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SOCIAL-COGNITIVE BIASES IN SIMULATED AIRLINE LUGGAGE SCREENING

by

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ABSTRACT

SOCIAL-COGNITIVE BIASES IN SIMULATED AIRLINE LUGGAGE SCREENING

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The study examined the role that social-cognitive biases play in decision making processes during airline luggage screening. Participants (n = 96) performed a computer simulated task where they tried to detect hidden weapons in 200 x-ray images of passenger luggage. Participants saw each luggage image for either two seconds (high time pressure) or six seconds (low time pressure). In addition, on each trial, participants observed the pictures of the "passenger" to whom the luggage purportedly belongs. The "pre-anchor group" answered questions about the passenger *before* the luggage image appears, the "post-anchor" group answered questions *after* the luggage appears, and the "no-anchor group" answered *no* questions. Participants then chose to either pass or stop the luggage, and rated their confidence in their decision. We hypothesized that participants in either the pre- and no-anchor groups and under high time pressure, would base their decisions more on the passenger who belonged to the luggage. While under low time pressure and for the no-anchor group participants were expected to base their decisions on the x-ray image itself rather than on the passenger. Results revealed that participants under high time pressure did indeed have lower hit rates and higher false alarms, when compared to participants under low time pressure. There were also significant differences between the pre-, no-, and post-anchor groups which were based on the gender and race of the passengers. Participants also had a higher false alarm rates in response to male passengers than female passengers.

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Visual Search Tasks

The primary goal of visual search tasks is to effectively differentiate critical signal stimuli from irrelevant non-signals (known as *distractors*). There have been various studies looking into different aspects of visual search tasks. Many of the visual search studies focus on visual clutter and its effects on the search task (Grahame, Laberge, & Scialfa, 2004; McPhee, Scialfa, Dennis, Ho, & Caird, 2004; Verghese, & McKee, 2004; Nagy, Neriani, & Young, 2005). Another factor that affects visual search is age (Grahame et al., 2004; McPhee et al., 2004). The reason visual search tasks are the focus of several researchers is that there are several jobs in the real world that use visual searching as the main component of the work. Some of these jobs are quality control, x-ray technicians, soldiers on the battlefield, and airport luggage screeners. In the subsections below we describe some of the studies that have been done, their impact on real world visual search tasks, some of the challenges in visual search tasks, and the goals of this thesis.

As mentioned above, one of the primary factors that affect the efficiency of visual search is visual clutter, typically caused by "distractors". Studies by Grahame et al., (2004) and McPhee et al. (2004) found that as clutter is increased, the time it takes to detect the target also increases. Furthermore, they found that the task increases in perceived difficulty as a consequence of increased clutter. This is because it is harder to recognize an object as the clutter increases (Bravo & Farid, 2006); as there are more objects to search through to find a target. The search will take longer and will be less efficient. In some instances, however, detection time can *decrease* with clutter, especially when the clutter causing objects are of a larger size than the target (Neider,

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2007). This is due to attention being drawn to the "empty" space between the clutter causing objects.

In addition to the amount of clutter, search efficiency is affected by what the clutter consists of, and its physical similarity or dissimilarity to the target. The more similar the distractor is to the target, in terms of color, brightness, and orientation, the more difficult it is to find the target (Verghese et al., 2004). Furthermore, target objects that have multiple colors or textures are harder to detect in a cluttered environment, especially when the clutter is of a similar color or texture to that of the target (Bravo et al., 2004).

In addition to clutter in the display, there are many extraneous factors that act as distractors in a visual search context. For example, quality control workers must deal with the noise from the factory machines or conveyor belts sending the products past the inspector. X-ray technicians must deal with communications from the patients as well as the beeps and hums from different pieces of equipment. For the airport luggage screener noise is present in the form of passengers talking, airport announcements, and hand held radios for communicating with the different security officers. Such secondary tasks typically interfere with the primary visual search task. As secondary task load increases in difficulty, the primary task becomes less accurate (Zook, 2006) and slower. A secondary task can also disrupt the participant from noticing a change (McCarley, Kramer, Wickens, Vidoni, & Boot, 2004). McPhee et al. (2004) found that a secondary task had an additive effect on accuracy and speed. The secondary task decreased accuracy and increased the time it took to detect the target. However, Young & Stanton (2007) found evidence for the contrary in that a secondary task inflates subjective workload, but does not necessarily interfere with the primary task.

Time pressure plays a large role in real world visual search tasks. Research has shown that people change their response pattern when under time pressure (Harreveld, Wagenmakers, & van der Maas, 2007; Light, Chung, Pendergrass, & Van Ocker, 2006; Milton, Longmore, & Wills, 2008). In the study by Harreveld et al. (2007), they found that for chess, where experience plays a large role in winning the match, when the amount of time for the game is decreased, so that the match lasts about 15 minutes, the experience of the player is negated and is not a determining factor for who wins the match. In the Light et al. (2006) study, participants were presented with a list of words to study. They were then presented with words one at a time, with the word either appearing for a short time (400 msec), or a long time (2400 msec). Participants had higher hit rates for the long time frame compared with the short time frame. Time pressure was also manipulated in the Milton et al. (2008) study wherein participants categorized objects by similarity. It was found that the higher the time pressure, the more difficult the task became.

Betsch, Fielder, and Brinkman (1998) manipulated time pressure and novelty using a simulated trucking game, which is perhaps most relevant to our proposed research. They used the trucking game to have participants learn the best truck routes depending on the truck starting time and the goal given to the truck. They found that when participants were under high time pressure to make the decision about which route to take, the participants chose more familiar routes, even if they were not the best route choices for the situation.

Airport luggage screening – a special case of visual search tasks.

Airport luggage screening is a special case of visual search tasks because it integrates several challenges of visual search tasks such as those described above into one complex situation. The primary task requires the screener to search through an x-ray image and detect a particular dangerous target from the clutter of non-lethal objects. On one level, luggage screening is a simple signal detection task where the screener must differentiate critical signals (or, threat objects) from background noise. However, the detection task is complicated by the fact that on several occasions, the threat object must be detected within an initial glimpse of the x-ray image, spanning just a few seconds. To facilitate this, modern x-ray scanners use multiple colors to represent different materials to try and enhance the detection of threat objects (Ghylin, Schwaninger, Drury, Redford, Lin, and Batta, 2008). However, according to this research there is no performance benefit to using different colors to highlight different portions of the x-ray image. Airport luggage screening is further complicated by the number and diversity of threat objects that might potentially be embedded in a piece of luggage. Lastly, much of the threat detection in bags is still done by visual inspection of the bag, rather than by automated methods. This is due in part to the uncertainty of what constitutes a threat and the definition of a "threat" that changes constantly.

Not surprisingly, luggage screening has generated a lot of interest among researchers in the last few years. One study examined how practice affects sensitivity and response time in the screening task. This study was done by McCarley et al. (2004) wherein participants were run through five different sessions, each one lasting three hours long. Each session consisted of participants looking for knives in x-ray images of luggage with a base rate of 20%. An eye tracker was used to get data on where participants were looking, and if the participants were using consistent visual search patterns. They found that practice did increase sensitivity and decreased response time. However, using eye tracking data, they found that although participants decreased their response times, their search patterns were not necessarily becoming more effective. This led the researchers to conclude that it was target familiarity and not modifying search patterns that led to the decrease in response time, and increased sensitivity. In other words, extended practice improved efficiency (speed & familiarity) but not effectiveness (the manner in which they searched the luggage).

Myles-Worsley, Johnston, & Simons, (1988) conducted a similar study on the effects of expertise on the ability to scan x-ray images in a medical context. They used four different levels of expertise for participants, who looked at chest and face x-rays. The participants were shown faces and chest x-rays, half of them being normal and the other half being abnormal. Then new chest x-rays and face images were added to the projector. The participants then decided whether the image they saw was from the old slides, or if they were new. All participants recognized the faces accurately, but the experts alone recognized the abnormal x-rays almost as well. These results could generalize to similar processes for recognizing abnormal objects in luggage x-ray images. Specifically, this could explain why experienced luggage screeners have faster response time when trying to detect a target object.

This brings up the related issue of whether or not luggage screeners categorize objects in order to help their search. This question is answered in Smith, Redford, Washburn, and Taglialatela's (2005) study in which participants looked for objects that had similar features to each other in a luggage screening context. Participants were shown four objects on a screen, and had to pick out the objects that had similar features. The researchers found that if the objects are sampled with replacement, the participants relied less on categorizing the different shapes, and more on recognizing the object itself. In other words, screeners perhaps rely less on the category a target belongs to; rather they rely more on the actual target in order to detect it on an x-ray image.

The visual complexities inherent in the scanning task are exacerbated by the fact that the base rate of threat objects in luggage is extremely low (Parasuraman, Warm, & Dember, 1987) Base rate refers to the probability of an object of interest occurring in the environment. Typically, low base rate situations lead to vigilance decrements, which, in turn, lead to decreases in sensitivities and shifts in response criterion settings. If an airline luggage screener misses a dangerous object due to the fact that they are experiencing vigilance decrements, the cost, in human lives, can be very dear.

A recent study, Madhavan, Gonzalez, and Lacson (2007) found that different target base rates during training have a significant effect on quality of transfer during luggage screening. A later study along similar lines by Brown and Madhavan (2008) supports these findings in that higher base rates did have a training advantage relative to lower base rates for hit rates, although higher base rates inflated false alarm rates and slowed response times at transfer. However, this research revealed that these findings held true only when transfer targets were physically different from training stimuli (i.e., "novel-targets scenario"). When transfer stimuli were the same as those used in training ("same-targets scenario"), target base rates during training did not significantly affect transfer performance.

