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**FIRST RESPONDER PROBLEM SOLVING AND  
DECISION MAKING IN TODAY'S ASYMMETRICAL  
ENVIRONMENT**

by

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March 2008

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**FIRST RESPONDER PROBLEM SOLVING AND DECISION MAKING IN  
TODAY'S ASYMMETRICAL ENVIRONMENT**

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## **ABSTRACT**

Today's first responders confront a common challenge, namely the lack of exposure to and experience with asymmetric threats (i.e., terrorism and natural disasters) in training venues that would enable them to develop familiarity with these novel situations. Different problem-solving strategies currently employed by today's first responders are described, along with situation awareness and how to best leverage first-responder experience. Literature on expert versus novice decision making, situation awareness, recognition-primed decision making, and scenario-based learning was leveraged to design the thesis experiment. Through scenario-based exercises, the thesis attempted to discover whether the decision-making skills of an experienced fire officer (expert) can be learned by newly promoted officers (novice). Results from this experiment provided insight and plausible remedies regarding today's asymmetric threats in the form of recommendations to enhance the first responder's ability to develop good situational awareness and decision making

The goal now is to use research results and recommendations as a springboard to develop training that helps a novice to effectively respond to asymmetric threats. Experiment results indicate that, by combining scenarios designed to expose novices to situations they may not experience during routine operations with timely expert feedback, an individual's decision-making skills and situation awareness can be improved.

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## I. INTRODUCTION

Naturalistic decision making is the way individuals use their experience to solve problems in real-world settings, identifying their situation and taking action during times of uncertainty. Decision-making theorist Gary Klein believes that today's first responders often use their "power of intuition" when problem solving in their respective lines of work. They have to — time is a rare commodity at a fire, in an emergency room, or at a crime scene. Experienced firefighters, nurses, and police officers exhibit expert problem-solving skills every day in their emergency response roles.

This research — and beliefs regarding naturalistic decision making, expert/novice problem solving, and situation awareness — remains loyal to those of Klein, Endsley, and Cohen. Namely, that effective first-responder problem solving is often a product of experience. While first responders have been interviewed and studied regarding their decisions making experience and processes employed, this thesis connects decision-making theory with current novel real-world problem scenarios by identifying the problems facing today's first responders, plausible solutions, and recommended treatments for training personnel on novel situations.

This research was conducted for several reasons. First, it joins the beliefs of today's leading decision-making theorist, Gary Klein with first-responder problem solving via real-world examples and scenarios. Second, through the use of real-world examples derived from personal experiences and shared story telling, an individual often sees the relevance of the theory to their particular domain. Third, when the connection between theory and reality is discovered, the learning has meaning. For instance, what does an expert consider and what analogues does he create when solving present-day problems? These considerations and analogues are captured through this thesis' scenario-based examples and experiments.

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*An expert and novice fire officer may intuitively agree on the risk vs. reward factors regarding the commitment of firefighting personnel to a vacant building fire.*

*When problems become complex, however, resulting in decision-making situations that require more than basic knowledge to solve, individuals must rely on more advanced skills to help them reach a decision. For example, when the officer in command receives reports that the building is now in danger of falling down and that squatters have been living in the building, the risk vs. reward factors become more complex.*

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By providing exposure to the skilled performance that reflects experts' intuitive thought processes during everyday emergencies, today's less-experienced decision makers can begin acquiring the same skills through structured scenario-based training. When expert feedback on their responses to asymmetric scenarios is provided to novices, the novices can begin to learn how to think through a problem in a way that is similar to the experts. Only then can one attempt to take those expert skills and talents and try to superimpose them onto a novice's problem-solving skills in an asymmetric environment.

#### **A. PROBLEM STATEMENT**

Fire service personnel solve fire ground problems using several decision-making strategies; one approach employs the recognition-primed decision-making (RPD) strategy. RPD includes several techniques: pattern matching, cue recognition, mental simulations, and mental models. Pattern matching helps fire personnel recognize similarities to other situations by matching cues from the current situation such as the color of smoke with templates stored in memory and finding a match. A template is a group of cues, stored in long-term memory that represents a particular instance of a situation, for example, a specific type of fire. Cue recognitions help the decision maker to identify critical pieces in the patterns. Mental simulation allows the decision maker to mentally simulate applying a particular course of action to see how well it will work.<sup>1</sup> Mental models store information in an organized fashion, and are often referred to as the decision maker's "schema."<sup>2</sup> Mental models afford decision makers the ability to

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<sup>1</sup> Gary Klein, *Sources of Power: How People Make Decisions* (Cambridge, Mass: M.I.T. Press, 1998), 92.

<sup>2</sup>Mica R. Endsley, "Expertise and Situation Awareness" (eds) Neil Charness et al., *The Cambridge Handbook of Expertise and Expert Performance* (New York: Cambridge University Press, 2006): 638.

construct personal paradigms (the individual lens we use to view the world) that can accommodate the current dynamic event. Many first responder decision-making techniques are learned through trial-and-error problem solving during emergency response events. Once these techniques are mastered, fire service personnel use them as decision-making tools to effectively assist them in their problem-solving strategies during an emergency response operation.

A second strategy uses fire service Standard Operating Procedures (SOPs). SOPs are developed from fire service training guides and related publication manuals. The procedures included in training guides are the result of over one hundred years of collective on-the-job experience, and are reinforced through training and exercises. For example, an effective method to evaluate a fire department's SOPs and operational readiness concerning a high-rise building fire is to conduct a full-scale exercise in a building of this type. From a decision-making standpoint, SOPs are imperative because fire service personnel from a variety of locals often respond to the same incident; to work together effectively, they need common points of reference and similar training backgrounds. The National Incident Management System (NIMS) addressed multi-department operations by introducing an incident management system that provides a consistent approach for all levels of response to work together in preparing for, responding to, and recovering from domestic incidents regardless of size or complexity.<sup>3</sup> New York City's Citywide Incident Management System (CIMS) is the City's implementation of NIMS for managing emergency incidents and planned events in New York City.<sup>4</sup> For example, an incident commander's operational decision needs to be understood, not only at that strategic level, but also at the tactical level. Because strategy and tactics are somewhat streamlined throughout the fire service, decisions made and problems solved will be predicated on the common goal of protecting life and saving property.

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<sup>3</sup> Department of Homeland Security, *National Incident Management System* (March 1, 2004): 1.

<sup>4</sup> New York City Office of Emergency Management, *Citywide Incident Management System* (April 6, 2005): 6.

In their attempt to solve problems and make effective decisions under emergency conditions, fire service personnel synthesize their own real-life firefighting expertise with the collective experiences of numerous fire service personnel conveyed via SOPs, training, and education. Experience, developed through direct participation and observation, has given the fire service a distinct advantage when it is required to solve problems in their area of domain-specificity.

In addition to their everyday problem-solving and decision-making responsibilities, fire service personnel are now confronting a novel concern: decision making in an asymmetric threat environment, or situations with environmental factors that are unorthodox, surprising, urgent, and unforeseen. The decision strategies normally employed by fire personnel are not always effective because these novel situations do not match the stored patterns the firefighter has accumulated from years of experience. Pattern matching, cue recognition, and mental simulations do not always apply to these unique situations. Examples of an asymmetric threat environment include chemical, radiological, biological, and other forms of terrorist attacks on critical infrastructure (such as 9/11), and natural disasters (wildland fires, hurricanes, earthquakes, and floods) that threaten a population that has grown in density over the past fifty years, and thus are of much greater consequence than those for which fire services were traditionally trained and prepared. Urbanization of the rural landscape has changed the way forest fires are fought. Trees are no longer the resources most severely exposed to fire, now it is the homes and the people living in the forest.<sup>5</sup> As James Davis has noted, “Fire managers across the nation are confronting the rapidly developing problem of people moving into wildland areas, increasing what has been termed the wildland-urban interface.”<sup>6</sup>

Most significant fire-related events have the potential to generate many casualties and cause widespread environmental damage. An asymmetric attack is not inherently worse, but is rather unconventional in some aspect, obliging responders to operate in a world of uncertainty. The fire service now confronts a new threat without the benefit of

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<sup>5</sup> WUI Professional Development Program, “Module 1: Trainer’s Guide Wildland-Urban Interface Issues and Connections.” <http://www.interfacesouth.org/products/pdf/mod1.pdf>. [Accessed June 8, 2007].

<sup>6</sup> James B. Davis, “The Wild land-Urban Interface: What It Is, Where It Is, And Its Fire Management Problems” (n.d.): 160. <http://www.cnr.berkeley.edu/~fball/050.pdf>. [Accessed June 8, 2007].

the real-life experience and the SOPs necessary to create effective situational awareness (SA). “Simply put, SA is knowing what is going on around you. Inherent in this definition is a notion of what is important.”<sup>7</sup>

Expert decision makers are said to think and act intuitively, often relying on “gut instinct” — honed by experience — to make crucial decisions. This is naturalistic decision making in its most basic form. Without experience, though, decision makers may reason like novices. Because they have no mental models stored (based on experience), there are no patterns to match or cues to recognize. In some cases, the decision maker relies on a rational choice strategy. These strategies may not produce the best course of action (COA) for first responder decision makers to use in emergency situations. The problem with rational choice strategies is that, because they involve methodical, multi-step processes, they are labor-and time-intensive; because of this, the decisions are often obsolete and ineffective when it comes time to institute them. The following seven-step problem-solving model from William Duggan’s “Coup D’oeil; Strategic Intuition in Army Planning.” is one such example of this lengthy process.

