Systematic Exploration of Public Response to Experimentally Manipulated Disaster Events (Terror and Non-terror) Using Video-based Scenario Simulation

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1. Executive Summary

The objective of this research is to formulate a better understanding of how the public perceives the risk associated with disaster events (terrorist attacks and natural disasters) and the influence this has on behavioral decision making. In the event of a disaster, a critical component of being prepared is anticipating how the public will react not only in terms of services needed, but also the extent to which details about the event influence decision making.

This work builds on prior years’ efforts to use survey design to (1) identify the psychological factors that influence individual decision making over time, and (2) study the actual decisions faced by U.S. residents in the period (weeks into months) following a disaster. Collecting and modeling data that captures the dynamics of public fears, beliefs and avoidance behavior in response to disaster events can be used by economic consequence modelers in their analyses and emergency responders in developing plans and programs to prepare and respond to various disaster events.

During Year 10 we made progress by further developing scenario simulations designed to (1) identify the psychological factors that influence individual decision making, (2) study the actual decisions faced by U.S. residents following an event within the U.S., (3) assess both short- and long-term affective and cognitive reactions, as well as behavioral decision making in response to a disaster situation, and (4) develop from study findings policy recommendations that help the U.S. prevent, prepare and respond to disasters. Research progress and accomplishments made throughout Year 10 are described in the pages of this document.

Overall, we conducted 5 research experiments throughout Year 10.

2. Research Accomplishments

2.1. Year 10 Study 1: A Longitudinal Study of Responses to Potential Nuclear Meltdown

The safety of nuclear power plants has caused extensive attention from the public, industries, and government. In this study, we are interested in public responses (emotional, cognitive, and behavioral) to the threat of a nuclear plant meltdown and how intra-individual responses change
as the event develops: from the beginning when an accident that could lead to nuclear meltdown was discovered, to an early stage when the accident was temporarily controlled, to a later stage when whether there was a long-term effect of the accident was decided. We anticipated that reactions in early stages would influence the reactions in later stages. In particular, we explored the causal, lagged and cross-lagged effects among emotional, cognitive and behavioral reactions.

In the meantime, we hypothesized that the information received at each stage would bring about inter-individual change. We therefore manipulated three factors at each stage respectively: (1) causal attribution for the accident, (2) causal attribution for halting the accident progression, and (3) resolution status. Specifically, at stage 1, the causal attribution for the accident was manipulated. The accident was caused by either a system glitch, or an earthquake, or a terrorist cyber attack. At stage 2, the causal attribution for halting the accident progression was manipulated. The accident was stopped by either the origin design of the system, or an individual expert, or a coincident system shutdown. The latter two contributors were near-misses situations. At stage 3, the accident was contained but the damage to the nuclear plant core was manipulated as none or uncertain.

A 3 (causal attribution for the accident) by 3 (causal attribution for halting the progression) by 2 (resolution) between-groups factorial design was used to explore responses to the threat of a nuclear power plant meltdown. Each participant was randomly assigned to one of the 18 conditions. The experiment contained three scenes representing three time points which described the development of the event. 773 participants were recruited from Amazon Mechanical Turk and were paid $1 of each for their completion of the survey.

Longitudinal cross-lagged regression models were used for testing hypotheses. Causal effects were found among reported negative affect, risk belief and behavioral intention in the same stage such that risk belief at stage t (t = 1, 2, 3) was positively influenced by negative affect at stage t and behavioral intention at stage t was positively influenced by negative affect and risk belief at stage t. We also found once lagged effects for the constructs themselves. Reported negative affect, risk belief and behavioral intention at stage t+1 (t = 1, 2) was positively influenced by reported negative affect, risk belief and behavioral intention at stage t respectively. Cross-lagged effects were found among the three constructs such that risk belief at stage t+1 (t = 1, 2) was negatively influenced by reported negative affect at stage t, and behavioral intention at stage t+1 was negatively influenced by reported negative affect and risk belief at stage t.

In addition, participants reported more negative affect when the accident was caused by a cyber attack than when it was caused by a system glitch at stage 1. At stage 2, participants reported more avoidance behavioral intention if the accident was controlled by an individual expert than if it was controlled by a coincident system shutdown. At stage 3, participants reported more avoidance behavioral intention if the accident was controlled by a coincident system shutdown.
than if it was controlled by the origin design of the system. Also, participants tended to experience more negative affect, perceive more risk and get away from the nuclear power plants if long-term damage could have been caused.