Contrary to the pattern observed in the novel-targets-scenario, the pattern of results for the same-targets-scenario suggested that just a few exposures of target stimuli (i.e., 20% base rate) during training were sufficient to create a stable mental representation of the target. Training participants with a 100% base rate did not lead to a transfer advantage in this scenario. The authors inferred that when the transfer task required detection of familiar targets, a larger base rate during training only led to higher levels of redundancy in knowledge acquisition.

The results of this two-scenario study are important in that security personnel at a real airport are likely to encounter a combination of both familiar and unfamiliar targets during the process of screening. While the relevance of higher training base rates to novel transfer scenarios is undeniable, the results of this study indicated that it is equally important to establish the training conditions that lead to optimal transfer when transfer conditions are similar to training conditions.

One main problem that is inherent in luggage screening is vigilance decrement. When people repeat the same task over and over, with a low base rate, performance declines over time. Washburn, Taglialatela, and Rice (2004), ran a study on how performance decreases over time. Participants looked for guns, knives, and scissors in x-ray images of luggage for 25 minutes. The researchers found that over time, performance did decrease, but it was dependent upon the participants' sustained attention skills as to how much the performance decreased.

A more recent issue with luggage screening and x-ray image processing has been how to automate the screening task and the effects of automation on the human screener (Ghylin et al., 2008; Wiegmann, McCarley, Kramer, and Wickens, 2006). The simplest form of automation of the screening process is changing the colors of different materials in the x-ray image (Ghylin et al., 2008) which was discussed earlier. In another study, the arbitrary color codes that are typically used at an airport were compared with two different color codes, one high contrast, the other low contrast colors (Hilscher, 2005). They found that the high contrast colors increased detection accuracy, specifically with correct rejections. This is extremely important in luggage screening. Being able to quickly detect what an object is and what it is made of can help the luggage screener either dismiss the object, or select it for further searching.

A study by Wiegmann et al. (2006), studied the effect of the type of automation on young and old screeners. All participants viewed x-ray images of luggage with a base rate of 20% for the target knife. Some participants received a textual cue to the target, whereas others received a spatial cue around the target area. It was found that the textual cuing improved the young screeners' performance alone, whereas the spatial cuing improved both the young and old screeners' performance. This study indicates that the best type of automation to be used in luggage screening would be spatial cuing, although there are some problems with spatial cuing. Some of these issues were looked at in a study on the effects of pre-cuing potential areas of lung tumors by Krupinski, Nodine, and Kundel, (1993). It was shown that detection performance was increased as the area outside the circle was systematically masked and the area containing the tumor was circled. However, detection of targets outside of the cued area decreased. The problem with having the target object circled by the automated aid is that targets that occasionally fall outside the cued area may often be missed.

All the studies described above have effectively addressed the cognitive aspects of visual search in luggage screening at the level of the individual. However, no study so far has attempted to address extraneous issues (social, cultural, environmental) that might potentially influence screening efficiency over and beyond those that extend beyond simple visual search processes. Specifically, all the previous studies have demonstrated that screeners are capable of decreasing detection time, and becoming more accurate at detecting targets on a computer screen in isolation without factoring in extraneous variables. But, what happens if screeners were given an opportunity to observe the passengers that were associated with a certain piece of luggage, similar to the real world?

In order to understand the plethora of variables that influence the screening process, it is extremely important to consider whether a passenger (or, piece of luggage) was being stopped due to security rules per se, the detection of an anomaly within the luggage, or from the screener's social biases or stereotypes. For example, we need to understand answers to some simple questions - Did the passenger wear certain clothing, or appear a certain way to arouse suspicion? Was the passenger of a different race than the screener? Was the passenger a man or a woman, young or old? The purpose of this study is to examine what effect, if any, these variables such as race, age and gender of the passenger would have on the screener's decisions to stop the passenger's luggage or not.

Social –Cognitive Biases

Age

Age bias is a social bias related to a person's age that can have an effect on decision making. Older people often tend to be discriminated against for jobs. Specifically, the belief is that older individuals are not as flexible in their thinking as younger individuals. Therefore a job that requires flexibility would not be a good fit for an older worker, (Craik, 2002) whereas younger people are believed to have more potential for development than the older people (Dickman & Hirnisey, 2007). Based on this, younger people may be more likely to be employed as airport luggage screeners, as their thinking must be very flexible to figure out what constitutes a target.

A study by Anastasi & Rhodes (2006) revealed that when trying to recognize faces of younger, middle aged, and older adults, all participants were better able to recognize a face that matched their own age group. In a study of older versus younger adults, it was found that older individuals show poorer performance in recognition of a perpetrator in a lineup when the lineup is of younger people. Younger people, on the other hand, were more likely to choose a perpetrator from an older lineup (Wilcock, Bull, & Vrij, 2007). Using this logic, a younger airport luggage screener might be more likely to stop an older passenger's luggage compared with a younger passenger's luggage.

However, the opposite might also be true. Younger screeners may trust older passengers more due to the fact that younger people are typically more likely to commit crimes (Dahlberg & Simon, 2006) and older people are more likely to have been the victims of crimes. Drug smugglers have used elderly people, without their knowledge, to try and smuggle drugs using wheelchairs and their own luggage items (Marino, 2008). Often, the influence of age interacts with the passenger's gender as described below.

Gender

When one gender is given preferential treatment over the other, it is typically referred to as "gender bias" (Baker, Craddock, &Orwig, 2002). Gender bias is pervasive especially in the workplace. When men and women are evaluated for the same type of work, male workers are often found to get better rewards for good evaluations compared to female workers; on the flip side, males also receive harsher punishments than females in response to poor evaluations (McKay & Tate, 2001). Research has revealed that performance ratings are more strongly related to promotions for female workers compared to male workers, which suggests that females are held to higher standards than males (Lyness & Heilmann, 2006). For example, in one study wherein men and women were fired from similar jobs, men received more compensation than women (Rollings-Magnusson, 2004). Furthermore, highly competitive jobs are typically considered "male oriented" and need "male traits" in order to perform them the best (Heilmann, 2001). Clearly, gender-related biases play a major role when decisions to hire, promote or fire are made in several job contexts.

Contrary to the apparent bias in favor of males in the workplace, males are also more likely to be associated with negative and destructive traits such as lying, stealing, aggression and physical violence. In 2006, there were 1,479,726 men in state and federal prisons compared with only 115,308 women (U.S. Bureau of Justice Statistics. 2007). This indicates that males are committing more crimes than females, and indicates a greater tendency for males to be violent.

Based on the above findings we hypothesize that security screeners would be more suspicious of males than females, and will be more likely to stop male passengers' baggage compared to female passengers' baggage. This introduces a gender bias into the luggage screening process based on the different traits that men and women purportedly possess.

Race

Though we would like to think differently, racial bias is still prevalent throughout the world. There have been numerous studies looking at racial bias among police and their decision to shoot or not shoot (Correll, Park, Judd, Wittenbrink, Sadler, & Keesee, 2007; Plant & Peruche, 2005). In the Correll et al. (2007) study, comparing police to civilians in the same district, civilians were found to be more likely to shoot when shown a minority suspect compared with the police. Both police and civilian participants took longer to react when the White suspect had a gun, and the minority suspect did not have a gun. The researcher concluded that seeing a white person with a gun violated people's expectations leading them to take longer to react; the opposite was true when observing a person of minority race who was perceived as dangerous even without a weapon (Correll et al., 2007).

In another study with just police participants, it was found that initially police officers were more likely to shoot an unarmed Black suspect compared to an unarmed White suspect (Plant et al., 2005). However, this study also showed that this racial bias can be "trained out", because the bias was not present in the later part of the study after training. The police officers in both studies were White, Black, Native American, and Hispanic so there was a mix of races in the both studies. In the Correll et al (2007) study, the civilians were also representative of these races.

In luggage screening, racial bias can be manifested in how passengers get stopped by screeners as a function of their race. The studies described above show that there is a bias present among some police officers towards minority groups (Correll et al., 2007; Plant et al., 2005). The same bias could be observed in the security officers at airports and would lead to minorities having their baggage stopped more often than White passengers' luggage no matter what the race of the screener is. Reportedly Black people are able to detect racial bias in another person more easily when given a small exposure to nonverbal behavior (Richeson & Shelton, 2005). This could stem from the fact that they are more sensitive to racial bias. The race of the screener could be an additional factor that determines whether or not they pass the passenger's luggage. Screeners that are screening luggage from a passenger of the same race may be more lenient on them, than on a passenger of another race (Lee & Ottati, 2002). On the other hand, all screeners, including minority screeners may uniformly favor Caucasians (Boldry & Kashy, 1999).

Impact of social-cognitive biases on luggage screening performance

The three biases discussed above: age, gender and race, are all likely to impact airport luggage screening in significant ways. Age bias could impact luggage screening in two different ways – on the one hand, younger screeners will be more likely to favor like-aged passengers. On the other hand, younger passengers might be viewed as more culpable relative to older passengers who may be viewed as more trustworthy just based on their age. Secondly, luggage screening is also likely affected by gender bias, leading to males being stopped more than females. Finally, racial bias could impact luggage screening in that minorities will be more likely to be stopped and have their luggage searched compared with White passengers. Passengers that are of a different race than the luggage screener may also be stopped more.

If these biases are allowed to affect airport luggage screening, tragic consequences can follow. While the screeners are focusing on the passengers that fit their expectations of their biases, there could be perpetrators using these biases against the screeners to get a dangerous object past security. Examples of this are reports of older persons or young children being unsuspecting "carriers" of weapons that they are completely unaware of (Marino, 2008). These biases have a big effect on luggage screening, and have seldom been well studied.

The purpose of the proposed study is to examine the effects that social-cognitive biases (engendered by passengers of different races, ages and genders) and time pressure have on the screening task. We first conducted a pilot test to examine if participants expressed different opinions of passengers as a function of their (passengers') gender, age and race prior to the actual screening task. This will be followed by the actual study wherein we will examine whether showing the picture of passenger will influence decisions to stop or pass luggage as a function of social-cognitive biases.