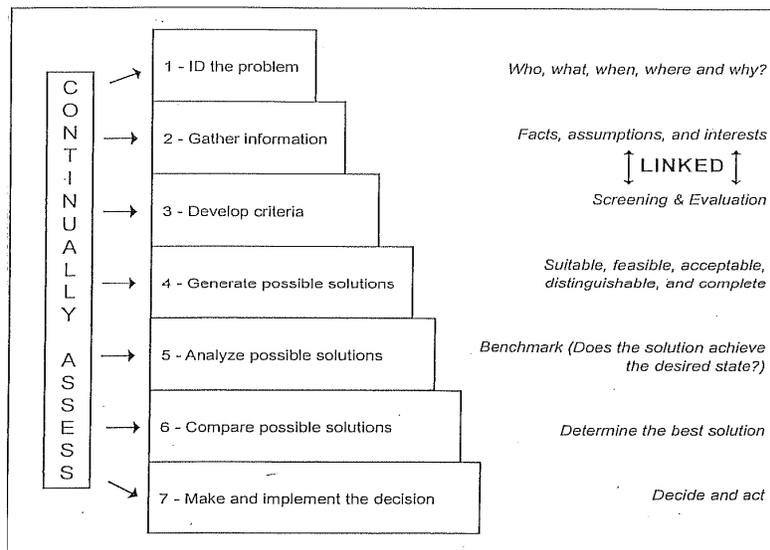


Figure 1. Seven-Step Problem Solving Model (from <sup>8</sup>)

<sup>7</sup> Endsley “Theoretical Underpinnings of Situational Awareness: A Critical Review,” *Situation Awareness Analysis and Measurement* (Mahwah, N.J.:Lawrence Erlbaum Associates, 2000): 2. <http://www.satechnologies.com/papers/pdf/satheorychapter.pdf> [Accessed April 2007].

<sup>8</sup> William Duggan, “Coup D’oeil: Strategic Intuition in Army Planning” (November 2005): 15. <http://www.StrategicStudiesInstitute.army.mil/> [Accessed January 3, 2007].

By relying on a rational thought process, Klein suggests that inexperienced decision makers are viewing the problem via a very specific narrow lens. Klein, a leader in the study of problem solving and decision making, calls this narrow vision approach “hyperrationality,” because decision makers try to solve all problems based on logical and analytical forms of reasoning.<sup>9</sup> Decision makers try to do all their thinking just by applying a rational procedure. Imagine the ramifications of incorporating a narrow lens approach while addressing a homeland security prevention, preparedness, or response related matter and not seeing the application process in its entirety. Envision a homeland security prevention initiative that was not based on experience in the decision-making process. Prevention planners use past events as starting points for future plans. By not utilizing their previous experience as a foundation for making decisions, planners are at risk of missing the “big picture.”

Many real-world events do not allow for an in-depth analysis and size-up of the scene. A fire officer operating at an expanding fire using a rational choice strategy would take so much time to finally decide on ordering an additional alarm response that the level of response would no longer be adequate due to the speed of the spreading fire. Instead, when responding to these events, firefighters frequently rely on spontaneous decision-making and problem-solving skills based on many years of accumulated experience and training that has enabled them to develop expertise. When operating in an environment that demands immediate action, use of the more analytic rational choice strategy would require too much time to be effective. Because many events are so dynamic, well thought-out decision-making strategies may not be applicable when it comes time to institute them.

## **B. RESEARCH QUESTION**

The research question investigated for this master’s thesis is: How to improve first responder problem-solving and decision-making skills in today’s new threat environment?

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<sup>9</sup> Klein, *Sources*, 260.

## C. LITERATURE REVIEW

The literature discussed in this chapter concerning first responder problem solving and decision making is divided into three categories: the asymmetrical environment, decision-making strategies, and scenario-based training.

First, is the asymmetric environment that first responders are currently experiencing, including both natural and man-made disasters. Experts in the field of terrorism and disaster preparedness (Hoffman, Falkenrath, and Linstrom) provide commentary on the current state of readiness and perceived threat. Discussions regarding first responder levels of preparedness, along with recommendations designed to enhance individual awareness levels regarding terrorism (McKinsey Report) and natural disaster readiness (Federal Response Plan to Hurricane Katrina), underscore the decision-making process.

Second, are decision-making strategies and theoretical frameworks, especially as they pertain to expert versus novice decision making and to rational choice versus recognition-primed decision strategies. How applicable are the fire/emergency decision-making strategies at a hurricane or radiological attack? How does an expert prioritize decision making? Klein, Duggan, and Endsley weave intuition, rational choice, and situation awareness into a montage of decision-making analogues.

Third is scenario-based training in the first responder decision-making equation. Scenario-based training can provide effective decision-making training without the expense and risk of full-scale types of exercises, and can be self-paced to accommodate various levels of an individual's level of expertise and competence. Scenario-based training helps practitioners connect theory with real-world applications/situations. A scenario-based experiment (paper and pencil) comparing first responder experts and novices was the focus of this thesis research.

### 1. Asymmetric Threats (Terrorism/Natural Disaster)

In his paper, *Problems of Preparedness: U.S. Readiness for a Domestic Terrorist Attack*, Richard A. Falkenrath, the Deputy Commissioner of Counterterrorism in the New

York Police Department, offers a suggestion to reduce the uncertainties of response. Citing chemical and biological weapons as examples of asymmetric threats (uncertainty), Falkenrath believes that first responders need to develop a deeper understanding of these weapons (i.e., the agent's properties of dissemination and interaction with the environment). Additional considerations include the effects of an asymmetric attack upon the civilian population, and how the civilian reaction will affect response plans. Will they become part of the problem? Falkenrath suggests that the public's reaction to a weapon of mass destruction (WMD) incident needs to be integrated into the response plan.<sup>10</sup> For example, a radiological "dirty bomb" attack may require a mass/gross (copious amounts of water) or technical (individual) decontamination of those exposed before medical triage, treatment, and transport operations can begin. The public will view decontamination as necessary or superfluous (depending on the degree of contamination), especially when medical treatment is vital. How do first responders corral possibly contaminated individuals so they can be assessed before they drift from the scene? Whereas gross decontamination is designed to decontaminate large numbers of people by passing them through a water shower/curtain often provided by a hose line, this procedure might not be practical or well received in colder temperatures. How much experience do first responders possess regarding the public's compliance/cooperation with these essential procedures?

In his article, "Weapons of mass destruction a threat from desperate al-Qaeda," Tom Allard reports that, according to Bruce Hoffman, an expert in the study of terrorism-suicide bombers, the possibility of a terrorist attack using chemical, biological and radiological weapons is growing. These weapons have not only a corrosive (physical) effect but also a psychological one. Hoffman believes that the most likely unconventional attack would come from a radiological or "dirty bomb." "In a city like New York, the

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<sup>10</sup> Richard A. Falkenrath, "Problem of Preparedness: U.S. Readiness for Domestic Terrorists Attacks," *International Security*, 4.(MIT Press: Spring 2001): 13. [http://www.uky.edu/RGS?Patterson/desch/Readings/02-13/02-13\\_falkenrath\\_1.html](http://www.uky.edu/RGS?Patterson/desch/Readings/02-13/02-13_falkenrath_1.html). [Accessed May 23, 2007].

economic impact would be immense.”<sup>11</sup> This type of device causes more panic than damage, while undermining public confidence in the government. Hoffman’s concerns regarding public reaction reinforce Falkenrath’s suggestions to incorporate public reaction into the response plan. Hoffman further cites the recent chlorine bomb explosions in Iraq as another “unconventional” weapon that caused minimal property damage while resulting in panic: “There are an endless number of truck bombs that have killed in the hundreds but look at the reaction of Iraqis to chlorine bombs. They are absolutely panicked.” Hoffman feels that the terrorists are more dangerous than before the September 11 attacks because they are more desperate.<sup>12</sup>

In *Psychology of Terrorism*, Richard Gist identifies the inherent resiliency of today’s first responders when it comes to post-traumatic disorders from the nature and emotional impact of their work. Several reports regarding post-traumatic stress disorder (PTSD) reveal that first responders are “uncommonly resilient.”<sup>13</sup> This resiliency enables firefighters to provide a social function that must be exercised for communities to prosper.<sup>14</sup> While fire organizations are their communities’ first resources, providing the normal functions related to hazards and safety, many fire organizations now require the expertise regarding hazardous materials identification and mitigation, mass casualty triage, decontamination, and technical rescues from natural disaster and structural collapse.<sup>15</sup> Acquisition of this expertise is correlated with decision making in two distinct ways. First, the recognition of first responder resiliency, understanding that firefighters do not get paid for what they do, but rather for what they might have to do, makes it

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<sup>11</sup>Tom Allard, “Weapons of mass destruction a threat from desperate al-Qaeda,” *Sydney Morning Herald* (May 24, 2007). <http://www.smh.com.au/news/world/weapons-of-mass-destruction-a-threat-from-desperate-alqaeda/2007/05/23/1179601492715.html>. [Accessed May 5, 2007]. n.p.

<sup>12</sup> Ibid.

<sup>13</sup> Richard Gist, “Promoting Resilience and Recovery in First Responders,” (eds) Bruce Bongar, Lisa M. Brown, Larry E. Beutler, James Breckenridge, Philip G. Zimbardo, *Psychology of Terrorism* (New York: Oxford University Press, 2007): 418.

<sup>14</sup> Ibid., 419.

<sup>15</sup> Gist, “Promoting Resilience and Recovery in First Responders,” 418.

imperative that decision making is at an expert level. Second is the recognition that additional expertise related to natural disasters preparedness is in accord with current asymmetrical threat planning.