The experiment and results are currently in the process of being written up for publication in an academic journal. The research team has plans to have the article submitted to a scholarly journal before the end of 2014.

### 2.2. Year 10 Study 2: Aviation Security Trade-Offs: Your Money, or Your Life, or Your Civil Liberty?

We conducted a study focused on examining public perception of different aviation policies by addressing two questions. First we assessed how the public makes trade-offs among conflicting priorities relevant to airport security policies, including concerns for civil liberty, safety, inconvenience, and monetary cost. Second we investigated public sensitivity to civil liberty concern about the selection process.

Two-hundred and twenty-two American travelers completed the study online. They were asked to indicate their preference for a security screening policies by choosing between airline alternatives. One of the alternatives is a one-stage procedure where all passengers are screened intrusively (high in civil liberty); the other alternative is a two-stage policy where some passengers are selected for a secondary screening in addition to a quick primary screening (low in civil liberty). Using a sequential binary choice procedure, trade-off values for civil liberty were quantified in terms of monetary cost, inconvenience (wait time), and safety compromise (false alarm rate and miss rate). Respondents were also randomly assigned to one of three versions of secondary screening procedures where passengers are selected: (1) randomly, (2) using behavioral indicators, or (3) based on racial/ethnic profiling.

Figure 1 graphically illustrates the methodology used to quantify trade-offs for civil liberty. Considering the trade-off between civil liberty and cost represented in a series of three binary-choice trials with two options, A and B_i (i = 1, ..., 7), where option A included a secondary selective screening; thus, civil liberty (or equity) level for A was low. However, the cost associated with option A (baseline value) was also low because the two-staged screening was more efficient. On the other hand, option B_i characterized a more costly screening (trade-off value) relative to A, but also was associated with no secondary selective screening. Thus, civil liberty for this option was high. Respondents were asked to choose either A or B_i. Depending on their choice in the first trial, the trade-off value in option B_i was adjusted dynamically while the cost for A was fixed; B_{i+1} > B_i if respondents chose B_i; conversely, B_{i+1} < B_i if A was chosen. The procedure was repeated until respondents were indifferent between the two options, and the implicit trade-off value was set at the value of option B_i.
The most notable finding from this study was that most respondents readily compromised equity for very small improvements in the other four attributes, regardless of how the two-stage screening selection procedure was defined (see Figure 2 below). In the Equity-Screening Fee assessment, 68.92% of respondents were only willing to pay an incremental (extra) amount of screening cost in the minimum range, between $0 and $5, to undergo the highly equitable screening. Similarly, in the Equity-Wait Time trade-off, 52% respondents only chose the equitable screening when the incremental wait time was in the minimum range between 0 and 5 minutes. Also 71% respondents choose the inequitable two-stage screening to obtain a safer screening measure, albeit the reduction in false negative rate was in the smallest defined range, between 0.01 and 0.03. To a lesser extreme, 57% respondents preferred to trade-off equity for a screening with lower false alarm cases even though the reduction in false positive rate was also in the minimum range (0.01-0.03).
Although respondents across all three experimental groups were willing to sacrifice equity for very small gains on other attributes, the cumulative distributions also suggest that they were sensitive to the procedural selection in the two-staged screening policy. K-independent sample Kruskal-Wallis tests identified differences between the distributions for the three experimental groups across all four civil liberty trade-offs, ps < .01. To study differences between groups, the Mann-Whitney (MW) test was used to assess pairwise comparison. A series of MW tests found significant differences in distributions between the racial/ethnic profiling and randomized security screening procedures in the Equity-Wait Time trade-off, $U = 1978$, $Z = -3.328$, $p = .001$; Equity-Screening Fee trade-off, $U = 2206$, $Z = -.72$, $p = .007$; Equity-False Positive trade-off, $U = 2015.5$, $Z = -3.357$, $p = .001$; and in Equity-False Negative trade-off, $U = 2099.5$, $Z = -3.19$, $p = .001$. Similarly, another series of MW tests found significant differences in distributions
between the racial/ethnic profiling and the behavioral security screening procedures in the Equity-Wait Time trade-off, $U = 1900, Z = -3.287, p = .001$; Equity-Screening Fee trade-off, $U = 2098, Z = -2.279, p = .023$; Equity-False Positive trade-off, $U = 1875.5, Z = -3.459, p = .001$; and Equity-False Negative trade-off, $U = 1913.5, Z = -3.66, p < .001$. MW tests did not find any significant differences between the behavioral and randomized selection procedures, $ps > .05$.