Pilot Test

The purpose of this pilot test was to examine the possible effects that social-cognitive biases have on the way people respond to statements about passengers, based on visual observations of photographs of passengers varying by race, age and gender. The social biases we examined were age, gender, and race. We also wanted to use the pilot test to connect social biases with airport luggage screening. Therefore, we did this by asking participants to imagine that the people in the photographs shown to them were passengers at an airport. We then framed the statements to represent issues that might be relevant to luggage screeners.

Method

Participants were 24 Old Dominion University undergraduate students, all of whom were enrolled in a Psychology class and completed the study for research participation credit. Students were given 1.5 credits for completing the study. A computer program was developed to present 100 pictures of 'passengers' in random order. The passengers varied by race, age, and gender. The races that were represented were White (34), Black (33), and Asian (33). See figures 1-6 for representative pictures of each category. Passengers within each race were divided into males and females (17 White males and 17 White females; 16 Blacks males and 17 Black females; 16 Asians males and 17 Asian females). Passengers were also divided into young and old, evenly split between the genders. The program also recorded the participants' responses to seven statements for each passenger. The program took 1.5 hours to complete and participants received 1.5 credits towards research for a class.

Procedure

Participants were assigned a participant number, which was based on the date they participated and the order in which they arrived, which was entered into the computer program after signing the informed consent forms. The participants were told that they would be rating seven statements for each person in the pictures, representing a

Figure 1. Representative pictures of an old and young Black female.

Figure 2. Representative pictures of an old and young Black male.

Figure 3. Representative pictures of an old and young Asian female.

Figure 4. Representative picture of an old and young Asian male.

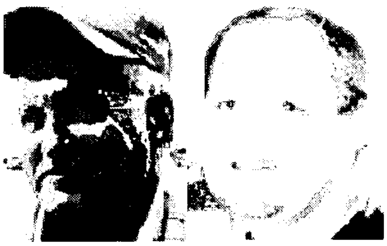

Figure 5. Representative picture of an old and young White male.

Figure 6. Representative picture of an old and young White female.

passenger, which were going to appear in the corner. They were then told to click next and were shown the statements that they would be rating for each picture. Each statement had a five point scale following it, with "1" being "disagree completely" and 5 being "agree completely". If the participant did not have questions, they were to continue through the program until it stopped. See appendix A for the seven statements.

Pilot Test Results

A 7 (statements) X 3 (passenger race) X 2 (passenger gender) X 2 (passenger age) mixed measures ANOVA on participant rating revealed that there was a significant main effect for the statements, $F(6, 528) = 91.087, p < .001, \eta^2 = .509$, and passenger gender, $F(1, 88) = 46.355, p < .001, \eta^2 = .345$ as well as an interaction between the statement and gender, $F(6, 528) = 48.782, p < .001, \eta^2 = .357$. There were also significant interactions between the statements and race $F(12, 528) = 2.862, p < .01, \eta^2 = .061$, statements and age $F(6, 528) = 13.799, p < .001, \eta^2 = .136$, and between the passenger gender and passenger age, $F(1, 88) = 7.134, p < .01, \eta^2 = .075$. Statement #4 had the highest score ($M = 3.51$, $SE = .02$) with statement # 7 having the lowest score ($M = 2.29$, $SE = .02$). Males had a significantly higher rating on all the statements ($M = 2.82$, $SE = .03$) compared to the females ($M = 2.50$, $SE = .033$).

To further understand the relationship between responses to each question and passenger attributes, we used multiple one way ANOVAs to test the simple effects of gender, age and race on participant responses.

Statement 1: "I think this person is attractive."

A one-way ANOVA revealed significant main effects for gender $F(1, 88) = 21.324, p < .001, \eta^2 = .195$, and age $F(1,88) = 58.890, p < .001, \eta^2 = .401$, as well as a significant interaction between the two variables, $F(1,88) = 10.597, p < .01, \eta^2 = .107$. Females were perceived as significantly more attractive ($M = 3.28$, $SE = .19$) than males ($M = 2.70$, $SE = .19$). Young passengers ($M = 3.25$, $SE = .18$) were found to be significantly more attractive than older passengers ($M = 2.50$, $SE = .22$). As can be seen in figure 7, there was a greater difference between the attractiveness of young males ($M = 2.86$, $SE =$ .26) and females ($M = 3.61$, $SE = .25$), compared with the older males ($M = 2.42$, $SE =$ .30) and females ($M = 2.58$, $SE = .32$). Perceptions of race, $F(2, 88) = 2.972$, $p = .056$, $\eta^2 = .063$, and interactions between gender and race, $F(2, 88) = 1.463$, $p = .237$, $\eta^2 = .032$, gender and age, $F(1, 88) = .666$, $p = .516$, $\eta^2 = .015$, and gender, age, and race, $F(2, 88) =$ 2.061, $p = .133$, $\eta^2 = .045$, were all found to be non-significant.

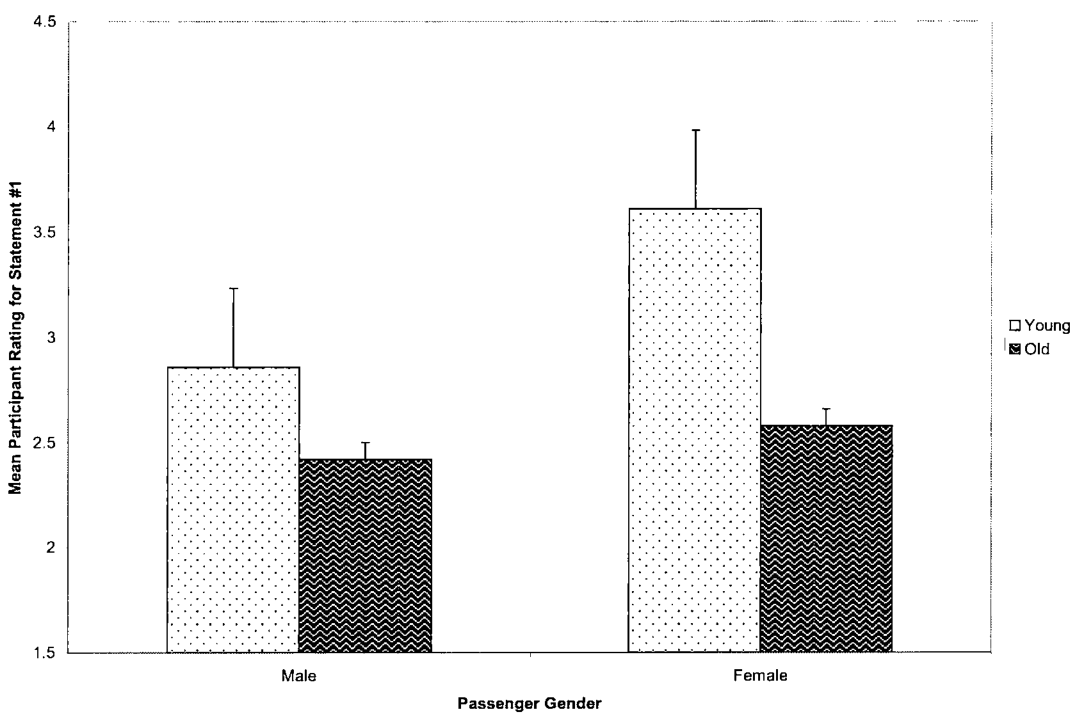

Figure 7. Graph of the interaction between gender and age for statement #1 *"I think this person is attractive."*

Statement 2: "This person might have a dangerous object in his/her luggage."

Statement #2 was revealed to be significant for main effect of gender alone $F(1, 88) =$ 65.040, $p < .001$, $\eta^2 = .425$. Males ($M = 2.71$, $SE = .18$) were thought to have more dangerous objects in there luggage than females ($M = 2.08$, $SE = .18$).

Main effects for the race of the passenger, $F(2, 88) = 2.920$, $p = .059$, $\eta^2 = .062$, and age of the passenger, $F(1, 88) = .584$, $p = .447$, $\eta^2 = .007$, were non-significant. The interactions between the passengers' gender and race, $F(2, 88) = .883$, $p = .483$, $\eta^2 = .019$, gender and age, $F(1, 88) = 2.584$, $p = .112$, $\eta^2 = .029$, race and age, $F(2, 88) = 2.022$, $p = .138$, $\eta^2 = .044$, and gender, race, and age, $F(2, 88) = .461$, $p = .632$, $\eta^2 = .010$, were also not significant.

Statement 3: "I will most likely stop this person's luggage."

The one way ANOVA for statement #3 revealed a significant main effect of gender $F(1, 88) = 54.934$, $p < .001$, $\eta^2 = .384$, and race $F(2, 88) = 4.128$, $p < .001$, $\eta^2 = .086$. Males ($M = 2.73$, $SE = .21$) were found to be more likely to be stopped than females ($M = 2.15$, $SE = .22$). White passengers ($M = 2.41$, $SE = .25$) and Black passengers ($M = 2.41$, $SE = .20$) although not significantly different from each other, were judged as significantly less likely to be stopped than Asian passengers ($M = 2.51$, $SE = .29$).

The main effect for age, $F(1, 88) = .579$, $p = .449$, $\eta^2 = .007$, and the interactions between gender and race, $F(2, 88) = 2.155$, $p = .122$, $\eta^2 = .047$, gender and age, $F(1, 88) = 1.898$, $p = .172$, $\eta^2 = .021$, race and age, $F(2, 88) = 1.687$, $p = .191$, $\eta^2 = .037$, and gender, race, and age, $F(2, 88) = .478$, $p = .621$, $\eta^2 = .011$, were all revealed to be non-significant.

Statement 4: "I will most likely pass (not STOP) this person's luggage."