John Linstrom retired at the rank of assistant chief after twenty years of service in fire departments in Texas and California; presently, he is an educational consultant for the Fire and Emergency Training Network (FETN). Linstrom's article, "Decision Making on High Alert with New Threats," reports that most responses are to fires, emergencies, and medical events that are small and manageable. However, in today's asymmetric threat environment, officers must be alert to responses that appear to be routine, but in fact are planned terrorist attacks. Lindstrom reports that 80 percent of terrorist attacks involve the use of explosives.<sup>16</sup> According to Grunnar J. Kuepper, the Chief of Operations with Emergency and Disaster Management Inc., Los Angeles, chemical, biological, and nuclear weapons pose the most significant challenges to emergency responders, but the weapons of choice creating an "asymmetric threat environment" are more often guns or explosives.<sup>17</sup>

At the Madrid train bombings, secondary explosive devices were placed to target first responders. In a Lessons Learned Information Sharing (LLIS) report entitled *Secondary Attacks: Failure to Perform Adequate Site Inspection Procedures*, the Madrid bombings highlight concerns about secondary attacks. At this incident, all unclaimed personal belongings were removed to the police station. Included in these belongings was a bag containing an explosive device wired to a cell phone. Fortunately, the cell phone and explosives were not properly connected, and the device failed to detonate. Lessons learned underline the inadequate site security and inspection procedures, while underscoring the cautions that need to be taken at terrorist sites.<sup>18</sup> These cautions need to be the stimulus for enhancing first responder asymmetrical decision making on a tactical

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<sup>16</sup> John Linstrom, "Decision Making on High Alert with New Threats," *Fire Chief* (April 2004): 29. [Accessed Proquest, January 2007].

<sup>17</sup> Grunnar J Kuepper, "Shooting at LAX on July 4, 2004: Lessons Learned," *IAEM Bulletin* (October 2002): 20. <http://www.LLIS.gov>. [Accessed May 25, 2007].

<sup>18</sup>"Secondary Attacks: Failure to Perform Adequate Site Inspection Procedures" (September 15, 2004). <http://www.LLIS.gov>. [Accessed May 25, 2007].

and strategic level. By sharing lessons learned from similar incidents, first responders operating at subsequent incidents will be more attentive to cues and aware of their importance. Via experience, they will have a greater capacity to connect the past and present, and not miss a cue/pattern that was overlooked because the knowledge/experience was missing.

Steve Lambakis et al., report in *Understanding “Asymmetric” Threats to the United States*, that a biological weapon’s attack against a population will have a much different effect than the same attack in a battlefield. Although masks are an acceptable means of protection against such an attack, will the masks and knowledge of attack be available? The United States does not have the monitoring capabilities to detect all types of agents. Unknown or generically altered agents will not be in the monitor’s “library.” Additionally, the Lambakis report claims that there are millions of locations where a detector can be placed; obviously not every location can be protected. Attackers know which agents have a vaccine and will avoid the use of particular agents. Lastly, effective treatment depends on a rapid diagnosis.<sup>19</sup>

A review of the McKinsey findings reveals that first responder experience and prior training (emergency response drills) allowed first responders to think and act intuitively at the Pentagon on September 11, and to make effective decisions. Conversely, due to a lack of familiarity and experience concerning today’s asymmetrical threat environment, first responder decision making at Ground Zero<sup>20</sup> and Hurricane Katrina<sup>21</sup> in the days following the event was not as effective. Analyses of such events have underscored the need for improved decision-making skills and provided tangible proof that recovery efforts were adversely affected when the decision-making and problem-solving tools were not available.

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<sup>19</sup> Steven Lambakis, James Kiras, Frstin Kolet, “Understanding ‘Asymmetric’ Threats to the United States,” *National Institute for Public Policy* (September 2002): 33. <http://www.nipp.org>. [Accessed May 23, 2007].

<sup>20</sup> New York Police Department, “Improving NYPD Emergency Preparedness and Response,” (New York: McKinsey and Company, 2002).

A RAND report titled, *Protecting Emergency Responders: Lessons Learned From Terrorist Attacks*, reviewed three first responder issues in the days following a terrorist attack, and how prior training may have assisted decision making. The successful establishment of a perimeter control at the two sites (Pentagon and Ground Zero) was influenced by many factors; the Pentagon was in a rural setting with limited access, while Ground Zero was in an urban environment with many access points. However, the number of access points and site location were not the sole contributing factors determining the accomplishment of the objective. For example, in reviewing post operations at the Pentagon, the RAND report points out that “Federal, state, and local agencies involved were accustomed to working with each other and had practiced emergency-response drills. Several firefighters agreed: ‘What made it [effective] was the training that we do all the time with the other jurisdictions, commands, and knowing the people.’”<sup>22</sup>

A post-9/11 report prepared by McKinsey and Company for the NYPD identifies site security at Ground Zero in the days immediately following September 11, 2001, as inadequate. Perimeter security was not adequately established, estimating the risk of a second attack was not made a priority, and leadership was unclear on how to obtain additional resources.<sup>23</sup> According to Falkenrath, “While preparedness plans should be addressed in exercises and simulations, no exercise can substitute for real world experiences, and because life safety and normal life activities cannot be sacrificed, exercises will always contain a certain element of uncertainty until played out in a real life experience. The question that remains unclear is how well the training will hold up at a real world incident.”<sup>24</sup>

Communication of risk and access to vital information in an asymmetrical threat environment is imperative. First responders need to make decisions predicated on

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<sup>22</sup> James T. Bartis, Irene Brahmakulam, Ari Houser, Brian A. Jackson, D. J. Peterson, Jerry Sollinger , Tom LaTourrette, “Protecting Emergency Responders: Lessons Learned From Terrorist Attacks.” *Rand and Science and Technology Policy Institute* (Arlington, Virginia, 2002): 48. [http://www.rand.org/pubs/conf\\_proceedings/CF176/index.html](http://www.rand.org/pubs/conf_proceedings/CF176/index.html). [Accessed May 2, 2007].

<sup>23</sup> New York Police Department, “Improving NYPD Emergency Preparedness and Response.”

<sup>24</sup> Falkenrath, “Problem of Preparedness,” 13.

dynamic, changing information provided by numerous agencies — information and situations they may not have confronted prior to 9/11. According to Bartis et al., a commander’s decision-making concerns included the following: “The desire to have accurate information was of particular concern to commanders, who were making decisions about what level of risk their personnel would face. ‘You’ve got to understand what you’re dealing with,’ said a law-enforcement representative. ‘We can equip our first responders to a certain level . . . but as managers, we have to understand what risks they are capable of dealing with or what hazards [are out there].’”<sup>25</sup> Decisions will be predicated on the situation and circumstances.

For example, are we as managers/leaders prepared to commit personnel to an environment that has not been properly evaluated, even though life and property may be at risk? If no one is exiting a subway station following reports of an explosion are we prepared to commit personnel to that same area, knowing that they (first responders) may become part of the problem? If we do not make initial decisions that protect first responders, the first responders will not be available to assist those in trouble.

Consider the following analogue:

One recommendation that came out of the McKinsey and Company report prepared for the FDNY concerning fire department operations at ground zero was the expansion of procedures for exchanging operational information with other agencies.<sup>26</sup> In the concluding remarks section of the RAND document, commanders discussed the difficulties with managing a terrorist attack site: “Given the understandable difficulty of making such decisions in the midst of a response effort, site commanders could greatly benefit from guidelines developed in advance of an incident.”<sup>27</sup>

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<sup>25</sup> Bartis et al., “Protecting Emergency Responders,” 40.

<sup>26</sup> Fire Department of New York, “Increasing FDNY’s Preparedness” (New York: McKinsey and Company, 2002): 57.

<sup>27</sup> Bartis et al., “Protecting Emergency Responders,” 80.

At the most fundamental level, part of the explanation for why the response to Katrina did not go as planned is that key decision makers at all levels simply were not familiar with the plans.<sup>28</sup>

*The Federal Response Plan to Hurricane Katrina: Lessons Learned* states that many key decision makers were not familiar with the National Response Plan (NRP), which led to ineffective coordination between federal, state, and city agencies. Local governments (first responders) were responsible for developing a plan that could be integrated into the NRP. Many of these plans, however, were still in the development stage or non-existent. The result was an operation void of SOPs, operational guidelines, and chain of command protocol.<sup>29</sup> *The Federal Response Plan* reports that in Louisiana, significant delays slowed down the delivery of pre-positioned medical, public health, and pharmaceutical assets:

In some cases, security and logistics may have been issues, but delays in “on the ground” decision making by local and state officials resulted in delays in the delivery of assets and services when and where they were needed.<sup>30</sup>

## **2. Decision Making**

Research on the problem-solving and decision-making strategies used by today’s first responders indicates that many decisions requiring immediate action are often made intuitively, utilizing a “gut like” decision-making process.<sup>31</sup> Gary Klein reports that first responder decision-making strategies at fires and emergencies involve experience and intuitive “gut instinct.”<sup>32</sup> By definition, one would believe experience and intuition to be in conflict regarding decision-making styles. The former is built on past events tried and true, while the latter is a “shooting from the hip response.” In reality, however, they

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<sup>28</sup> Federal Response Plan to Hurricane Katrina: Lessons Learned, February 2006. <http://www.whitehouse.gov/reports/katrina-lessons-learned.pdf>. [Accessed May 2, 2007]. 58.

<sup>29</sup> *Ibid.*, 202.

<sup>30</sup> Federal Response Plan to Hurricane Katrina: Lessons Learned, 202.

<sup>31</sup> Klein, *Sources*, 33.

<sup>32</sup> *Ibid.*

complement each other. Experience mentally warehouses information and intuitions pull the knowledge from the shelves.<sup>33</sup>

In *Sources of Power: How People Make Decisions*, Klein describes the decision-making and problem-solving techniques of people who make decisions under stressful, time-pressured circumstances. Klein interviewed firefighters, nurses, air traffic controllers, and military leaders to determine why they decide to go left or right, to run or stay put. What makes a fire officer decide to evacuate a perfectly sound building, only to have it collapse minutes later? “Firefighters rely on recognition of familiarity and prototypicality,”<sup>34</sup> Klein explains, meaning they often rely on mental models to anticipate what will happen next. Although one would believe that most decisions made under life-and-death circumstances would require a more analytical decision-making process reflective of the “Seven Step Problem-Solving Model” cited earlier in the chapter, Klein has discovered that many emergency decisions are made to the contrary. Decision makers rely on experience; they use their knowledge of past events to help them solve present day problems. Experience allows them to think intuitively, in a blink of an eye. A seasoned attending nurse has seen enough cases concerning an infant’s ill health to diagnosis a problem and institute a remedy long before a blood test can be verified. Nurses can do this because they are exposed to numerous trials with similar symptoms (patterns). When there are enough commonalities, the nurses’ perceptions and comprehension of the current situation are compared to their mental model of the situation. By connecting the past to the present, intuition assists in the decision-making process.