This work has been written up and submitted for publication. The research team is currently waiting for feedback on publication status.

**2.3. Year 10 Study 3: Longitudinal study of aviation security trade-offs following the disappearance of Malaysian Airlines flight 370**

Using the experiment design described in Study 1, we collected at six different points in time following the disappearance of Malaysian Airlines flight 370. More specifically, the first set of data was collected the first Tuesday after the disappearance of the Malaysian jet, and every Tuesday thereafter for five consecutive weeks. The survey instrument and experiment procedure was identical for each data collection. The experiment was hosted on Qualtrics.com and a total of 1069 air travelers completed the study online. The average number of respondents completing the survey at each time point was 178. The experiment began with a four minute video describing the study, including a detailed explanation of the priorities and a careful description of the choice task. Each respondent was randomly assigned to one of the three conditions for secondary selection: (1) randomization, (2) behavioral indicators, or (3) racial/ethnic profiling. Respondents completed all possible assessment pairs including the five priorities (cost, wait time, civil liberty, false alarm rate, and miss rate), with up to three binary choices per assessment (30 in total). The order of the ten trade-off assessments was random. The experiment ended with respondents providing demographic information about their race, frequency of travel, income, and sex.

Preliminary analyses suggest that respondents’ trade-offs for safety were not contingent upon the development of the incident over time. Interestingly, respondents indicated willingness to sacrifice civil liberty in exchange for larger benefits in terms of other objectives, including reducing screening fees, increasing safety, and decreasing inconvenience. Our manipulation also appears to have had an effect on the trade-offs for civil liberty. Respondents were more willing to tolerate longer wait times and higher false alarm cases to avoid a policy that undermines civil liberty when racial/ethnic profiling was the criterion for security screening selection rather than behavioral or randomized detection.

Next steps involve conducting a more thorough and comprehensive data analysis using an MAU model framework and then writing up the experiment for publication in an academic journal. The
research team has plans to have the article submitted to a scholarly journal before the end of 2014.

2.4. **Year 10 Study 4: Analysis of the impact of information specificity on behavioral responses to severe weather warnings following experiences with recent hits, false alarms and near**

We completed the analysis of an experiment conducted during Year 9 that used scenario simulation to explore the decision making of residents in the event of severe weather warnings, specifically tornado warnings. The Year 9 study involved the development and implementation of a scenario simulation experiment that used video simulation of a series of location news reports to immerse respondents in the developing details of a series of tornado warnings in Oklahoma. The unfolding scenario was presented in discrete episodes, allowing us to track responses over the episodes and evaluate changes in affect, risk perceptions, beliefs about consequences and intended avoidance behavior. More specifically, we used a 4 (episode) by 2 (information) by 5 (outcome) design. Respondents were randomly assigned to one of ten conditions, defined by crossing two levels of information and five levels of outcome.

Information and outcome were manipulated independent variables. The 2 information conditions were Doppler radar as the primary source for tornado information and advanced information sources for tornado information (e.g. National Weather Service products such as polygon warnings and Pathcast). The five severe weather event outcomes were a false alarm, resilient near-miss, vulnerable near-miss, no-information control, and strike. The scenario simulation was designed to narrate through four video segments over a 24 hour period leading up to the occurrence of the severe weather event. All participants received the same first episode, and then the information manipulation was included in episodes two and three of the scenario. Episode four only included the outcome manipulation.