The one-way ANOVA for statement #4 was found to be significant for gender $F(1, 88) = 48.177$, $p < .001$, $\eta^2 = .354$, and race $F(2, 88) = 3.811$, $p < .05$, $\eta^2 = .08$. Females

(M = 3.79, SD = .30) were more likely to not have their bag stopped than males (M = 3.22, SD = .50). White (M = 3.56, SE = .33) and Black passengers (M = 3.52, SE = .23) were judged as significantly less likely to be stopped compared to the Asians (M = 3.43, SE = .26), though there was not a significant difference between Whites and Blacks.

Main effects for age, $F(1, 88) = .799$, $p = .374$, $\eta^2 = .009$, and the interactions between gender and race, $F(2, 88) = 1.557$, $p = .217$, $\eta^2 = .034$, gender and age, $F(1, 88) = .726$, $p = .397$, $\eta^2 = .008$, race and age, $F(2, 88) = 1.346$, $p = .266$, $\eta^2 = .030$, and gender, race, and age, $F(2, 88) = .452$, $p = .638$, $\eta^2 = .010$, were all found to be non-significant.

Statement 5: "I think this person looks suspicious."

For statement #5 the main effect for gender alone was found to be significant $F(1, 88) = 49.917$, $p < .001$, $\eta^2 = .362$. Males (M = 2.67, SE = .11) were found to look more suspicious than females (M = 1.97, SE = .18).

The main effects for race $F(2, 88) = 1.611$, $p = .206$, $\eta^2 = .035$, and age, $F(1, 88) = 3.002$, $p = .087$, $\eta^2 = .033$, of the passengers was revealed to be not significant. Also, the interactions between passengers' gender and race, $F(2, 88) = 1.534$, $p = .221$, $\eta^2 = .034$, gender and age, $F(1, 88) = .860$, $p = .356$, $\eta^2 = .010$, race and age, $F(2, 88) = 1.079$, $p = .344$, $\eta^2 = .024$, and gender, race, and age, $F(2, 88) = .414$, $p = .662$, $\eta^2 = .009$, were revealed to be non-significant

Statement 6: "I think this person would lie to me."

For statement #6, the main effect for gender $F(1, 88) = 43.347$, $p < .001$, $\eta^2 = .330$, and the gender-age interaction $F(1, 88) = 4.107$, $p < .05$, $\eta^2 = .045$ were found to be significant. Males ($M = 2.97$, $SE = .24$) were found to be more likely to lie, than females ($M = 2.51$, $SE = .24$). Among male passengers, young passengers ($M = 2.94$, $SE = .33$) were found to be less likely to lie than older passengers ($M = 3.02$, $SE = .31$). On the contrary, as can be seen in Figure 8, younger females ($M = 2.56$, $SE = .35$) were more found to be more likely to lie than older females ($M = 2.40$, $SE = .49$). The perceived difference between the older passengers was greater than the difference between the younger passengers.

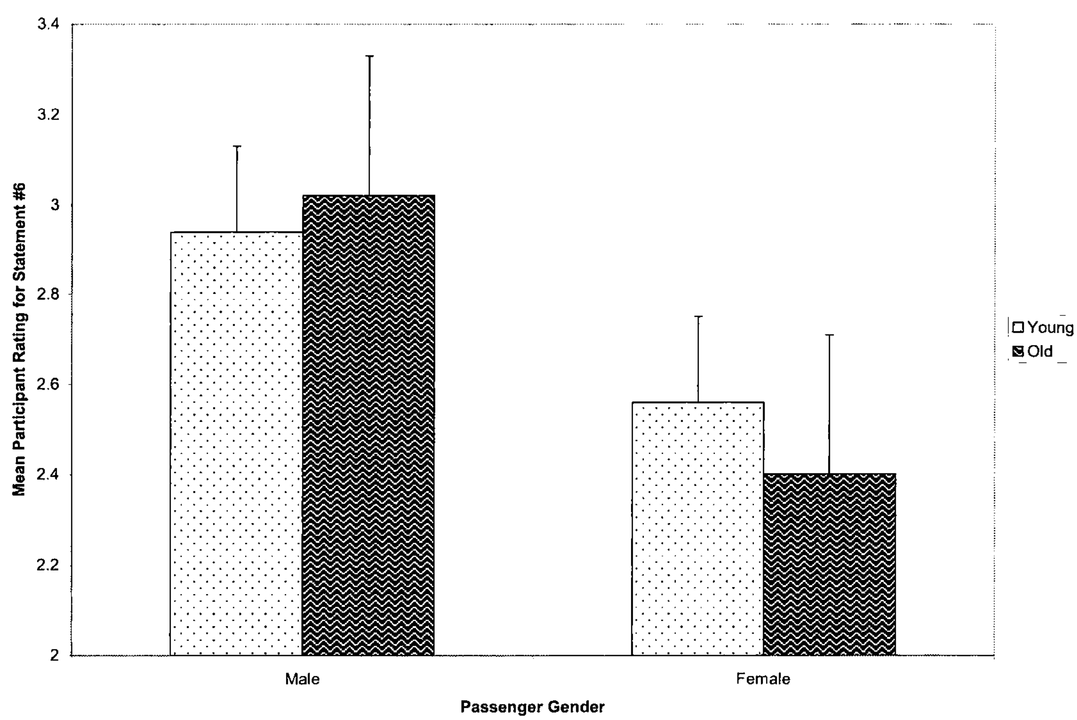

Figure 8. Graph of the interaction between gender and age for statement #6: "I think this person would lie to me."

The main effects for passengers' race, $F(2, 88) = 1.120$, $p = .331$, l $\eta^2 = .025$, and age, $F(1, 88) = .019$, $p = .891$, $\eta^2 = .000$, were revealed to be non-significant. The interactions between the passengers' gender and race, $F(2, 88) = 1.410$, $p = .250$, $\eta^2 = .031$, race and age, $F(2, 88) = 2.272$, $p = .109$, $\eta^2 = .049$, and gender, race, and age, $F(2, 88) = .316$, $p = .730$, $\eta^2 = .007$, were revealed to be non-significant.

Statement 7: "I think this person might be dangerous."

For statement #7, the main effect for gender alone was found to be significant, $F(1, 88) = 59.111$, $p < .001$, $\eta^2 = .402$. Similar to the previous statements, males ($M = 2.59$, $SE = .19$) were thought to be more dangerous than females ($M = 1.98$, $SE = .19$).

The main effects for passengers' race, $F(2, 88) = 2.885$, $p = .061$, $\eta^2 = .062$, and age, $F(1, 88) = 1.098$, $p = .298$, $\eta^2 = .012$, were found to be non-significant. The interactions between the passengers gender and race, $F(2, 88) = .988$, $p = .376$, $\eta^2 = .022$, gender and age, $F(1, 88) = 1.485$, $p = .226$, $\eta^2 = .017$, race and age, $F(2, 88) = 1.809$, $p = .170$, $\eta^2 = .039$, and gender, race, and age, $F(2,88) = .571$, $p = .567$, $\eta^2 = .013$, were all revealed to be non-significant.

Summary of results

For all of the statements that the participants were asked to rate, there was a main effect for gender, i.e., male passengers were perceived as significantly different from the female passengers. For instance, male passengers were more likely to be thought of as dangerous and willing to lie. Also the participants said that they were more likely to stop male passengers than female passengers. The different races had a significant effect for statements #1 (*"I think this person is attractive."*) and #4 (*"I will most likely pass (not STOP) this person's luggage."*), which indicates that the decision to stop a bag could be partially due to the race of the passenger. The difference between young and old passengers was found to have a significant effect for statement #1 alone (*"I think this person is attractive."*). Younger passengers were found to be more attractive than older passengers. Based on this pilot test, we hypothesized that these inherent biases would affect screener performance in the real world. At most airports, the luggage screeners for carry-on luggage are able to see the passengers themselves, therefore is a strong possibility that there must be some interaction between them. This leads us to the luggage screening study described below.

The Luggage Screening Study

As found in the pilot study, participants verbalized significant opinions about male and female passengers and between different races just by visually observing the pictures. The next step was to examine whether the social-cognitive biases that were present in the pilot test would influence the decision making process in an actual luggage screening context. What makes this study unique is the focus on social-cognitive biases which differs from existing studies that have focused on either the luggage screening process (Hilscher, 2005; McCarley et al., 2004) or on the decision making made by the luggage screener (Brown, et al., 2008; Madhavan et al., 2007; Parasuraman et al., 1987). Having established in the pilot study that social-cognitive biases do exist in the way people perceive others just by looking at them, this study was designed to examine whether these biases will influence active decision making during the luggage screening process.

Method

Participants

Participants were 96 Old Dominion University undergraduates completing the study for class credit. The study took approximately 1 hour to complete, for 1 hour research credit.

Materials

Gateway computers were used, which were running Microsoft XP with service pack 2. These computers were used to run a computer simulation of airline luggage screening created by E-prime 2.0.

Procedure

Participants were randomly assigned to a control group, (n=24), and three experimental groups (n= 72) in a 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, no-anchor, post-anchor) design. Participants filled out an entrance questionnaire prior to running the study (see appendix B). The task was for participants to detect the presence of dangerous objects in x-ray images of passenger luggage. Participants scanned 200 images distributed into two blocks of 100 images each. At the beginning of each block, participants were shown the five targets that they need to look for in the 100 bags that were to follow (see appendix C). For the experimental groups, the appearance of the luggage image on each trial was preceded by the picture of a random passenger (drawn from a new set of 100, that includes the following races: White, Black, Asian, Middle Eastern, and Hispanic) to whom the bag supposedly "belongs". For each of the experimental groups, half the participants performed the task under high time pressure (2 seconds for each luggage image exposure) and the other half performed under low time pressure (6 seconds for each luggage image exposure). After deciding whether to pass the bag or not, participants rated their confidence in their decision on a five point scale.