While Klein discusses numerous strategies decision makers utilize to think and act intuitively, he also studies the strategies decision makers use when experience is not a viable tool, when decision makers are in “uncharted waters.” Using mental simulation to construct plausible outcomes is one such strategy. Good situation awareness facilitates the decision maker in diagnosing the problem; mental stimulation provides the ability to

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<sup>33</sup> Duggan, “Coup D’oeil: Strategic Intuition in Army Planning,” 1.

<sup>34</sup> Ibid.

rehearse numerous scenarios until one works.<sup>35</sup> Mental simulation and the rational choice strategy both involve comparing options and mentally playing out the situation to see if a particular course of action really works. Mental simulation is a rapid decision-making process, while rational choice strategy is more deliberate. Also, unlike rational choice decision making, mental simulation employs the art of “satisficing,” namely, taking the first option that works, not necessarily the best.

The recurring theme in Klein’s *Sources of Power* is that experience is a major contributor to successful decision making under pressure. However, when experience is not available, as is often the case in an asymmetric threat environment, experts must devise alternative methods to problem solve. Klein’s recognition-primed decision model (RPD) suggests the use of mental simulation as one alternative method when we have to make sense of different clues.<sup>36</sup> Mental simulations allow the decision maker to mentally rehearse a series of decisions. If they make sense, the decisions are implemented, if not, different actions are considered. “In order to build an effective mental simulation, we need to have good mental models (formed from stored experiences) of how things work.”<sup>37</sup>

Crandall et al., report that stored experiences assist the decision maker in recognizing patterns/matches during current situations, building mental models to be stored in memory and referenced during future situations, and recognizing similarities between like events.<sup>38</sup> The art of correctly sizing up a fire incident and deciding whether it should be expanded via the request for additional units, scaled down by reducing unit commitment, or remaining the status quo by keeping the present alarm assignment, is an example of combining experience with critical thinking.

Linstrom employs Klein’s recognition-primed decision model when he discusses the various methods a fire officer uses to size up a situation. According to Linstrom, a

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<sup>35</sup> Klein, *Sources*, 89.

<sup>36</sup> Ibid.

<sup>37</sup> Gary A. Klein, *The Power of Intuition* (New York: Currency Doubleday, 2004): 27.

<sup>38</sup> Beth Crandall et al., “Training Decision Makers for the Real World,” *Decision Making In Action: Models And Methods* (ed). Roberta Calderwood et al. (Norwood, New Jersey: Ablex Publishing Corporation, 1993) 312.

first responder matches cues/clues from the current event with stored experiences from past events. These experiences are stored as templates or schemas. The decision maker compares cues such as the color of smoke (black, gray, white) with the cues experienced in previous fires to help assess what kind of fire or stage of fire they are dealing with. Once a pattern is matched, the response action that worked in the previously experienced situation will be recalled and can be applied. By making this comparison, a first responder can mentally draw from similar situations, recalling which decisions were effective, and decide on an appropriate course of action for the current situation. From this analysis, a course of action is developed. It may not be the best or only choice, but it is one that works.<sup>39</sup>

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*Imagine that a fire officer is responding to an alarm reporting an explosion inside a building. Unbeknownst to the officer, this is a terrorist-related incident. According to Linstrom, without prior knowledge of these facts and not possessing the experience/training to size up an incident and detect possible terrorist related activities, the officer might commit his units to an interior attack, exposing them to a possible secondary device.<sup>40</sup>*

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The fire officer may find himself at a distinct disadvantage because he does not have the experience to dissect the situation — nor the SA that would help him create patterns/matches with previously-experienced situations to develop similarities. This is because terrorism is an asymmetric event, and many fire officers have not yet developed the expertise to think and act decisively in these novel situations. Instead, they will rely on a more traditional, rational decision-making model. Linstrom calls this a “no slide in the slide tray” moment: The cues are foreign to the officers’ experiences and training.<sup>41</sup>

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<sup>39</sup> Linstrom, “Decision Making,” 30.

<sup>40</sup> Ibid.

<sup>41</sup> Ibid., 32.

“Slide tray” slides are synonymous for the long-term memory stores (also referred to as “schemas” or templates) that often separate a novice from an expert.

### **3. Situational Awareness**

Simply stated, situational awareness (SA) is the art of understanding your surroundings while developing three distinct levels of environmental awareness, namely perception (level 1), comprehension (level 2), and projection (level 3).<sup>42</sup>

For example, an experienced fire ground commander, moving through the SA levels of perception, comprehension, and projection, quickly sizes up the scene (perception), understands the possibilities and ramifications of fire spread (comprehension), and quickly orders a response that complements the present and future status of the fire (projection).

Effective first-responder decision makers create parallels between SA levels of perception, comprehension, and projection and RPD pattern-matching/cue recognition/mental model construct. Is SA part of the decision-making process? In *Theoretical Underpinnings of Situational Awareness: A Critical Review*, Endsley reports it is not. Endsley feels that SA is the precursor to decision making. SA provides a representation of the environment; then the decision maker decides what to do, based on the information.<sup>43</sup> According to Endsley, effective decision making, leading to effective performance, often depends on high levels of SA.<sup>44</sup> But, good SA is not a guarantee for good decisions. For example, SA could be correct, yet the wrong decision is made.

Marvin Cohen tells us that good SA helps experts to solve problems in familiar situations by pattern matching similarities. By first developing an accurate SA helps decision makers make sense of unfamiliar surroundings. Cohen states that one way to

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<sup>42</sup> Mica R. Endsley, “Expertise and Situation Awareness,” (eds) Neil Charness, K. Anders Ericsson, Paul J. Feltovich, and Robert R. Hoffman, *Expertise and Expert Performance* (New York: Cambridge University Press, 2006): 634.

<sup>43</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 4.

<sup>44</sup> Endsley, “Expertise and Situation Awareness,” 634.

attain this skill is to have decision makers think more critically about novel situations.<sup>45</sup> Klein, in his recognition-primed decision-making model, sees a direct linkage between recognition of the situation and actions taken.<sup>46</sup> Cohen agrees that recognition is imperative to the process; however, there are other factors to be considered. For example, what happens if the SA is inaccurate? Cohen suggests the process of meta-recognition to verify and improve recognition results. Meta-recognition probes for mistakes, corrects what it finds, and evaluates the results. Cohen believes that by studying the strategies that experienced decision makers use when dealing with uncertainty, training can be enhanced.<sup>47</sup> This is encouraging because it shares Klein's view of cognitive modeling and expert/novice contrasts.

#### **4. Expert vs. Novice: Characteristics of Expert Decision Making**

When confronting a naturalistic decision-making (NDM) situation characterized by uncertainty, dynamic conditions, ill-structured problems, and time constraints, experts focus on comprehending the situation first and developing a course of action in the decision-making process second.<sup>48</sup> Experts will spend more time developing situational awareness and, once they recognize the problem as familiar, they implement a course of action. Conversely, novices spend more time comparing different options because they do not have the stored experiences (mental models) that would help them recognize the problem.<sup>49</sup>

Richard Adams of the Florida Institute of Technology advises the Federal Aviation Administration (FAA) on aeronautical decision making. Of particular importance to Adams and the FAA are the decision-making skills of pilots and how they

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<sup>45</sup> Marvin S. Cohen and Bryan B. Thompson, "Training Teams to take Initiative: Critical Thinking In Novel Situations," *Cognitive Technologies, Inc* (September 11, 1999): 5. <http://www.cog-tech.com/Publications/PubsRM.htm>. [Accessed April 10, 2007].

<sup>46</sup> *Ibid.*, 4.

<sup>47</sup> Marvin S. Cohen and Jared T. Freeman, "Thinking Naturally About Uncertainty," *Cognitive Technologies, Inc* (n.d.):1. [http://www.cog-tech.com/papwer/humfac/hf\\_1996.pdf](http://www.cog-tech.com/papwer/humfac/hf_1996.pdf) [Accessed April 2007].

<sup>48</sup> H. Lauren Pugh, Josephine M. Randal, and Stephen K. Reed, "Differences in Expert and Novice Situation Awareness in Naturalistic Decision Making," *International Journal of Human-Computer Studies* 45, no. 5 (November 1996). 580. [Accessed Pro Quest August 2007].

<sup>49</sup> *Ibid.*, 582.

overcome adversity in everyday flights. Adams' identification of seven distinguishable characteristics of expert decision making is germane to many fields of expertise (e.g., pilots, first responders, nurses):<sup>50</sup>

1. Experience and training develop an expert's knowledge base. This knowledge base allows the expert to perceive large meaningful patterns. The experts see in "chunks" rather than individual snippets of information. Because pattern recognition occurs so rapidly, it is sometimes described as being intuitive.
2. Because an expert can construct associations between the past and present, short-term working memory is available to address the problem at hand and the expert is not pre-occupied attempting to make sense of existing circumstances.
3. Expert knowledge is procedural and goal oriented. Experts know SOPs and understand situations where procedures are useful.
4. Experts solve problems faster because experts are (1) faster at skill-based tasks; (2) more working memory capacity is available; and (3) employ intuitive decision-making strategies (arrive at solutions faster without extensive search).
5. Experts excel at both routine and adaptive decision-making opportunities. They can lean on knowledge or improvisation when confronting everyday or novel decision-making situations
6. Experts have the capability to revise procedures while validating situational interpretations through the process of mental simulation.
7. Because experts possess greater domain-specific knowledge, they spend more time analyzing and predicting problem complexity predicated on the underlying principles of a problem. This reflection results in better management regarding the allocation of time to problem solving.<sup>51</sup>

Good situational awareness and comprehensive mental models are two reasons experts are better decision makers. First, when advancing through the various levels of

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<sup>50</sup> Dick McKinney, American Airlines, Retired. Decatur, Texas, "On Improving Tactical Decision Making." 3. <http://www.crm-devel.org/resources/paper/On%20Improving%20Tactical%20Decision%20Making%20McKinneD.pdf>. [Accessed November 22, 2007].

