Why laptops should be screened separately when conventional x-ray screening is used.* Paper presented at the proceedings of the 46th International Carnahan Conference on Security Technology (ICCST), Boston MA. IEEE. doi:10.1109/CCST.2012.6393571

Menneer, T., Barrett, D. J. K., Phillips, L., Donnelly, N., & Cave, K. R. (2007). Costs in searching for two targets: Dividing search across target types could improve airport security screening. *Applied Cognitive Psychology, 21,* 915-932. doi:10.1002/acp.1305

Michel, S., Hattenschwiler, N., Kuhn, M., Strebel, N., & Schwaninger, A. (2014). *A multi-method approach towards identifying situational factors and their relevance for X-ray screening.* Paper presented at the 2014 International Carnahan Conference on Security Technology (ICCST) (pp. 1-6). Rome, Italy. IEEE. doi:10.1109/CCST.2014.6987001

Molesworth, B. R. C., Seneviratne, D., & Wilcock, C. (2019). Communicating safety information: Investigating how distractors affect the recall of key safety information in pre-flight safety briefings. *Applied Ergonomics, 81,* 102899-102899. doi:10.1016/j.apergo.2019.102899

Nevin, J. A. (1969). Signal detection theory and operant behavior: A Review of David M. Green and John A. Swets' Signal Detection Theory and Psychophysics. *Journal of the Experimental Analysis of Behavior, 12,* 475-480. doi: 10.1901/jeab.1969.12-475

Nie, X., Batta, R., Drury, C. G., & Lin, L. (2009). Passenger grouping with risk levels in an airport security system. *European Journal of Operational Research, 194*(2), 574-584. doi:10.1016/j.ejor.2007.12.027

O'Connor, M. (2018). How early should I get to an airport for a domestic flight. *USA Today.* Retrieved from https://traveltips.usatoday.com/early-should-airport-domestic-flight-61860.html

O'Mahony, M., & Hautus, M. J. (2008). The signal detection theory roc curve: Some applications in food sensory science. *Journal of Sensory Studies, 23*, 186-204. doi:10.1111/j.1745-459X.2007.00149.x

Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review, 76*, 241-263. doi:10.1037/h0027272

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology/Revue Canadienne De Psychologie, 45*, 255-287. doi:10.1037/h0084295

Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology, 5*, 176-206. doi:10.1016/0010-0285(73)90032-7

Parikh, R., Mathai, A., Parikh, S., Chandra Sekhar, G., & Thomas, R. (2008). Understanding and using sensitivity, specificity and predictive values. *Indian Journal of Ophthalmology, 56*, 45-50. doi:10.4103/0301-4738.37595

Pavlas, D., Rosen, M. A., Fiore, S. M., & Salas, E. (2008). Using visual attention video games and traditional interventions to improve baggage screening. *Human Factors and Ergonomics Society Annual Meeting Proceedings, 52*(19), 1493-1497. doi:10.1177/154193120805201940

Pekoske, D. (2018). 'Though 9/11 is our reason for existing, it does not define who we are: TSA administrator. *USA Today.* Retrieved from https://www.usatoday.com/story/opinion/2018/09/11/remember-sept-11-attacks-9-11-tsa-transportation-security-terrorism-airlines-column/1254851002/

Pendergraft, D. R., Robertson, C. V., & Shrader, S. (2004, December). *Simulation of an airport passenger security system.* Paper presented at the Proceedings of the 2004 Winter Simulation Conference (pp. 874-878). Washington, DC. IEEE. doi:10.1109/WSC.2004.1371402

Peterson, B. (2016). How airport security has changed since 9/11. CNN Traveler. Retrieved from https://www.cntraveler.com/story/how-airport-security-has-changed-since-september-11

Popken, B. (2013). TSA says you can keep your shoes on at more airports. *NBC News.* Retrieved from https://www.nbcnews.com/business/travel/tsa-says-you-can-keep-your-shoes-more-airports-flna8C11073594

Reitsma, J. B., Glas, A. S., Rutjes, A. W. S., Scholten, R. J. P. M., Bossuyt, P. M., & Zwinderman, A. H. (2005). Bivariate analysis of sensitivity and specificity produces informative summary measures in diagnostic reviews. *Journal of Clinical Epidemiology, 58*, 982-990. doi:10.1016/j.jclinepi.2005.02.022