Participants in the *pre-anchor group* (n = 24) were first required to answer two statements about the passenger *before* the x-ray image appears. After answering the statements, they clicked "next" and the x-ray image was brought up onto the screen, after which, they rateed their confidence on their decision of whether or not to pass the bag. The two statements that were used were statement #1: *"I think this person is attractive"* and statement #3 *"I will most likely stop this person's luggage."* We chose these two statements because there were large main effects as well as interactions among variables for these statements in the pilot test reflecting strong social-cognitive biases. Thus, these two statements appear to be the most powerful indicators of the existence of such cognitive biases.

For participants in the *no-anchor group* (n = 24), after 4 seconds of the passenger appearing the x-ray image of a bag appeared beside the passenger. These participants were not required to answer any questions about the passengers, but they still rated their confidence on their decision to pass or not pass the luggage.

For the *post-anchor group* (n = 24), the program ran the same experimental procedure as for the no-anchor group. However, participants were required to answer the two statements answered by the pre-anchor group about each passenger *after* the participant has chosen whether or not to pass the bag and rated their confidence in that decision.

Once they have answered the questions and clicked "next", the next picture of a passenger appeared. This procedure continued until the end of the trial block.

A control group (n = 24) performed the screening task alone without observing the pictures of passengers. Of these 24 participants, 12 participants performed under high time pressure and the other 12 performed under low time pressure. This group served as a baseline for performance under each level of time pressure without the additional anchoring information provided by the passengers' pictures.

The base rate for the targets is 50% for all groups. Participants were not informed about the base rate. At the end of each trial, participants received feedback in the form of a text message, telling them whether they made a correct decision or not. Also they received a cumulative percent correct score shown after each decision to pass or not pass the bag. At the end of the experiment, participants filled out a final "task knowledge" questionnaire (see appendix D). The participant with the highest score for their experiment session received a piece of candy as a prize.

Data Analysis

The data was analyzed for normality. If normality is violated, box plots were used to examine which sections of the data were outliers, and the outliers were brought to 2 standard deviations away from the mean. A 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, post-anchor, no-anchor) X 5 (passenger race: White, Black, Asian, Middle Eastern, Hispanic) X 2 (passenger gender: male vs. female) mixed measures ANOVA was ran for each dependent variable. For the interactions that were significant, a mixed measures ANOVA was ran, followed by paired t-tests with a bonferroni correction. Age was not included in this analysis since the data in the pilot study showed that age was not a significant factor for most of the statements that participants were asked to judge.

The dependent variables of interest are:

- Hit rate - the probability of correctly detecting a target.
- False alarm rate - probability of incorrectly saying there is a target present, when there is no target
- Sensitivity (d') – the perceptual ability to differentiate between a target and non-target.
- Response criterion setting (c) – the propensity to generate "yes" or "no" responses.
- Confidence- belief in how accurate one's response is
- Data from the "Task knowledge questionnaire"

The data analytic strategy was based on a two-pronged approach. We used hit rate and false alarm rate as pure performance measures which directly measure a participant's performance on the task. In addition, we used the signal detection variables sensitivity and response criterion setting in order to understand the decision making processes that drive performance (resulting in hit and false alarms). For instance, the higher the hit rate and the lower the false alarm rate, the higher the participant's sensitivity will be. This means that participants are correctly detecting targets when they are present, and correctly recognizing when there is not a target present, indicating good decision making. We contend that it is important to understand both the decision making process as well as the performance effects in order to generalize the results of this study to an actual luggage screening context.

Hypotheses

1. Effects of time pressure and anchor

- Based on the data from the pilot test, we hypothesize that participants will judge whether to pass the bag based more on the passenger's picture than the x-ray image when time pressure is high and they will have less confidence in their decision. This is because when the time pressure is high, the participant will have only two seconds to detect the target. Due to this time constraint, they will rely more on the passenger and how dangerous the passenger "appears" as a heuristic to decide to stop or pass the bag. This will lead to an increase in false alarm rates due to an inflation of "target present" responses and will be confirmed by their responses on the "Task knowledge questionnaire". Since their decisions will be based on the passenger's picture, their sensitivity to the target (i.e., their ability to detect the target) will not change per se; however, their response criterion will change as a function of more "yes" responses.

- Under low time pressure, participants will base their decision to pass or not pass the bag based on the x-ray image (again, supported by their responses on the "Task knowledge questionnaire") as they will have more time to look at the bag. This will lead to a higher hit rate, lower false alarm rate, and higher confidence in their decision than the high time pressure group. Participants' sensitivity to the target objects will increase (as a larger exposure time will improve their target detection abilities), while their response criterion setting will stay constant.
- For participants that have an anchor either before or after, they will be more likely to base their decisions to pass the bag or not on the passenger's picture, and therefore have less confidence in their decision. Here we hypothesize shifts in response criterion setting (a shift in "yes" or "no" responses) while sensitivity (detection ability) remains the same.
- The post-anchor group will take more trials to base whether they pass the bag or not on the passenger's picture relative to the pre-anchor group.
- For participants that do not have the anchor, the decision to pass the bag could be based on either the passenger's picture or the x-ray image. This will be determined by the degree of time pressure. When they base their decision on the passenger, their confidence will be lower than if they base it on the x-ray image.

2. Effects of gender and race of passengers

- In the pilot test, participants judged males as significantly more likely to have their baggage stopped, and were significantly more likely to be on the negative side of all of the statements participants were told to rate. Therefore, in the screening task, passengers that are male will be more likely to have their bag stopped compared to female passengers.

- Asian passengers in the pilot study were judged as significantly more likely to have their baggage stopped compared with the White and Black passengers. Therefore, in the screening study, Asian passengers will have their bags stopped more often than both White passengers and Black passengers. The difference between the White and Black passengers will not be significantly different.

Results

Due to the complexity of the experimental design, the study was broken up into two different sets of variables. Hit rate and false alarm rate are grouped under "performance analysis", and sensitivity and response criterion setting are grouped under "signal detection analysis". Also, the confidence ratings and task knowledge questionnaire did not contain any significant results, so these sections were left out.

Performance Analysis

Hit Rate

All "p" values below .05 are statistically significant. The hit rate data was normally distributed with no outliers, therefore no data cleaning was necessary.
A 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, post-anchor, no-anchor) X 5 (passenger race: White, Black, Asian, Middle Eastern, Hispanic) X 2 (passenger gender: male vs. female) mixed measures ANOVA was used to analyze the hit-rate data. The mixed measures ANOVA revealed that there was a significant main effect for time pressure ($F(1,66) = 56.18$, $p \leq .001$, $\eta^2 = .46$). Participants under low time pressure had higher hit rates ($M = .82$, $SE = .01$) than the participants high time pressure ($M = .69$, $SE = .01$). All other main effects and interactions were statistically non-significant.

False Alarm Rate

The data set was not normally distributed, and the box plots revealed 12 outliers, which were brought in to within 2 standard deviations of the mean. This made the data set normally distributed. A 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, post-anchor, no-anchor) X 5 (passenger race: White, Black, Asian, Middle Eastern, Hispanic) X 2 (passenger gender: male vs. female) mixed measures ANOVA, similar to that used for the Hit Rate analysis, was used to analyze the False Alarm Rate data. The results of the ANOVA revealed that there was a significant main effect for passenger gender ($F(1, 66) = 7.81, p = .007, \eta^2 = .11$), and time pressure ($F(1, 66) = 10.80, p = .002, \eta^2 = .14$). Participants had a significantly higher false alarm rate for male passengers ($M = .16$, $SE = .01$) than they did for the female passengers ($M = .13$, $SE = .01$). Participants under high time pressure ($M = .19$, $SE = .02$) had significantly more false alarms than did the participants under low time pressure ($M = .11$, $SE = .02$). All other main effects and interactions were statistically non-significant.

Signal Detection Analysis

Sensitivity: d'

Sensitivity, also known as discriminability index, is a measure of how far apart the signal and noise curves are for an individual (Heeger, D., 1997). In other words, this implies that the more the signal (or, target) stands out from back ground clutter, the easier it will be for the human to locate the target. So, in this experiment, the higher the sensitivity it implies that the easier it was for the participant to distinguish the target from non-targets. Specifically, higher the sensitivity, the better was the detection performance of the participant.

The sensitivity data was normally distributed with no outliers, therefore no data cleaning was necessary. A 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, post-anchor, no-anchor) X 5 (passenger race: White, Black, Asian, Middle Eastern, Hispanic)

X 2 (passenger gender: male vs. female) mixed measures ANOVA was used to examine the data obtained for sensitivity. The main effect of time pressure ($F(1, 66) = 47.34$, $p \leq .001$, $\eta^2 = .418$) and the interaction between passenger gender, passenger race, and anchor ($F(8, 264) = 3.34$, $p = .001$, $\eta^2 = .092$) were both significant. Under low time pressure ($M = 2.23$, $SE = .07$) participants had higher sensitivity than did participants under the high time pressure ($M = 1.54$, $SE = .07$).

To further analyze the relationship between passenger gender and passenger race within each anchor group, a 2 (gender) X 5 (race) mixed measures ANOVA was run within each of the anchor groups and is described in the following sections.

i) *Pre-anchor*: All of the main effects were non-significant which include the following: passenger gender and passenger race. The interaction between passenger gender and passenger race was significant ($F(4, 92) = 2.863$, $p = .028$, $\eta^2 = .102$). Sphericity was violated, and by using the Greenhouse-Giesser (p=.063), Huynh-Feldt (p=.057), and the Lower Bound (p=*.104*) correction the interaction became statistically non-significant. All of the other interactions were found to be non-significant which include the following: passenger gender by time pressure, passenger race by time pressure, and passenger gender by passenger race by time pressure.

ii) *No-anchor*: All of the main effects were non-significant which include the following: passenger gender and passenger race. The only interaction that was found to be significant was the interaction between passenger gender and passenger race ($F(4, 92) = 2.621$, $p = .04$, $\eta^2 = .102$). Sphericity was violated and by using the Greenhouse-Giesser (p=.048), and Huynh-Feldt (p=.04) correction the interaction was still statistically significant. However, using the Lower bound (p=.119) correction rendered the interaction statistically non-significant. All of the other interactions were found to be non-significant including the following: passenger gender by time pressure, passenger race by time pressure, and passenger gender by passenger race by time pressure.