<sup>51</sup> Ibid., 3.

SA, experts expend more time making sense out of uncertain environments. While a novice will become overwhelmed in the complexities of situational comprehension (SA – Level 2), the expert will be selective regarding what is and is not relevant to the current situation. This selectivity translates into limited choice selection regarding SA –Level 3 projection. The expert has less to consider because they are able to eliminate non-essential cues, they are therefore more likely to make a suitable choice that solves the problem at hand. Conversely, the novice in the same situation finds himself or herself tangled in a decision-making quagmire attempting to select the best course of action from a diverse menu of self-created options. Second, exposure to numerous decision-making situations has allowed the expert to develop effective mental models. As experience grows, the expert’s mental models became more complex and comprehensive.

According to Crandall et al., an expert knows how to use his/her domain knowledge, while the novice relies on general knowledge.<sup>52</sup> Experts have numerous advantages; they see incidents in terms of patterns, they plan and they do not need to consider numerous alternatives.<sup>53</sup> An expert takes the first option that works; a novice will consider many options. Experts frame the problem looking for similarities and pattern matches; a novice will allow the complexities of an incident to confuse what is relevant and what can be discarded. The good news is that as experience and knowledge grow, novices often turn into experts.<sup>54</sup>

Table 1. Comparison of Expert and Novice Decision-Making Characteristics

<b>Expert</b>	<b>Novice</b>
Spends more time developing SA	Spends more time weighing options <sup>55</sup>
Uses domain knowledge	Relies on general knowledge
Frames problems by finding similarities	Allows complexities of incident to confuse decision-making
Sees in patterns and does not consider multiple options, takes first option that works	Considers multiple options <sup>56</sup>

<sup>52</sup> Crandall et al., “Training Decision Makers for the Real World,” 312.

<sup>53</sup> Ibid.

<sup>54</sup> Ibid., 311.

<sup>55</sup> Pugh, “Differences in Expert and Novice Situation Awareness in Naturalistic Decision Making,” 580.

<sup>56</sup> Crandall et al., “Training Decision Makers for Real World,” 312.

Comparing the proficiency of an expert and novice in their ability to develop SA, an analogy can be made to driving on the freeway. In a paper titled “Anticipatory Thinking,” Klein et al., discuss the anticipatory thinking that often overlaps with the prediction that occurs in Level 3 of SA. For example, while an experienced driver will scan the road for potential problems, using their peripheral vision to take in the “big picture,” an inexperienced driver will be more focused, concentrating not on potential problems, but rather on road issues in their immediate line of sight — namely, keeping their car between the white lines while ignoring potential trouble spots.<sup>57</sup> The novice’s SA is handicapped via a “tunnel vision” mentality regarding environmental awareness. They are unable to process auxiliary information because all attention is focused on the basic task itself. Because the experienced driver can “automatic pilot” certain aspects of their driving SA and decision making, they are more attentive to the weak signals that may indicate a future problem, thereby recognizing a small problem while it is small and manageable.

To presume that experts do not think before they act is not completely accurate. While their thought process may be ongoing and non-reflective, experts do, time permitting, ponder their options. Experts, however, do not allow themselves to get caught up in the rules and reasons behind a decision, because if they did they would be reverting back to a novice decision maker.<sup>58</sup> Rather they reflect on the goals and actions to achieve them. This process is often referred to as “deliberate rationality.” However, this cognitive process should not be confused with a rational choice analysis, but rather one that understands goals and objectives and how best to achieve them.<sup>59</sup> Experts employ deliberate rationality with the intent to improve one’s intuitive behavior without resorting to the more theory-based actions a novice may rely on.<sup>60</sup> The expert has synthesized SA

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<sup>57</sup> Gary Klein, Chew Lock Pin, and David Snowden, “Anticipatory Thinking,” (eds) U. Fisher and K. Mosier, *Proceedings of the Eight International NDM Conference* (Pacific Grove, California, June 2007):120.

<sup>58</sup> Hubert L. Dreyfus. “Intuitive, Deliberate, and Calculative Models of Expert Performance,” (eds) Gary Klein and Caroline E. Zsombok, *Naturalistic Decision Making*, Lawrence Erlbaum Associates, Mahwah, New Jersey, 1997): 28.

<sup>59</sup> *Ibid.*, 28.

<sup>60</sup> *Ibid.*

levels 1 and 2 by considering goals and objectives (perception and comprehension) and, when time permits, using available information to make a level 3 SA (projection) decision.

In Dreyfus' chapter, "Intuitive, Deliberative, and Calculative Models of Performance," he discusses philosopher Martin Heidegger's three kinds of skilled responses to a situation. Heidegger says there are three methods of coping, namely ready-to-hand, present-at-hand, and unready-to-hand. (1) Everyday coping can be described as *ready-to-hand*; we react without any thought, (2) *present-at-hand* coping involves those circumstances that are unfamiliar and where experience is irrelevant, and (3) when we resort to *unready-to-hand* we usually deal with a situation where the decision maker has a great deal of domain experience. They do not react intuitively, however, and instead stop and think. This coping should not be confused with rational deliberation. Unlike dealing with the unknown, deliberation takes place in a familiar context. Reasons for this coping process can include situations that are unusual or those requiring justification.<sup>61</sup>

Heidegger's analysis is interesting for several reasons. First, *ready-to-hand* coping is a relative term because decisions that seem easy to some may be extremely difficult to others, merely because of domain knowledge. *Ready-to-hand* is a good example of previously discussed first responder experts. Second, *present-at-hand* coping provides no resident expert. For example, "space exploration" has little available experiential information so has little value to research. Lastly, first responders operating in an asymmetrical environment (novice) appear to be closely identified with *unready-to-hand* decision making. They have some experience, but matters at hand are somehow unusual.

A question concerning the expert/novice relationship may not be how we get a novice to think like an expert, but instead, how we get a novice to learn like an expert! An expert learns by engaging in deliberate practice, compiling an extensive experience

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<sup>61</sup> Dreyfus. "Intuitive, Deliberate, and Calculative Models," 27

bank, obtaining feedback, and gaining new insight and lessons from mistakes.<sup>62</sup> Crandell et al., describe how experts fine-tune their knowledge by:

chunking information, recognizing patterns and being aware of the critical information while disregarding less important information...decisions in a natural setting are determined by individual experiences, pattern recognition and creating an association between familiar patterns and actions...through years of experience and thousands of trials, experts come to see the world in patterns.<sup>63</sup>

In Table 2, Klein identifies skills that can be taught, along with methods designed to make individuals better decision makers. Klein’s statement that these skills are not generic suggests that trainers must tailor the training to meet decision maker’s specific needs.<sup>64</sup>

Table 2. Skills to be Trained and Methods

Skills Trained	Methods for Training
Situational awareness, pattern matching, cue learning	Strategies for considering alternative hypothesis / explanations
Typical cases/anomalies	Strategies to detect earlier warning signs /contingency preparation
Mental models/mental simulations	Cognitive modeling and expert /novice contrasts
Managing uncertainty/time pressure <sup>65</sup>	Tactical decision games / develop metacognitive skills

## 5. Rational Choice and Naturalistic Decision Making

An important prerequisite for effective rational choice problem solving/decision making is the availability of vital information; time to compare options, well-defined goals, and static conditions. Rational choice decision making is reliable, it helps novices, it is rigorous, and, in general, can be applied to other situations.<sup>66</sup> The characteristics and

<sup>62</sup> Klein, *Sources*, 104.

<sup>63</sup> Crandell et al., “Training Decision Makers for the Real World,” 314.

<sup>64</sup> Gary Klein, “An Overview of Naturalistic Decision Making Application,” *Naturalistic Decision Making*, (eds) Gary Klein and Caroline E. Zsombok (Mahwah, New Jersey: Lawrence Erlbaum Associates, 1997), 53.

<sup>65</sup> *Ibid.*, 54.

<sup>66</sup> Klein, *Sources*, 29.

urgency of a decision-making event often determines the feasibility and practicality of a particular decision-making strategy. This is not to suggest that individuals ponder decision-making strategies before addressing a problem. Quite the contrary, decision makers make decisions as best they can, unaware of how they do it. The strategies they use are a product of experience, rather than an intimate discussion with oneself, arguing the advantages of rational choice over intuition! In *Sources of Power*, Klein identifies situations where a rational choice strategy may be the best choice:

- Is there a need for justification; will actions be scrutinized by a higher authority?
- Conflict Resolution: need to place all considerations into a common format
- Optimization: finding the best course of action, time to compare (time is not a factor)
- Lack of experience: lack of portfolio of experiences
- Conditions are static
- Goals are defined<sup>67</sup>

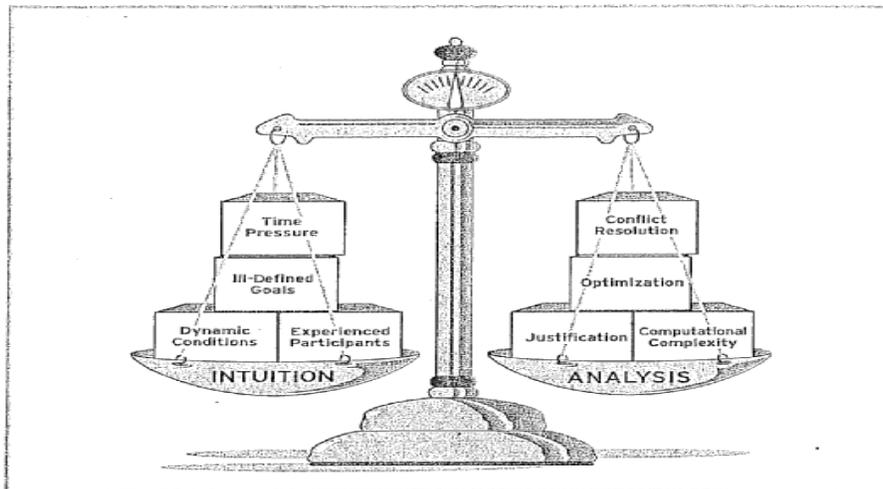


Figure 2. Conditions Favoring Intuitive and Analytical Approaches.<sup>68</sup>

<sup>67</sup> Klein, *Sources*, 96.