Rice, S., & Winter, S. R. (2018). To drive or fly: Will driverless cars significantly disrupt commercial airline travel?. *International Journal of Aviation, Aeronautics, and Aerospace, 5*(1). https://doi.org/10.15394/ijaaa.2018.1222

Rosen, E. (2017). As billions more fly, here's how aviation could evolve. *National Geographic.* Retrieved from https://www.nationalgeographic.com/environment/urban-expeditions/transportation/air-travel-fuel-emissions-environment/

Sakano, R., Obeng, K., & Fuller, K. (2016). Airport security and screening satisfaction: A case study of U.S. *Journal of Air Transport Management, 55*, 129-138. doi:10.1016/j.jairtraman.2016.05.007

Schwark, J. D., MacDonald, J., Sandry, J., & Dolgov, I. (2013). Prevalence-based decisions undermine visual search. *Visual Cognition, 21*, 541-568. doi:10.1080/13506285.2013.811135

Schwark, J., Sandry, J., & Dolgov, I. (2013). Evidence for a positive relationship between working-memory capacity and detection of low-prevalence targets in visual search. *Perception, 42*, 112-114. doi:10.1068/p7386

Seidenstat, P. (2004). Terrorism, airport security, and the private sector. *Review of Policy Research, 21*, 275-291. doi:10.1111/j.1541-1338.2004.00075.x

Shen, Z., Xue, C., & Wang, H. (2018). Effects of users' familiarity with the objects depicted in icons on the cognitive performance of icon identification. *I-Perception*, *9*, 1-17 doi:10.1177/2041669518780807

Song, C., & Zhuang, J. (2018). Modeling precheck parallel screening process in the face of strategic applicants with incomplete information and screening errors. *Risk Analysis, 38*(1), 118-133. doi:10.1111/risa.12822

Sterchi, Y., & Schwaninger, A. (2015, September). *A first simulation on optimizing EDS for cabin baggage screening regarding throughput.* Paper presented at 2015 International Carnahan Conference on Security Technology (ICCST) (pp. 55-60). Taipei, Taiwan. IEEE. doi: 10.1109/CCST.2015.7389657

Stewart, M. G., & Mueller, J. (2011). Cost-benefit analysis of advanced imaging technology full body scanners for airline passenger security screening. *Journal of Homeland Security and Emergency Management, 8*. doi: 10.1007/s12198-018-0196-y

Tehrani, M., & Molesworth, B. R. C. (2015). Pre-flight safety briefings, mood and information retention. *Applied Ergonomics, 51*, 377-382. doi:10.1016/j.apergo.2015.06.015

Transportation Security Administration (2016). Training for new-hires now at central TSA academy. Retrieved from https://www.tsa.gov/blog/2016/02/23/training-new-hires-now-central-tsa-academy

Transportation Security Administration (2019). TSA reminds travelers of security procedures for the carnival travel season. Retrieved from https://www.tsa.gov/news/releases/2019/05/02/tsa-reminds-travelers-security-procedures-carnival-travel-season

Turcsany, D., Mouton, A., & Breckon, T. P. (2013). *Improving feature-based object recognition for X-ray baggage security screening using primed visual words.* Paper presented at the 2013 International Conference on Industrial Technology (ICIT). (pp. 1140-1145). Cape Town, South Africa. IEEE. doi:10.1109/ICIT.2013.6505833

U.S Department of Transportation. (2003). *Aviation security costs, Transportation Security Administration.* (CC-2003-066). Retrieved from https://www.oig.dot.gov/sites/default/files/cc2003066.pdf

U.S Travel Association. (2016, May 25). *Study: Long TSA lines will ground one in five flyers*. Retrieved from https://www.ustravel.org/press/study-long-tsa-lines-will-ground-one-five-flyers

van Boekhold, J., Faghri, A., & Li, M. (2014). Evaluating security screening checkpoints for domestic flights using a general microscopic simulation model. *Journal of Transportation Security, 7*, 45-67. doi:10.1007/s12198-013-0129-8

van Stralen, K. J., Stel, V. S., Reitsma, J. B., Dekker, F. W., Zoccali, C., & Jager, K. J. (2009). Diagnostic methods I: Sensitivity, specificity, and other measures of accuracy. *Kidney International, 75*, 1257-1263. doi:10.1038/ki.2009.92