Participants had a non-significant difference between the male and female passengers for the following races: Black passengers (male: $M = 1.75$, $SE = .14$; female: $M = 1.70$, $SE = .16$), Asians (male: $M = 1.63$, $SE = .18$; female $M = 1.89$, $SE = .14$), Middle Eastern (male: $M = 1.63$, $SE = .18$; female: $M = 1.83$, $SE = .14$), and Hispanic (male: $M = 1.78$, $SE = .19$; female: $M = 2.13$, $SE = .24$). However, for White passengers, participants had higher sensitivity for detecting targets when the passengers were male

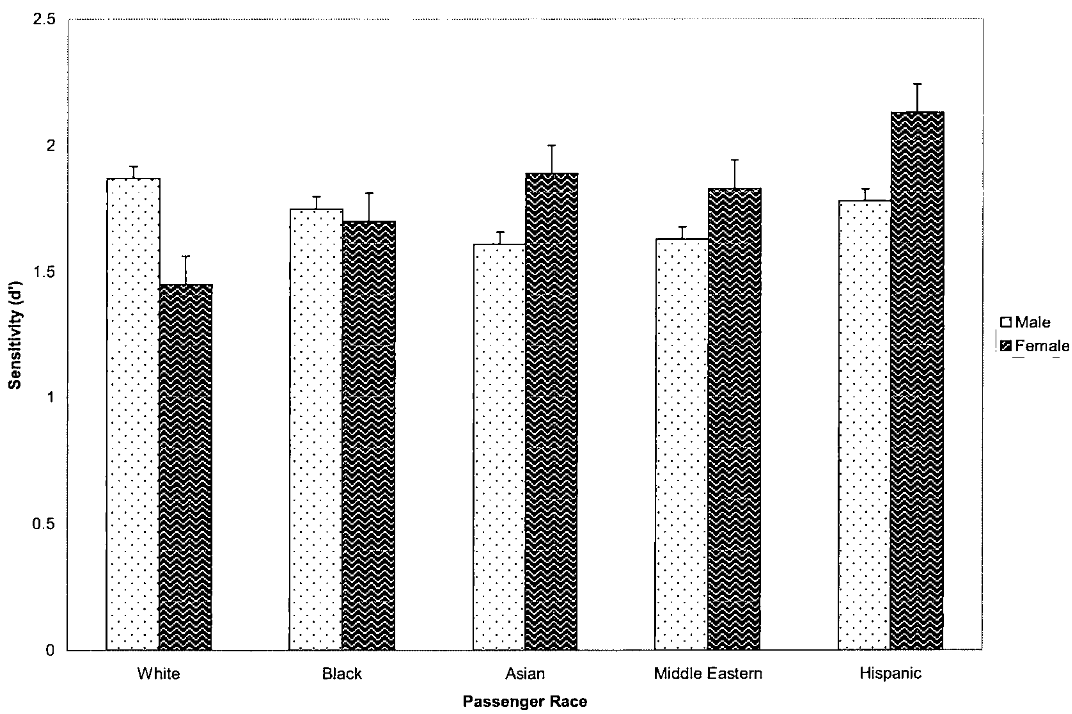

Figure 9. Passenger gender by passenger race interaction for the no-anchor group in sensitivity analysis.

compared to females (male: $M = 1.87$, $SE = .17$; female: $M = 1.45$, $SE = .16$; $t = 2.786$, $p = .011$). See Figure 9.

iii) *Post-anchor*: All of the main effects were non-significant which include the following: passenger gender, and passenger race. The interaction between passenger gender and passenger race was statistically non-significant.

Response Criterion Setting: c

Response Criterion Setting is the propensity to generate "yes" or "no" responses. This means hat the human sets an arbitrary threshold or "cutoff point" for responding; when the signal to noise ratio is perceived as being above this level, the participant will indicate a target is present. Likewise, if the ratio is perceived as being below this threshold, they will indicate that a target is not present (Heeger, D., 1997). Typically, if the participant sets his/her response criterion high such that the criterion setting is high or positive, responding is said to be conservative. This means than the participant has a propensity to say "no" more often than "yes". The opposite occurs when a participant sets his/her response criterion low. In such cases, responding is said to be more liberal; this will result in low or negative criterion settings and a general tendency to say "yes" more frequently than "no".

The data set was not normally distributed, and the box plots revealed 12 outliers, which were brought in to within 2 standard deviations of the mean. This made the data set normally distributed. A 2 (time pressure: high vs. low) X 3 (anchor: pre-anchor, post-anchor, no-anchor) X 5 (passenger race: White, Black, Asian, Middle Eastern, Hispanic) X 2 (passenger gender: male vs. female) mixed measures ANOVA was used to analyze the response criterion setting data. The ANOVA indicated a significant main effect of passenger race ($F(4, 264) = 8.48, p \leq .001, \eta^2 = .114$) and an interaction between passenger gender, time pressure, and anchor ($F(2, 66) = 3.50, p = .036, \eta^2 = .096$). Participants had significantly more conservative response criteria for passengers of Hispanic race ($M = 1.19, SE = .09$) compared to all the other races (White $M = .85, SE = .05, t = 3.97, p \leq .001$; Black $M = .83, SE = .05, t = 4.33, p \leq .001$; Asian $M = .82, SE = .05, t = 4.35, p \leq .001$; Middle Eastern $M = .92, SE = .06, t = 3.14, p = .002$). This means that participants were less likely to say there was a target present when confronted with a Hispanic passenger relative to passengers of other races.

To further examine criterion settings within anchor groups, a 2 (gender) X 2 (time pressure) mixed measures ANOVA was run within each of the anchor groups described below.

i) *Pre-anchor*: All of the following main effects were non-significant: passenger gender and time pressure. The interaction between passenger gender and time pressure was found to be non-significant as well.

ii) *No-anchor*: For this group all the main effects were non-significant which include passenger gender and time pressure. The interaction between passenger gender and time pressure ($F(1, 22) = 8.391, p = .008, \eta^2 = .276$) was found to be statistically significant. See figure 10. One tailed t tests were used for post hoc analysis of the interaction. The t-tests revealed that there was a non-significant difference for participants' response criterion setting for the male versus female passengers under low time pressure. However, under high time pressure criterion setting for male passengers ($M = 1.14, SE = .71$) was significantly higher than for female passengers ($M = .84, SE = .70, t = 2.18, p = .036$).

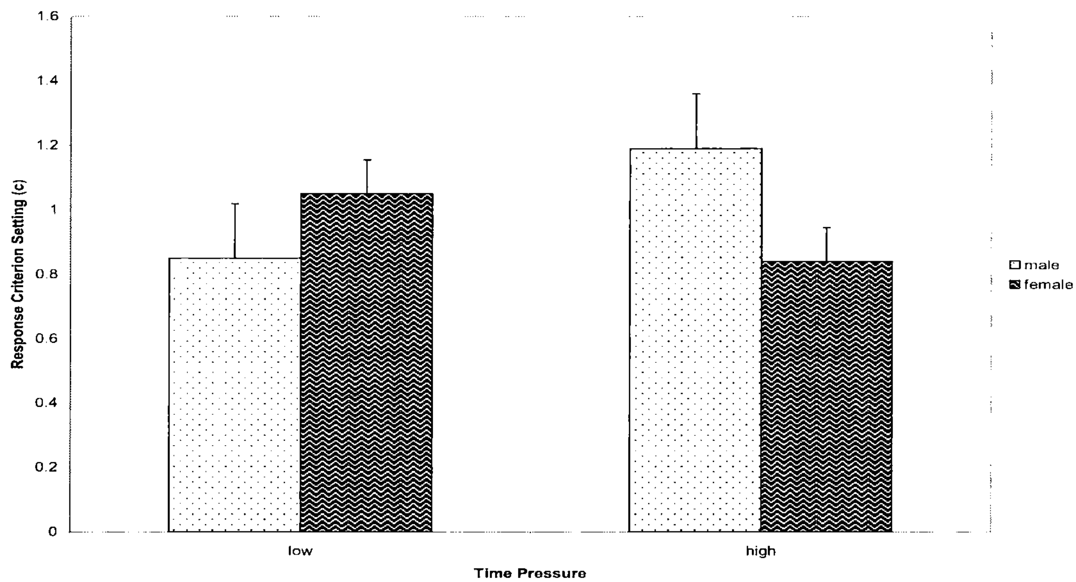

Figure 10. Passenger gender by time pressure interaction for the no-anchor group in response criterion settings analysis.

iii) *Post-anchor*: As with the pre-anchor group, all of the main effects were non-significant, which include the following main effects being non-significant: passenger gender and time pressure. The interaction between passenger gender and time pressure was also found to be non-significant.

Discussion

Most luggage screening studies to date have focused on either mechanics of the luggage screening process (Hilscher, 2005; McCarley et al., 2004) or on the decision making of luggage screeners (Brown, et al., 2008; Madhavan et al., 2007; Parasuraman et al., 1987). What has seldom been addressed in these studies, in particular the decision making studies, is a consideration of extraneous factors, namely social-cognitive variables, that can affect the decision making process. One of these factors is the passenger himself/herself, and any biases the screener may have towards the passengers. The purpose of this thesis was to examine whether such social-cognitive biases as age bias, gender bias, and racial bias would influence decision making during the luggage screening process. We were also interested in examining the role of time pressure, and if the screening process would be affected by decision heuristics such as anchoring.