Thomas Karp, a Ph.D. candidate at Rushmore University, stated, “Intuition and analysis (rational choice) are essential complementary components of effective decision making,”<sup>69</sup> which suggests a mutual dependency between the two strategies. In *Strategic Intuition in Army Planning*, William Duggan, an associate professor at Columbia Business School, explores the idea of combining the decision-making strategies of intuition and rational choice to form a more complete strategy.

Duggan addresses the concept of “intelligent memory,” which is a union of intuition and rational choice decision making. He makes an interesting analogy between the human mind and a warehouse: we stock our warehouse shelves (human brain) with information obtained from knowledge and experience, storing what we view as important; this is analysis (rational). According to Duggan, when confronting a decision-making opportunity, intuition utilizes the stock from our shelves:<sup>70</sup> “The divide between analysis (rational) and intuition reflects an outmoded view of the human mind that science no longer supports...In the new view, analysis, and intuition are so intertwined that it is impossible to separate the two. Some scientists call this ‘intelligent memory,’ where analysis puts elements into your brain and intuition pulls them out and combines them into action.”<sup>71</sup>

In *Thinking Naturally About Uncertainty*, Marvin Cohen asks the question, “Has natural decision making matured enough to face uncertainty head on?”<sup>72</sup> Cohen proposes several “what if”: scenarios. For example, when patterns and similarities do not exist, can the decision maker use mental simulations to rehearse possible outcomes? How do you mentally rehearse a course of action when you have no prior operational experience? Possibly, using story building to help organize events while relating a real-life experience regarding a similar event to the problem at hand may be one option.

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<sup>68</sup> Gary Klein, *The Power of Intuition* (New York: Currency Doubleday, 2004): 67.

<sup>69</sup>Thomas Karp, “Intuitive Decision Making in Strategy Management,” *Research Paper-Rushmore University* (2002): 11. <http://tom.karp.as/idm.pdf> [Accessed January 3, 2007].

<sup>70</sup> Columbia Ideas at Work, “Strategic Intuition: The Keys to Innovation,” *Columbia Business School* (Summer 2006): <http://www.gsb.columbia.edu/ideas>. [Accessed January 2006].

<sup>71</sup> Duggan, “Coup D’oeil: Strategic Intuition in Army Planning,” V.

<sup>72</sup> *Ibid.*, 2.

## 6. Computer-Based Simulation Technologies

The military conducts war games designed to train commanders, soldiers, naval battle groups, and wings of an aircraft. In his article, *The Application of Existing Simulation Systems To Emergency Homeland Security Training Needs*, Smith suggests modifying war games by replacing the military with the fire service. Smith says that a fire chief could replace a military commander, firefighters replace soldiers, and fire trucks replace naval battle groups. The new enemy would be a fire, chemical release, or a building collapse. Fire ground commanders would be required to solve problems and make decisions based on the map display interface of a building instead of a battlefield.<sup>73</sup> Today's technology makes this idea a possibility while providing first responder training with a "tool" that has already been field-tested. First responder communities, much like a military unit, are often required to problem solve and make choices under stressful conditions. An asymmetrical threat scenario designed to evaluate current decision-making capabilities can be developed for this simulation system.

Douglas Page is a science and technology writer. In his *Fire Chief* article, "Simulator Goes to Head of Class," Page asks the question, "How do you prepare for your first blaze/fire situation that you have never been in before?"<sup>74</sup> Page reports that current virtual reality fire simulators are being retrofitted to demonstrate how life-threatening fire conditions can develop. In his article, "Make the right call," Charles Burkell, the program chair for executive development at the National Fire Academy, suggests the following concerning simulation training:

Fire service organizations need to include time pressure, shifting conditions and information gaps in training exercises. Simulations and vicarious experiences are a way to build proficiency in lieu of actually having "been there and done it."<sup>75</sup>

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<sup>73</sup> Roger Smith, "The Application of Existing Simulation Systems To Emergency Homeland Security Training Needs," *Titan Corporation, Simulation Interoperability Workshop* (Europe 2003): 3. <http://www.modelbenders.com/papers/03E-SIW-012.pdf>. [Accessed June 15, 2007].

<sup>74</sup> Douglas Page, "Simulator Goes to Head of Class," *Fire Chief* (December 2003): 14. [Accessed Proquest, January 2007].

<sup>75</sup> Charles J. Burkell, "Make the right call," *Fire Chief* (March 1999): 45. [Accessed Proquest, January 24, 2007].

Refinements to training include tactics tested on a computer without risking life and limb, simulated smoke, hot air, fire gases, and wind ventilation ramifications.

According to Page, from a decision-making perspective, first responders will be able to observe the implications of their actions.<sup>76</sup> The ability to immediately observe implications of actions is a major advantage of simulator training, according to Klein.<sup>77</sup> Burkell adds that

There are no foolproof strategies. A fundamental principle in the military is that commanders must make decisions within times of uncertainty, under great pressure. It is just part of the business. While highly experienced command officers strive for “zero defects,” the reality is that some level of error will exist. Improving one's ability to make the right decisions relies on supplementing actual experience with simulation-based training.<sup>78</sup>

Burkell believes there are not enough real-world opportunities for first responders to develop effective decision-making skills, especially when operating in a world of uncertainty. However, simulation training – creating computer-based scenarios and situations that compel first responders to make choices – is a conduit to developing decision-making skills.<sup>79</sup>

In her article, “Collective Essentials for Test Pilot Leadership Training,” Roxana Tiron, a writer for *National Defense*, reports that to test the decision-making and communication skills of military pilots, instructors will often introduce ad hoc injects or “curveballs” into the scenario.<sup>80</sup> These last-minute inserts are designed to disturb the pattern matching/recognition process that the intuitive decision maker relies on.

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<sup>76</sup> Page, “Simulator Goes to Head of Class,” 14.

<sup>77</sup> Crandall et al., “Training Decision Makers for the Real World.” 314.

<sup>78</sup> Burkell, “Make the right call,” 43.

<sup>79</sup> Ibid., 43.

<sup>80</sup> Roxana Tiron, “Collective Simulation Essential For Pilot Leadership Training,” *National Defense* (December 2004): <http://www.nationaldefensemagazine.org/issues/2004/Dec/CollectiveSimulation.htm> [Accessed June 15, 2007].

According to Tiron, when pilots make a bad decision during simulation training, they have the opportunity to go back and determine where they went wrong.<sup>81</sup>

## 7. Decision Skills Training

“Decision skills training (DST) addresses domain-specific training designed to accelerate the transition toward expertise.”<sup>82</sup> Rather than attempting to teach decision-making strategies, DST attempts to enhance a decision makers experience bank (mental models) in specific domains, thereby increasing their recognition decision-making skills.<sup>83</sup> DST is based on a list of training strategies that provide opportunities for practitioners to learn more rapidly. Namely: (1) engaging in deliberate practice; (2) obtaining feedback that is accurate; (3) building mental models; (4) recognizing opportunities to learn.<sup>84</sup>

DST is often carried out via a low-fidelity simulation exercise (pencil and paper) referred to as tactical decision games (TDG). Using a facilitator-led discussion, participants provide responses (decisions) predicated on carefully constructed scenarios that are domain-specific. For example, scenarios are read aloud to specific decision points, and participants are then given an agreed upon time limit to prioritize decision making predicated on an existing scenario. According to Klein et al., “Tactical decision games add to the trainees' experience base, prepares them to respond under uncertainty and time pressure, and requires them to formulate their intent.”<sup>85</sup> Real world dilemmas often include high levels of uncertainty and time pressure. Participants are given a finite time limit regarding game-decision responses.<sup>86</sup>

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<sup>81</sup> Tiron, “Collective Simulation Essential For Pilot Leadership Training.”

<sup>82</sup> Gary Klein, Karol G. Ross, Jennifer L. Schafer, “Professional Judgments and Naturalistic Decision Making,” (eds) Neil Charness et al., *The Cambridge Handbook of Expertise and Expert Performance* (New York: Cambridge University Press: 2006): 412.

<sup>83</sup> Gary Klein, Rebecca M. Pliske, Michael J. McCloskey, “Decision Skills Training: Facilitating Learning From Experience.” (eds) Gary Klein and Eduardo Salas, *Linking Expertise and Naturalistic Decision Making* (Mahwah, New Jersey: Lawrence Erlbaum Associates, 2001): 40.

<sup>84</sup> *Ibid.*, 41.

<sup>85</sup> *Ibid.*

<sup>86</sup> Appendix C. Decision Skills Training, C-1, [http://www.nifc.gov/safety/phaseiii\\_chapters/WFSAS-AppendixC.pdf](http://www.nifc.gov/safety/phaseiii_chapters/WFSAS-AppendixC.pdf). [Accessed December 10, 2007].