Our analysis involved an assessment of participants’ positive and negative affect, as well as perceptions of risk, personal control, possibility of loss/injury and future behaviors (e.g. seek shelter). Each dependent variable was analyzed independently in the following two models: a 3 (time) by 2 (information) repeated measures ANCOVA, and a 5 (outcome) by 1 (time) between subjects ANCOVAs. The results of the 3 x 2 repeated measures ANCOVA found that time was significant for all dependent variables (see a subsample of results in Figure 3 below), suggesting the presence of an escalation effect. Over time as the storm developed further, participants experienced an increase in positive and negative feelings, were more likely to think that the damage to their home or within five miles of their home would be increased, were more likely to think that there would be a higher likelihood of property damage and personnel loss, and that their personal risk increased with each passing scene.
A second analysis was conducted to explore whether variations in the outcomes of personal experiences influenced respondents’ negative feelings, beliefs about consequences, and avoidance behavior about future tornado warnings. We ran a between subjects ANOVA with one within subjects factor (five outcomes) assessed during one time period, episode four. The findings suggest that outcome had a significant effect on negative emotions, whether participants attributed their preparedness to external or internal forces, their impressions of the probability a future tornado would cause consequences for their home or community, as well as their impressions on the probability of a future tornado causing injury around their home or
community. A linear polynomial contrast revealed that the vulnerable near miss and the strike outcomes had the greatest effect on negative affect, external attribution Internal Attribution, and future probability of consequence, but not future consequence of injuries.

These findings, among others, are currently in the process of being written up for publication in an academic journal by the end of 2014.

2.5. Year 10 Study 5: Innocation Analysis
As part of a research project for the TSA, we conducted an experiment investigating public reaction across two groups (risk-message and control groups) in response to three attacks on the transportation systems of Los Angeles: an IED attack near a passenger-security checkpoint area at LAX killing 20 people and injuring 98; a cyber attack on a metro train system killing 26 passengers and injuring 63; and an IED attack on a mass transit bus near a crowded area killing 19 people and injuring 82. This study was the final set of data collected as part of a longitudinal study of five waves of data collection. A nationwide panel evaluated all three scenarios in random order and described their perceptions of terrorism risk, emotional reaction to the attacks, and confidence in DHS/TSA to handle the threat of terrorism and travel decisions. Reactions to the attack near the passenger-security checkpoint area were used to estimate potential economic impacts on the airline industry.

Using the data from the TSA project, we slightly modified the experimental design to a 3 x 3 between subjects design; 3 conditions – control vs. risk message, plus a second “control” group that did not participate in any of the prior waves of data collection (see prior paragraph for TSA study design) by three scenarios – LAX (suicide bomber in terminal), LA Metro (cyber attack), LA Transit Buses (crash into Union Station). Each participant was presented with a series of questions aimed at detecting perceived risk, affect, travel decisions, changes to daily routines, and confidence in security officials. 453 respondents participated in the survey. ANCOVAs were performed for the six dependent variables. Results indicate that condition significant influenced affect, and scenario had a significant effect on the decision to follow through with travel plans and traveler confidence.

In addition, a logistic regression was run assessing the impact of scenario, condition, age, education and gender on the decision to travel for business, special event, family event or leisure. For business travel, we found that participants were 2.64 times more likely to continue with their travel plans by plane. For a special event, we found that participants were 2.7 times more likely to continue with their travel plans by plane. For a family event, we found that participants were 2.33 times more likely to continue with their travel plans by plane. For a leisure trip, we found that participants were 2.24 times more likely to continue with their travel plans by plane.
The research team is in the process of summarizing the results and preparing the work for publication in a journal article by the end of the year.

2.6. Research Transition
Public perceptions of terrorism risk already have been recognized by the TSA as valuable input in calculating the indirect costs of transportation-related terrorism events. CREATE in collaboration with Decision Research has received funding and completed a project for the TSA using the scenario simulation approach. In our recently completed project, CREATE researchers used scenario simulation to assess the how risk communication could be used to prevent airline losses following an attack.

We are planning to continue our relationship with the TSA.

3. Education Products

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Funded by CREATE
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Adam Syed, Undergraduate Student, USC
Providence Ilisevich, Undergraduate Student USC
Elyse Plotin, graduated USC student
4. Project Performance Metrics

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4.1. Publications
- All of the described research projects are currently under development and expected to be submitted for publication by the end of 2014.
  - We expect to submit five papers out of the described research projects.

4.2. Presentations (additional presentations not listed)


Rosoff, H. & John, R. S. *The influence of disaster severity and outcome attribution on travel behavior*. Decision Analysis Society sponsored presentation at the annual meeting for the Institute for Operations Research and Management Science (INFORMS), Minneapolis, Minn., October 6-9, 2013.