Role of time pressure

Time pressure plays an important role in everyday life. Sometimes time pressure can be beneficial, it helps to encourage the timely completion of work. However, time pressure can also be harmful leading to lapses in performance, especially in the case of detecting dangerous objects such as in this study. Consistent with most existing research (Harreveld, et al., 2007; Light, et al., 2006; Milton, et al., 2008) the results of this study revealed a significant effect of time pressure on decision making in the luggage screening context.

When participants were under high time pressure, they had significantly fewer hits for dangerous objects than did the participants under low time pressure. This was true across all experimental conditions indicating that the low time pressure group had a higher probability of correctly identifying targets compared to the high time pressure group. The higher hit rate for the low time pressure group also led to this group having a higher sensitivity for detecting targets and ultimately demonstrating better performance than participants under high time pressure. This is most likely due to the simple fact that the participants under low time pressure have more time to search for the object. High time pressure, in addition to degrading hit rates, also led to higher false alarm rates; false alarms take up valuable time in the real world since the bag must be opened and physically checked with no ultimate long term benefit. The higher false alarm rates were clearly due to the fact that the participants had less time to search the bag. Research has revealed that in general humans are reasonably efficient at localizing a target (i.e., pointing to a general area that might contain a target), but are not necessarily good at identifying the target accurately (McCarley, et al., 2004). In this study, it is possible that under high time pressure participants localized areas where the target might potentially be rather quickly, thereby generating several false alarms. However, their inability to correctly identify real targets under time pressure simultaneously decreased their hits. These findings support our hypothesis that participants are relying more on the picture of the passenger when under high time pressure, than on the luggage image itself. While the participants responses under low time pressure support the hypothesis that they will base their decisions more on the x-ray image, with higher hit rates, and lower false alarm rates.

Time pressure also affected response criterion settings. Response criterion setting is a threshold that a person sets internally for their responding. When the signal is above this internal threshold, the participant typically generates a "target present" response, when the perceived signal is below this threshold, they tend to generate a "target absent" response (Heeger, D., 1997). Under low time pressure participants had a lower response threshold for male passengers than female passengers. This implies that participants were more liberal in their responding and said "yes" more often when passengers were male than female passengers under low time pressure. When the participants were under low time pressure, they had more time to search the luggage image, and therefore likely had more time to think or strategize. This could logically have led them to using reason to say males are more aggressive and therefore led participants to say "yes" more often (Graham & Wells, 2001) when the luggage belonged to a male passenger. However, the opposite was true for high time pressure; participants indicated a higher response threshold, so were more conservative and generated more "no" responses for male passengers when compared to female passengers. At first glance this appears contradictory to our expectations that males are perceived as more capable of aggression than females. However, this unexpected trend under high time pressure could possibly be due to gender bias. When time pressure was high and participants did not have sufficient time to think of decision strategies, participants perhaps prone to the typical gender bias wherein they showed preferential treatment to male passengers relative to female passengers (Heilmann, 2001; McKay, et al., 2001). This could have led to a greater tendency to 'discount' or allow male passengers to go unchecked, thereby leading to a higher or more conservative response threshold for the male passengers. This is evidence for the hypothesis that participants response criterion setting will change based on time pressure and their own personal biases towards the passengers.

Role of anchoring

While time pressure played a significant role in the results, we found that anchoring also played a significant role in impacting decision making. Anchoring is the tendency for decision makers to focus on one particular piece of information and use that to base subsequent decisions (Tversky and Kahneman, 1974). The anchoring heuristic works by giving people a reference point to help them make a decision. For example, in an early experiment on anchoring, when asked a question, "is the percentage of African countries in the United Nations greater than or less than a 25 percent?" (Tversky et al., 1974) participants generally used the "25 percent" to base their judgment of exactly what percentage of African countries is in the United Nations. This worked even when the percentage was randomly selected in front of the participant. In general, if an anchor is present, the anchor can influence the decision making process of a participant, and therefore influence overall performance.

In this study, the "anchor" was a series of questions drawing attention to the passenger to whom the luggage belonged. The anchor was either presented at the beginning of the trial immediately following the passenger image (pre-anchor group) or at the end of the trial (post-anchor group). In some cases, the anchor was not present at all (no-anchor group). Results revealed that when participants had the anchor, either before (pre-anchor) or after (post-anchor) they saw the luggage image, it appeared to suppress rather than enhance the social-cognitive biases, relative to the participants in the no-anchor group. The results also revealed significant interactions between cognitive anchoring and race and gender of passengers on performance. Contrary to our initial expectations and hypothesis, this anchoring effect was particularly salient when time pressure was low and participants had more time to 'attend to' the passengers.

The results suggest that participants used their personal biases as 'anchors' to help in the decision making process, particularly when they had time to pay more attention to passengers. Research has revealed that minority races, such as Hispanics, have been associated with negative behavioral connotations. For instance studies of police officers and their decisions to shoot or not shoot (Correl et al., 2007; Plant et al.,2005), have demonstrated that police were more likely to shoot suspects of minority races even when they did not have a gun. The higher hit rate associated with the Hispanic male passengers in our study could possibly be due to the interaction of these social-cognitive biases. Based on the surmise that the participant already had a negative association with male members of minority races, it is possible that they were more suspicious of the two passenger categories (men and minority races) during the luggage screening process. Therefore, when searching through the x-ray image, they perhaps used gender and race as decision heuristics, paid more attention to the items in bags that were accompanied by male passengers of Hispanic race, and detected the targets more accurately when they were indeed present. This actually suggests a potential benefit of social-cognitive biases in this instance! However, it must be noted that this effect was only observed under conditions of low time pressure when there was ample time to attend to the bags.

The existence of social-cognitive biases in detection behavior is supported, albeit in a slightly different manner, by the false alarm analysis as well. Similar to the effects found in the hit rate data, male Hispanic passengers had a higher false alarm rate associated with them than female Hispanic passengers. Interestingly, the false alarm effect was found under conditions of high time pressure rather than low time pressure. This indicates the negative effects of social-cognitive biases. Although target detection was benefited to an extent due to anchoring under low time pressure, high time pressure led to negative effects in the form of higher false alarms.

Similar effects for racial bias were found in participants' criterion settings wherein participants had a more conservative response criterion setting for certain passenger races. This means that participants were more conservative and had to have a higher subjective evidence of a target being present before they would indicate that one was present. This is very interesting since we have already seen in the false alarm rate data that participants also had a higher false alarm rate for the male Hispanic passengers compared to the other races of passengers. At first glance the conservative criterion setting for Hispanic passengers appears to contradict the finding that participants stopped luggage more (i.e., said "target present" more) in response to these passengers. Is it possible that participants' lower response criterion for the female Hispanic passengers relative to male Hispanic passengers has raised the criterion setting for the Hispanic passengers overall, although this is not evident in a statistically significant difference between the male and female Hispanic passengers per se. As hypothesized, the participants had higher false alarm rates for minority passengers than they did for the White passengers.

As hypothesized, participants had a higher false alarm rate when the passenger was male which would lead them to being stopped more. Also the interaction between passenger gender and time pressure for the no-anchor group was an interesting indication of how not providing an anchor significantly impacted performance more than providing anchors in this study. When time pressure was low, participants had a more liberal response to the male passengers thereby stopping the luggage belonging to male passenger more often. Conversely, participants had a more conservative response towards the female passengers, thereby stopping their luggage with lower frequency than for male passengers. Surprisingly, the opposite became true under high time pressure; participants had a higher, more conservative response to the male passengers, while they had a more liberal response to the female passengers. It is possible that when participants had time to think about the passenger and the luggage, as in the case of the low time pressure group, their biases against male passengers were mitigated to an extent leading them to become more conservative. The opposite might be true for female passengers wherein the index of suspicion possibly increased with the availability of more time to scan the image.

The data from the pilot test indicated that participants rated the female passengers as more attractive than male passengers. This could have potentially impacted performance in the main study. However, contrary to the pilot study, the main luggage screening study did not reveal any significant differences in the ratings of attractiveness for the male and female passengers, nor for the different races. A possible reason for the difference between the pilot test and the main study could be the fact that in the main study, the participants were focusing mostly on the luggage screening task which was the primary task; the "attractiveness" questions were just a secondary task and served as an anchor. Therefore, we can surmise that the likelihood of attractiveness being confounded with race and gender in the main study was relatively low.

Implications for Training and Design

The implications of this study are numerous. Foremost, this study shows that social-cognitive biases may be present and can influence the decision making process of luggage screeners. This has implications for the ways in which luggage screening stations are set up are airports. One such change would be to ensure that screeners cannot see the passengers themselves in order to mitigate biases. This would ensure that screeners are basing their decision to pass the bag or not on the actual luggage and not on the passenger. However, this suggestion is a double edged sword given that some of our results actually point to social-cognitive biases benefiting the screening process. Another recommendation would be to ensure there are a sufficient number of screening stations to increase the amount of time screeners at each individual station can examine the luggage image. This is extremely important since when under high time pressure, participants made significantly more mistakes relative to participants that were not under the high time pressure.

One important finding of this study is that even though the social-cognitive biases are inherently present, these biases can be mitigated if the luggage screener is made aware of them via anchoring (or, specifically drawing their attention to the passengers by asking them questions about the passengers). This could be achieved in the real world through training programs to make the luggage screeners aware of their social-cognitive biases. One way of doing this is a simple Implicit Association Test in which participants would associate different races and genders with positive and negative words. The reaction times to the different races and genders towards particular positive or negative words can then be compared and this can be used to create awareness of inherent biases among screeners (Greenwald, McGhee, and Schwartz, 1998).