DST scenarios are designed so novices and experts alike experience the following: (1) limits of their current repertoire of mental models; (2) practice in cue recognition/pattern matching, goal identification and checking expectancies; (3) practicing mental simulation via mental models; (4) receipt of expert feedback regarding mental models and COAs; and (5) comparing their decisions with others. Because expert knowledge is believed to be tacit knowledge, it is difficult to share; how can you tell someone to perform an unconscious process? There are no lectures on how to make decisions. Instead, a realistic scenario incorporating recognizable cues and patterns provide novices the opportunity to perform and reflect upon their decisions. Scenario problems require both SA and a decision-making process. Upon completion of decisions, a facilitator-lead discussion provides trainees with expert feedback and a structured dialogue on recognition and mental simulation process.<sup>87</sup>

Incorporating the use of tactical decision games, or a similar method into first responder decision-making training should receive careful consideration for the following reasons:

- They provide a good opportunity to practice the skills that would be required in the management of an emergency situation.
- Participants make decisions while considering the consequences of a selected course of action, and have the opportunity to compare this with other possible courses of action.
- Decision makers evaluate the rationale behind decisions, rather than only focusing on the decision made.
- No limits are placed on the decisions that can be made. They are not script-driven.
- Scenario-based exercises allow participants to explore alternative task strategies, to collect an extensive experience bank, and to enrich experiences.
- Participants develop a repertoire of patterns of response; opportunities to practice recognition-primed, rule-based and knowledge-based decision making.
- Trainees receive immediate feedback from peers about their solutions to the scenarios.<sup>88</sup>

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<sup>87</sup> Klein, "Professional Judgments and Naturalistic Decision Making," 413.

<sup>88</sup> Margaret T. Crichton, Rhona Flin, William A. R. Rattray, "Training Decision Makers – Tactical Decision Games," *Journal of Contingencies and Crisis Management* 8, no. 4, December 2000: 211. [Accessed JSTOR December 2007].

## **8. Literature Summary**

References in the literature from real-world terrorism and natural disasters events highlight the need for greater first responder operational awareness for this new environment. Experts in the field of counterterrorism (e.g., Falkenrath and Hoffman) believe we are entering a period of first responder asymmetric warfare, with the growing threat of chemical, biological, radiological, nuclear and explosive (CBRNE) incidents to be a real possibility. Klein et al., describe the decision-making strategies that individuals may use when required to problem solve under stressful conditions, often comparing a novice to an expert. Duggan takes the process a step further by proposing a possible unification of strategies to create more effective decision makers. Additional research needs to identify the differences in decision-making strategies between conventional (routine) and unconventional (asymmetric) environments and how to bridge this gap. Training provides methods for enhancing first responder decision-making expertise by including computer-based simulations and scenario-based instruction.

### **D. HYPOTHESIS**

Through experience and training, today's first responders have acquired the decision-making skills to think and act decisively when operating at fires, emergencies and other related events. They demonstrate these skills at the numerous real-world incidents they routinely respond to and mitigate. However, first responders may lack experience for responding to asymmetrical scenarios, and lack the expertise to successfully think through and mitigate incidents that are often novel in nature and filled with uncertainty.

Several strategies, both on the national and local level, have addressed this new threat. For example, first responder protocol is required to become compliant with the National Incident Management System (NIMS). Included in this initiative is the application of an Incident Command System (ICS) designed to assist an Incident Commander when managing significant events. At a local level, many cities are writing Emergency Response Plans (ERP) for CBRNE responses. The FDNY recently published an ERP for a radiological response. While these initiatives are forward thinking, they still

lack one key ingredient, which is experience, and experience entails exposure to variants of the expected situation with opportunities for trial-and-error learning in order to master the type of responses that will be required.

In essence, this asymmetrical threat environment places the expert decision maker in situations where they think and react more like a novice due to the lack of an experience base from which to draw. The goal of this thesis is to develop a strategy for developing decision-making expertise for this asymmetrical environment. This strategy will be developed by identifying the problem (lack of experience) along with implementing methods that have been successful in the past such as simulation and scenario-based training. Having participants develop a course of action for responding to these asymmetric threats is anticipated to fast-forward the acquisition of experience.

The literature reveals that first responders will not be afforded the luxury of time when confronted with these new asymmetric threats. They need to develop alternative ways to acquire the decision-making skills they are unable to acquire through experience. Decision-making strategies of pattern matching, cue recognition, and mental modeling assist fire ground commanders when making “gut-like” intuitive decisions. Can these same skills be exploited and applied to an asymmetrical circumstance such as a radiological attack? I believe they can.

As previously discussed, experience allows us to: (1) match a pattern stored in memory based on a preceding experience with the situation the decision maker is currently experiencing, (2) see similarities between present and past events in terms of actions that will be successful, and (3) make rationalizations concerning the current situation and use cues to help problem solve. A first responder’s ability to develop accurate SA when confronting a challenging problem can be enhanced in numerous ways. One way is to create deliberate practice, making sure they establish goals, have practice in making the types of difficult judgments that the job requires, and rehearse decision skills that need improvement. Another method is to expose the first responder to numerous decision-making situations via simulator/scenario-based training; the trainer can provide direct feedback and evaluation, creating a correlation between SA and

decisions made, good or bad.<sup>89</sup> Skills requiring remedial training can then be separated from the practice and exercised separately. Developing strategies for considering alternative explanations about what is really going on — not becoming fixated with your SA and being flexible in your initial judgment — is another method for enhancing decision-making skills.

Today's emergency responders are making decisions in a world filled with uncertainties, employing decision strategies that rely on a combination of a naturalistic (intuitive) style that relies more on experience and “gut instinct” when making choices and a traditional (rational) decision-making process that is methodical, regimental, time consuming, and deliberate in its choice selection (decision-making steps). Developing good decision-making skills will enable a decision maker to think critically while remaining flexible when managing uncertain, asymmetric events. Consider the following:

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*You are a fire lieutenant working a night tour in Ladder Co. 198. You are new to the area and unfamiliar with the types of buildings in your response district. At 0330 hours, you receive a water flow alarm for a local factory. Upon arrival, you observe no indications of fire and the building is well sealed. The dispatcher tells you there is no additional information on the alarm. A few of the firefighters inform you that they get this alarm occasionally. There is a small discharge of water coming from the side of the building. The chief is not available for the alarm. It is getting cold!*

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Regarding the lieutenant's actions/options at the reported water leak response, was there not room for both a rational and intuitive decision-making thought process? If the lieutenant mentally rehearsed possible reasons for the water flow alarm and then performed a methodical investigation regarding the source of the alarm, was he not making decisions by using characteristics of the situations (namely, static conditions, need for justification, time to compare, uncertainty)?

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<sup>89</sup> Klein, *Sources*, 104.

Is decision-making training designed to turn a novice into an expert decision maker a guarantee of effective decisions? Absolutely not! Numerous factors such as motivation, ambition, and level of effort must be considered. However, if a novice decision maker learns to act like an expert when operating in an emergency environment, would it not make sense to assume that expert decision makers can learn the same skills to make decisions and solve problems when operating at natural disasters and terrorist events? Experienced decision makers have the “skills” and “tools” already at their disposal. The question is how to retrofit these decision-making skills to include an uncertain, asymmetrical threat environment. Cohen addresses this issue when he asks, “Is there a naturalistic way to handle uncertainty?”<sup>90</sup> By providing exposure to the skilled performance that reflect experts’ intuitive thought processes during everyday emergencies, today’s less experienced decision makers can begin acquiring the same skills through structured simulation/scenario-based training, and receiving feedback on their performance. The expert/novice contrast is designed to persuade novices to learn from experts, thereby enhancing their decision-making process at asymmetrical threats that are plagued with uncertainty, surprise, and chaos.

## **E      METHODOLOGY**

In addition to the literature review, an in-depth analysis of first responder situational awareness, naturalistic decision making, and decision-making stratagems were conducted. Where applicable, real-world examples are used to create a connection between theory and reality. Finally, a scenario-based experiment was conducted. Experimental and control groups’ responses were compared against each other and with an expert group to determine the influence/effectiveness of training and expert feedback during a time-sensitive exercise. Results from the experiment were analyzed and recommendations made.

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<sup>90</sup> Klein, *Sources*, 4.

## **F. SUMMARY**

The remaining thesis chapters will discuss, in greater depth, the decision-making theories/strategies that are part of the first responders decision-making matrix, while striving to unite decision-making theory and reality. Real-life scenarios provide applicable examples designed to illustrate the relevance of first responder decision-making training in today's asymmetrical threat environment. Chapter II will discuss the three levels of Situational Awareness (SA) along with supporting cognitive mechanisms; Chapter III defines naturalistic decision making including cue recognition, pattern matching, mental models, and mental simulations; Chapter IV will orchestrate and articulate a stratagem to transform first responders into better decision makers when confronting uncertainty, while identifying the characteristics that constitute an effective decision-making strategy. Throughout the course these chapters, scenario-based examples will connect theory with reality.

Chapter V expands upon the aforementioned scenario-based learning while clarifying the experimental design facet of this research. This scenario-based experiment tasked two groups of first responders (experts and novices) to problem solve and make decisions regarding several realistic asymmetrical-type scenarios. The group of novices (experimental) received supplementary information/training (independent variable) while the other group (control) received none.

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## II. SITUATIONAL AWARENESS

Chapter II identifies and defines the three levels of situational awareness (SA) known as (1) perception (observation of the incident), (2) comprehension (understanding what you observe), and (3) projection (taking action predicated on understanding). Additionally, Chapter II explains the supporting cognitive mechanisms that are part and parcel of the development of SA while describing their influence on an effective decision-making/problem-solving process.

“SA is defined as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.”<sup>91</sup> Individuals perceive an incident, comprehend their perception (understand the relationships between perceived cues and the current surrounding environment and desired goals), and — through their analysis of the correlation between perception, comprehension, and desired goals — project future events.