Van Wert, M. J., Horowitz, T. S., & Wolfe, J. M. (2009). Even in correctable search, some types of rare targets are frequently missed. *Attention, Perception, & Psychophysics, 71*, 541-553. doi:10.3758/APP.71.3.541

Vasel, K. (2016). Who's to blame for the long airport security lines? *CNN Money.* Retrieved from https://money.cnn.com/2016/05/18/pf/blame-for-airport-security-lines/index.html

Vergauwe, E., & Langerock, N. (2017). Attentional refreshing of information in working memory: Increased immediate accessibility of just-refreshed representations. *Journal of Memory and Language, 96*, 23-35. doi:10.1016/j.jml.2017.05.001

Wetter, O. E. (2013). Imaging in airport security: Past, present, future, and the link to forensic and clinical radiology. *Journal of Forensic Radiology and Imaging, 1*, 152-160. doi:10.1016/j.jofri.2013.07.002

Whitehouse, A. J. O., Maybery, M. T., & Durkin, K. (2006). The development of the picture-superiority effect. *British Journal of Developmental Psychology, 24*, 767-773. doi:10.1348/026151005X74153

Wickens, C. D., Lee, J. D., Liu, Y., & Becker, S. E. G. (2004). *An introduction to human factors engineering* (Second ed.). Upper Saddle River, N.J: Pearson Prentice Hall.

Wolfe, J. M., Brunelli, D. N., Rubinstein, J., & Horowitz, T. S. (2013). Prevalence effects in newly trained airport checkpoint screeners: Trained observers miss rare targets, too. *Journal of vision, 13(3),* 1-9. doi:10.1167/13.3.33

Wolfe, J. M., Horowitz, T. S., & Kenner, N. M. (2005). Rare items often missed in visual searches: Cognitive psychology. *Nature, 435*(7041), 439-440. doi:10.1038/435439a

Wolfe, J. M., Horowitz, T. S., Van Wert, M. J., Kenner, N. M., Place, S. S., & Kibbi, N. (2007). Low target prevalence is a stubborn source of errors in visual search tasks. *Journal of Experimental Psychology: General, 136,* 623-638. doi:10.1037/0096-3445.136.4.623

Wong, S., & Brooks, N. (2015). Evolving risk-based security: A review of current issues and emerging trends impacting security screening in the aviation industry. *Journal of Air Transport Management, 48,* 60-64. doi:10.1016/j.jairtra-man.2015.06.013

Yonelinas, A. P., & Parks, C. M. (2007). Receiver operating characteristics (ROCs) in recognition memory: A review. *Psychological Bulletin, 133,* 800-832. doi:10.1037/0033-2909.133.5.800

Appendix A

Informed Consent Form for Study 1

INFORMED CONSENT FORM

An Alternative Method of Providing TSA Screening Information to passengers

Purpose of this Research: I am asking you to take part in a research project for the purpose of ascertaining public sentiment on the use of various informational instruments when providing TSA screening information to intended audiences. This research may contribute to the improvement of the airport security experience. During this study, you will be asked to undergo a simple written evaluation and complete a post-study survey. The total expected duration of this study is approximately 30 minutes.

Eligibility: To be in this study, you must be 1) 18 years or older and 2) Enrolled at Embry-Riddle Aeronautical University (ERAU) Daytona Beach.

Risks or discomforts: The risks of participating in this study are minimal, no more than what is experienced in everyday life.

Benefits: While I do not expect you to benefit directly or personally from the study, the results and conclusions derived from your participation will help me investigate if my proposal can improve certain aspects of the passenger experience pertaining to airport security. This study may eventually provide significant insight into improving airport security in the United States and may one day benefit you as well.