Limitations and Conclusions

One of the limitations of this study is that the participants were undergraduate university students, and therefore do not have the training of real world luggage screeners. Another limitation is that we did not introduce tangible consequences for correct and incorrect decisions. In the real world, there are severe consequences when a dangerous object is missed in the security scan ranging from loss of lives, to eroding of morale and to property damage. On the other hand, when a security screener has a false alarm, it takes time to search through the bag, and therefore costs the airport money in the form of man hours. Furthermore, the more false alarms there are, the more time it takes passengers to get through security, and time is money in the airline industry. In future studies, placing consequences in the luggage screening task will be an important part of creating more realism.

Despite these limitations, the results of this research have demonstrated how social-cognitive biases affect people in the real world and how they could subsequently impact the luggage screening process and eventually national security. Through the use of computer simulation we have also shown that social-cognitive biases actually do have an effect on the detection of anomalies during luggage screening wherein decision makers use these inherent biases as decision heuristics, particularly under conditions of time pressure. Importantly, our results revealed a clear relationship between decision making process and performance. Through the use of both signal detection variables and performance variables in our analyses, we are able to draw conclusions not just about the impact of social-cognitive variables on performance, but also the processes that led to the observed behaviors. This is especially important in the current security conscious world we live in and for training of personnel for optimal decision making that is free of biases and prejudices. An associated goal of this research is to the design community for improving the design of imaging equipment and luggage screening stations.

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Appendix A

Imagine that the person in this photograph is a traveler at an airport. We are interested in how YOU feel about this person and the luggage he/she might carry. In pictures where there are children, please focus on the adult alone. Indicate whether you agree or disagree with the following statements on a scale of 1 to 5. We are just interested in your opinions and there are no correct or wrong answers. Your answers are confidential. Please give us your most honest opinion.

1. I think this person is attractive.

1 ------------------------2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

2. This person might have a dangerous object in his/her luggage.

1 ------------------------2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

3. I will most likely stop this person's luggage.

1 ------------------------2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

4. I will most likely pass (NOT stop) this person's luggage.

1 ------------------------ 2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

5. I think this person looks suspicious.

1 ------------------------ 2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

6. I think this person would lie to me.

1 ------------------------ 2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

7. I think this person might be dangerous.

1 ------------------------ 2----------------------3--------------------4------------------------5

disagree completely disagree somewhat neutral agree somewhat agree completely

Appendix B

Entrance Questionnaire

1) Status (circle one) Undergrad Grad Faculty Staff N/A

2) If Undergrad, please circle year. Freshman Sophomore Junior Senior Senior

3) Department / Major ____________________

4) Date of Birth (MM/DD/YY) ______/______/______ 5) Age ___________

6) Sex (circle one) Male Female

7) Race (circle one) African American Caucasian Asian Hispanic Native American Other

8) How often do you use a computer? (circle one)

5-7 days/week 2-4days/week 1 day/week 2-3 days/month 1 day/month less

9) Which statement below better describes your attitude towards computers and other automated devices in general? (Check one)

______ Computers and automated devices are generally reliable until they prove otherwise.

______ Computers and automated devices are generally unreliable until they prove otherwise.

10) Compared to other college students, how would you rate your problem-solving skills?

-4 -3 -2 -1 0 1 2 3 4

Worse than most *about the same* *better than most*

11) Compared to other college students, how would you rate your decision-making abilities?

-4 -3 -2 -1 0 1 2 3 4

Worse than most *about the same* *better than most*

12) Compared to other college students, how big of a risk taker are you?

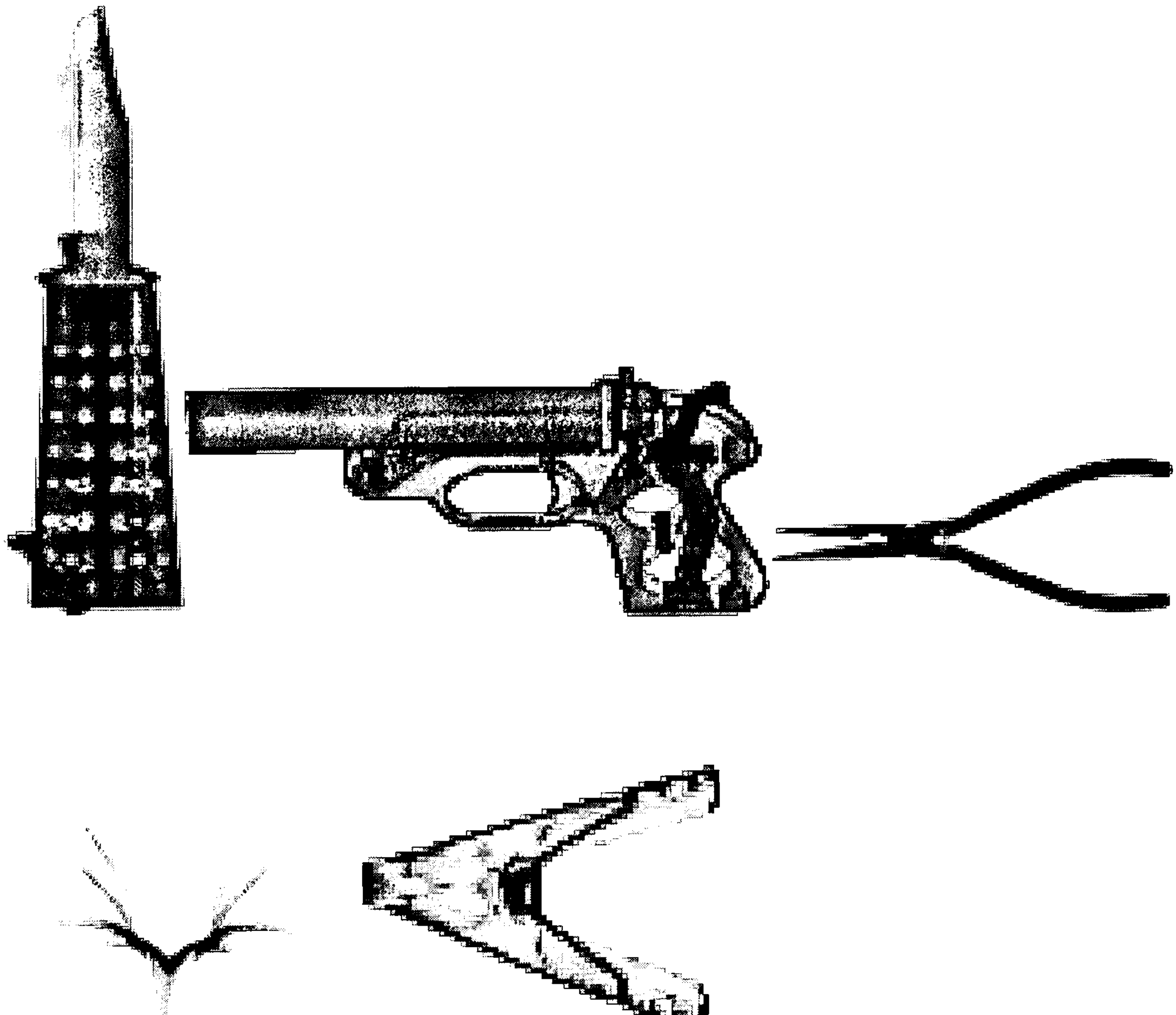
-4 -3 -2 -1 0 1 2 3 4

less risky than most *about the same* *riskier than most*

Appendix C

X-ray Image Targets

(enlarged for easier viewing)



Appendix D

Task Knowledge Questionnaire

1) Based on your experience with the task, estimate the percentage of trials that contained targets. ___________%

2) Rate the overall difficulty of the task: 1(very easy) ------ 5(extremely difficult): ___________

3) How accurate do you think you were on trials in which:

   a. the target was present?_________%

   b. the target was not present?_______%

4) For each statement below, circle to what extent did you base your decision to pass or not pass (stop) the luggage based on the passenger's (*note: circle only one option for each statement*):

(a) Race:	1) Never	2) Seldom	3) About half the time	4) Usually	5) Always
(b) Age:	1) Never	2) Seldom	3) About half the time	4) Usually	5) Always
(c) Gender:	1) Never	2) Seldom	3) About half the time	4) Usually	5) Always
(d) Attractiveness	1) Never	2) Seldom	3) About half the time	4) Usually	5) Always

5) If you were an airport luggage screener, would you prefer to see the passenger or not see the passenger while screening luggage? (Choose **only one** of the following)

(a) see passenger and luggage_______

(b) not see passenger, only their luggage_______

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EDUCATION

Old Dominion University, Norfolk, VA
Doctor of Philosophy, concentration in Human Factors Psychology and Modeling and Simulation, May 2012.

Old Dominion University, Norfolk, VA
Masters of Science, concentration in Human Factors Psychology and Modeling and Simulation, August 2009.

North Carolina State University, Raleigh, NC
Bachelors of Arts, concentration in Psychology, Deans list last semester. December 2006.

WORK EXPERIENCE

Research Assistant *August 2007-Present*
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- Create Programs for Running Psychological experiments
    - Fixed problems with the computer program making sure it ran smoothly
    - Wrote computer code, and used programs to create experiments that recorded data on participant performance.
- Ran Participants through computer program experiments
- Analyzed experimental data
    - Used hand and computer calculations to analyze experimental data
- Use Experimental tools to facilitate experiments
    - Used eye tracking camera and software to track where participants look on a computer screen
- Other duties as assigned
    - Supervise undergraduate assistants and instruct them on experimental procedures

CONFERENCES

- CAPSTONE VMASC (2009)
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PRESENTATIONS AND PUBLICATIONS

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HFES National Conference (2008)

Second Place in CEDM technical groups Best Student Paper

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Microsoft Office programs, Arena DES, Matlab Simulink, Solid Works 3-d Engineering CAD, GMAX 3-d Design, E-Prime Experiment Builder, SPSS statistical program, NetLogo.