Confidentiality of records: Your individual and personal information will be protected in all data resulting from this study. Your responses in this study will be confidential. No personal information will be collected other than basic demographic descriptors. I will be the only one that will have access to your personal information. To ensure the confidentiality of your responses, I will provide each participant with a unique ID for the study. Any collected data or personal information will be entered and stored in a password protected file on a password-protected computer or in a locked file cabinet. The data will be stored for 3 years after any publication, if any, and then will be shredded. Information collected as part of this research will not be used or distributed for future research studies.

Compensation: There is no compensation offered for taking part in this study.

Contact: If you have any questions or would like additional information about this study, please contact Joel Lee (386) 284 8481, leej143@my.erau.edu or the faulty member overseeing this project, Dr. Andrew Dattel at (386) 226- 7795, andy.dattel@erau.edu. For any concerns or questions as a participant in this research, contact the Institutional Review Board (IRB) at 386-226-7179 or via email teri.gabriel@erau.edu

Voluntary participation: Your participation in this study is completely voluntary. You may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Should you wish to discontinue the research at any time, no information collected will be used.

Participant Privacy: Any personal information that can identify you will be removed from the data collected and this data will **not** be used or distributed for ***future research studies.***

CONSENT. By signing below, I certify that I am 18 years or older, enrolled at ERAU Daytona Beach, understand the information on this form and voluntarily agree to participate in the study.

If you do **not** wish to participate in the study, simply close the browser which will direct you out of the study.

Please print a copy of this form for your records. A copy of this form can also be requested from Joel, leej143@my.erau.edu

Signature of Participant _____Date: _____

Printed Name of Participant _____

Appendix B

Stimuli for Study 1

B1 Sample Standing Signpost Information.

B2 Sample Non-modified Boarding Pass (Front and Back).

B3 Sample Modified Boarding Pass (Front and Back).

Figure B1. Sample standing signpost

Intentionally left blank

Figure B2. Sample regular, non-modified boarding pass (front and back).

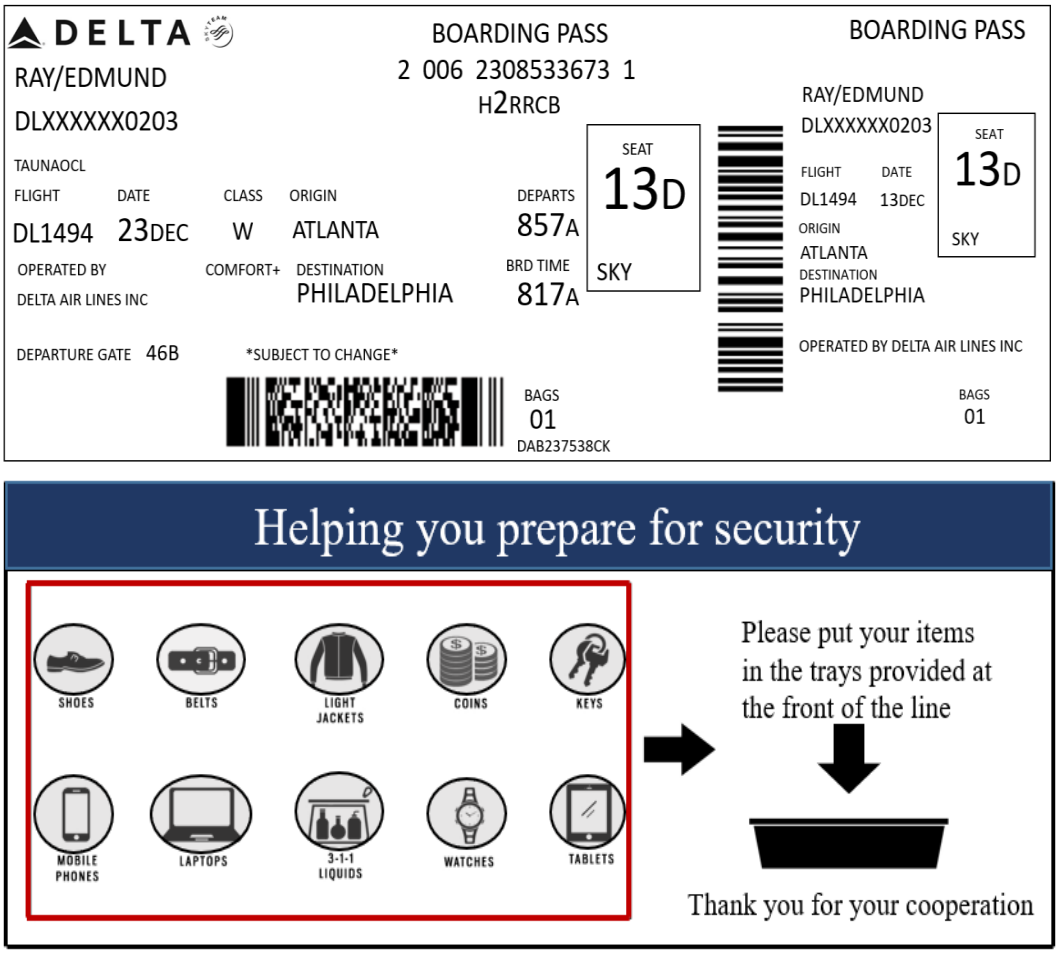

Figure B3. Sample modified boarding pass (front and back).

Appendix C

Test Papers for Study 1

Recall Evaluation C1 (Group 1)

Recall Evaluation C2 (Group 2)

Recall Evaluation C3 (Group 3)

Participant Number: _____

Recall Evaluation C1

Please answer the following question:

1. List the items that passengers are required to remove prior to security screening from their person and their carry-on bags (TSA Pre-Check is excluded)

Note: The items were listed on the standing signposts outside

Participant Number: _____

Recall Evaluation C2

Please answer the following question:

1. List the items that passengers are required to remove prior to security screening from their person and their carry-on bags (TSA Pre-Check is excluded)

Note: The items were listed on the underside of your boarding pass

Participant Number: _____

Recall Evaluation C3

Please answer the following question:

1. List the items that passengers are required to remove prior to security screening from their person and their carry-on bags (TSA Pre-Check is excluded)

Note: The items were listed on the underside of your boarding pass and on the standing signposts

Appendix D

Post-evaluation Surveys for Study 1

Post-evaluation survey D1 (Group 1)

Post-evaluation survey D2 (Group 2)

Post-evaluation survey D3 (Group 3)

Participant Number: _____

Post-evaluation survey D1

Demographics:

Please answer the following questions:
*You may choose to not answer all the questions in this section

1. What is your age? _____
2. What is your gender? _____
3. What is your ethnicity? _____

Please answer the following questions (circle the answers)

1. Did you notice the TSA signage post outside the test room? (yes / no)
   *If no, skip to question 5.
2. Did you read the contents of the TSA signage post? (yes / no)
3. Did you have sufficient time to read the contents? (yes / no)
4. Was the TSA signage post helpful in recalling the items to remove before security screening? (yes / no)
5. In your opinion, how useful are TSA signposts at airports during security screening?

1	**2**	**3**	**4**	**5**
Not useful				**Very useful**

Thank you for your participation

Participant Number: _____

Post-evaluation survey D2

Demographics:

Please answer the following questions:
*You may choose to not answer all the questions in this section

1. What is your age? _____
2. What is your gender? _____
3. What is your ethnicity? _____

Please answer the following questions (circle the answers)

1. Did you notice the TSA information on the underside of the boarding pass? (yes / no)
   *If no, skip to question 5.
2. Did you read the contents on the underside of the boarding pass? (yes / no)
3. Did you have sufficient time to read the contents? (yes / no)
4. Was the underside of the boarding pass helpful in recalling the items to remove before security screening? (yes / no)
5. In your opinion, how useful can the boarding pass you received, be during security screening if used at airports?

1 2 3 4 5
Not useful Very useful

Thank you for your participation

Participant Number: _____

Post-evaluation survey D3

Demographics:

Please answer the following questions:
*You may choose to not answer all the questions in this section

1. What is your age? _____
2. What is your gender? _____
3. What is your ethnicity? _____

Please answer the following questions (circle the answers)

1. Did you notice the information on the TSA signage posts? (yes / no)
2. Did you notice the information on the underside of the boarding pass? (yes / no)

3. Did you read the contents of the TSA signage posts? (yes / no)
4. Did you read the contents on the underside of the boarding pass? (yes / no)

5. Did you have sufficient time to read the contents of the TSA signage posts? (yes / no)
6. Did you have sufficient time to read the contents on the underside of the boarding pass?
   (yes / no)

7. Was the TSA signage posts helpful in recalling the items to remove before security screening? (yes / no)
8. Was the underside of the boarding pass helpful in recalling the items to remove before security screening? (yes / no)

Please flip to the next page

9. In your opinion, how useful are TSA signposts at airports during security screening?

1	2	3	4	5
Not useful				**Very useful**

10. In your opinion, how useful can the boarding pass you received, be during security screening if used at airports?

1	2	3	4	5
Not useful				**Very useful**

11. In your opinion, how useful would the use of both TSA sign posts and the boarding pass you received, be during security screening if used at airports?

1	2	3	4	5
Not useful				**Very useful**

Thank you for your participation

Appendix E

Informed Consent Form for Study 2

INFORMED CONSENT FORM

An Alternative Method of Providing TSA Screening Information to passengers

You are invited to participate in a research survey conducted by Joel Lee, a graduate student in the Masters of Science in Aeronautics (MSA) department at Embry-Riddle Aeronautical University (ERAU).

Purpose of this Research: I am asking you to take part in a research for the purpose of investigating the perceived usefulness of the modified boarding pass that will be shown to you. During the survey, you will be asked several questions pertaining to your opinion toward the modified boarding pass sample. The expected duration of the survey is approximately 5 minutes.

Benefits: While I do not expect you to benefit directly or personally from the study, the results and conclusions derived from your participation will help me investigate if my proposal can help passengers better prepare for security screening with the hope of reducing congestion at security checkpoints. This study may eventually provide significant insight into improving airport security in the United States and may one day benefit you as well.

Confidentiality of records: The information gathered about you will only be your demographics and responses to the survey questions. This information will be protected and confidential. I will be the only one that will have access to your personal information. Any collected data or personal information will be entered and stored in a password protected file on a password-protected computer or in a locked file cabinet. The data will be stored for 3 years after any publication, if any, and then will be shredded.

Contact: If you have any questions or would like additional information about this study, please contact Joel Lee (386) 284 8481 or leej143@my.erau.edu. You can also contact the research advisor, Dr. Andrew Dattel at (386) 226- 7795 or andy.dattel@erau.edu.

The ERAU Institutional Review Board (IRB) and Daytona Beach International Airport (DAB) have approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services.

Voluntary participation: Your participation in this survey is completely voluntary. You may stop or withdraw from the study at any time or refuse to answer any question that you are uncomfortable answering without penalty.

CONSENT. Your consent means that you understand the information on this form, that any and all questions you may have about this study have been answered, and you voluntarily agree to participate.

Disclaimer: This survey is not sponsored by Daytona International Airport (DAB) or the Transportation Security Administration (TSA). It is strictly for ERAU research purposes only.

If you do **not** wish to participate in the survey, simply tick the disagree box below or let the researcher (Joel) know.

Please tick to indicate if you agree or disagree to participate in this study

Agree ☐ Disagree ☐

Appendix F

Survey for Study 2

Age: Gender:

Please circle your responses

1. Are you aware of <u>all</u> the personal possessions that are needed to be removed in preparation for TSA screening?

1	2	3	4	5	6	7	8	9	10
Not Aware At All									Very Aware

2. At times, are you frustrated by other passengers who did not know of all the items to remove for screening?

1	2	3	4	5	6	7	8	9	10
Never									All The Time

3. Have you forgotten to remove an item during screening that you know you should have removed?

1	2	3	4	5	6	7	8	9	10
Never									Always

4. Do you believe security screening should be made more convenient for passengers?

1	2	3	4	5	6	7	8	9	10
Not At All									Yes Definitely

5. TSA screening protocol can differ between airports. This sample boarding pass can help notify you of these changes. Would this information on the sample boarding pass be useful to you in preparing for screening?

1	2	3	4	5	6	7	8	9	10
Not At All									Yes Definitely

6. Do you think the sample boarding pass can be more useful for passengers compared to current TSA methods (such as signposts and announcements)?

1	2	3	4	5	6	7	8	9	10
Not At All									Yes Definitely

7. Which airline do you fly the most often? _____ (Please fill in)