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*Imagine a seasoned fire officer and a newly promoted probationary firefighter standing in front of a burning building, trying to size up the situation. The building in question is a four-story wood frame building in a row of similar attached buildings. The fire is on the top floor. Both individuals perceive the same set of circumstances (top floor fire). However, while the seasoned officer understands that the fire will now begin to spread horizontally, the less experienced firefighter may not. Using existing cues, both individuals have entered level 2 SA. One of them, however, is at a distinct disadvantage!*

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Experienced fire commanders begin their decision-making process by perceiving the elements of an event (fire conditions and resources present) and then comparing these observations with templates stored in memory. These templates are based on previous training and experience. For example, do operational goals include extinguishing the fire,

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<sup>91</sup>Endsley, “Theoretical Underpinnings of Situational Awareness,” 3.

or rescuing occupants and protecting exposures while conceding the fire building? Integrating multiple pieces of information and comprehending the relationship between elements of the problem situation and operational goals is significant in the decision-making progression.

Continuing with the earlier scenario, the fire commander conducts an exterior evaluation (size-up) of a top floor fire in a row of attached wood-frame buildings (perception). Understanding that fires have a tendency to extend horizontally when they can no longer extend vertically (comprehension), the commander orders the stretching of a hose line to the top floor of the adjoining attached structure to stop possible extension of fire (projection). However, by the time the hose line reaches its intended destination, the fire has already gained a foothold in the adjoining structure. When the desired objectives/goals of fire extinguishment (prevent fire extension) are in conflict with existing conditions (fire in adjoining exposure), the commander makes contingency plans by calling for additional help (projection).

While a large majority of SA development involves the systematic process of collecting, understanding, and forecasting, the transition from one SA level to the next does not always follow a linear pattern. For example, while progression from one level to the next may be indicative of a novice decision maker confronting uncertainty or novel circumstances, an expert with good schemata may not need to process information through levels 2 and 3 SA.<sup>92</sup> Perception or size-up (level 1) leads to projection or action (level 3). Good schemata results in minimal conscious deliberation. Comprehension is less deliberate and more intuitive. In brief, a schema is a person's prototypical mental model for certain situations; they recognize the situation as typical and have a predetermined "game plan" or schema to implement.<sup>93</sup> Mental models, stored in long-term memory, help to explain the way the world works. "Mental models provide the basis for describing causal relations among events, for predicting what will happen as a

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<sup>92</sup> Endsley, "Expertise and Situation Awareness," 639.

<sup>93</sup> *Ibid.*, 639.

consequence of an event...”<sup>94</sup> Prototypical situations can be learned through experience or deliberate practice.<sup>95</sup> For example, deliberate practice in the form of simulations/scenario-based exercises can be designed around patterns of recognition that would normally take years to experience naturally.<sup>96</sup> Because the information is stored in long-term memory, the expert recalls the schema and applies it to the current situation.<sup>97</sup>

Use of schemas (mental models) is one type of decision-making strategy for managing a problem. Therefore, it would seem logical to believe that the greater the number of opportunities a first responder has to utilize stored schemas in the decision-making process, the faster and more intuitive they will become. In natural disasters and terrorism-related threat environments filled with uncertainty, however, first responders may not have stored schemas they can draw on to help them recognize a situation and know how to respond. The development of good SA, as described in the proceeding chapter, may help to overcome this experience deficit.

#### **A. LEVEL 1 SA: PERCEPTION**

Level 1 SA is defined as the “perception and awareness of elements in the environment.”<sup>98</sup> This level involves knowledge of surroundings, recognizing familiarities along with inconsistencies, and sizing up an incident through observation and surface identification.<sup>99</sup> The ability to recognize elements that do not require immediate investigation or cataloging typifies an expert operating in level 1 SA. This type of situation assessment often results in a familiar “been there before” moment, initiating the

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<sup>94</sup> Judith M. Orasanu, “Shared problem models and flight crew performance.” (eds) N. Johnston, N. McDonald, and R. Fuller, *Aviation Psychology in Practice* (Aldershot, England: Ashgate Publishing Group, 1994). 2.

<sup>95</sup> Endsley, “Expertise and Situation Awareness,” 639.

<sup>96</sup> Beth Crandell, T. Owens Jacobs, Barbara Means, Eduardo Salas, “Training Decision Makers for the Real World,” (eds) Roberta Calderwood, Gary A. Klein, Judith Orasanu, Caroline E. Zsombok, *Decision Making in Action: Models and Methods* (Norwood, New Jersey: Ablex, 1993), 307.

<sup>97</sup> Mica R. Endsley, “The Role of Situation Awareness in Naturalistic Decision Making,” (eds) Gary Klein and Caroline E. Zsombok, *Naturalistic Decision Making* (Mahwah, New Jersey: Lawrence Erlbaum Associates, 1997): 270.

<sup>98</sup> Endsley, “Expertise and Situation Awareness,” 634.

<sup>99</sup> *Ibid.*, 270.

cognitive process that allows for a decision without proceeding through successive SA levels.<sup>100</sup> The experienced decision maker can quickly determine that the situation is benign and requires no action. However, there is a down side: An inaccurate assessment at this level increases the odds of an incorrect picture forming. “Studies found that 76 percent of SA errors in pilots could be traced to problems in perception of needed information.”<sup>101</sup>

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*An analogy can be made to a fire commander’s initial SA size-up at a building collapse. The commander performs level 1 SA of this incident by conducting a surface reconnaissance of the area, creating a “mental blueprint” of existing surroundings. For instance, existing voids created from fallen debris may be apparent or perceived; however, exploration considerations involve an understanding/comprehension of “risk vs. reward” (placing firefighters’ lives in danger for unknown life hazard) consequences and are part of the subsequent level of SA.*

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## **B. LEVEL 2 SA: COMPREHENSION**

Level 2 SA involves the comprehension of surroundings, helping the decision maker to recognize the relationship of elements identified in the current situation, and understand how level 1 SA (perception) affected an individual’s goals and objectives.<sup>102</sup> For example, it is during level 2 SA that the fire commander will determine the relevance of void exploration by considering defined goals (rescue) in conjunction with comprehension of level 1 SA acuity (risk vs. reward). At level 2 SA, novice decision makers may experience their first frustration with uncertainty, failing to integrate goals

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<sup>100</sup> Endsley, “Expertise and Situation Awareness,” 639.

<sup>101</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 3.

<sup>102</sup> William M. Jones and Mica Endsley, United States Air Force Armstrong Laboratory, “Situation Awareness Information Dominance & Information Warfare” (February 1997): 14. [http://mentalmodels.mitre.org/cog\\_eng/reference\\_documents/situation%20awareness%20information%20dominance%20information%20warfare.pdf](http://mentalmodels.mitre.org/cog_eng/reference_documents/situation%20awareness%20information%20dominance%20information%20warfare.pdf) [Accessed November 2007].

and data to achieve comprehension.<sup>103</sup> Although they can conduct an effective level 1 SA investigation (perception), they often have difficulty converting perception into comprehension to identify the significance of events, and thus are unprepared to make good decisions at the following level.<sup>104</sup>

### C. LEVEL 3 SA: PROJECTION

Level 3 SA involves the projection of future events, governed by the decision maker's synthesis of perception acuity and comprehension. Determination of situational elements and their potential impacts upon the environment is imperative at this level.<sup>105</sup> Knowledge regarding elements of the environment, in conjunction with an understanding of the dynamic situation, helps to form level 3 SA.

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*The fire commander's goals/objectives (saving lives / protecting property) have been aligned with his current understanding of the environmental elements (unsafe operating conditions). Based on this understanding, he believes there is no immediate life hazard. His decision to delay void exploration until dangerous, unexplored areas can be adequately reinforced with building materials has been made.*

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“In almost every field I have studied (aircraft, air traffic control, power plant operations, maintenance, and medicine), I have found that experienced operators rely on future projections heavily. It is the mark of a skilled expert.”<sup>106</sup> Level 3 SA is the commander's ability to “see over the horizon” regarding current circumstances and their relationship to future events. Where is this fire going? Do I have enough resources? Do I need additional alarms according to my understanding of the situation? Having the

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<sup>103</sup> Endsley, “The Role of Situation Awareness,” 271.

<sup>104</sup> Ibid.

<sup>105</sup> Ibid.

<sup>106</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 4.

knowledge to project future events predicated on dynamic conditions is SA at its highest level. “This is analogous to having a high level of reading comprehension as compared to just reading words.”<sup>107</sup>

SA can proceed in a progression of awareness from one level to the next or occur so quickly that it appears to bypass the comprehension and projection levels and straight to intuitive decision making utilizing experience and knowledge, along with predisposed schemata stored in long-term memory. Being proficient in perceiving the elements of your environment is not sufficient SA. This is rudimentary, conducted on a basic level. At this level, a novice and expert may be on a level playing field. The decision maker proceeds from level 1 to level 2 SA by successfully linking perception and comprehension through considering situational goals. Levels 3 SA captures this synthesis while projecting the actions of the elements upon the environment.<sup>108</sup>

SA is an ongoing dynamic process that evolves throughout the course of an event; goals are achieved, redefined, or abandoned predicated on situational size-up. A word of caution is required concerning the relationship between SA and decision making. Good SA does not imply good decision making. An individual can successfully size-up a situation and still make a bad choice. Conversely, poor SA can be formed, yet a good decision is made nonetheless.<sup>109</sup> The following factors impact the decision-maker’s ability to develop good SA and decision-making strategies in complex settings.

### **1. Limited Attention and Working Memory**

A decision maker’s limited attention will have a direct bearing on the amount of information they can absorb and process. Complex situations, dynamic conditions, and the need for multiple tasking are commonplace characteristics of emergency events and often result in certain pieces of information receiving more attention than others. The more time and attention an individual must devote to information they do not understand or have sufficient knowledge of, the greater the possibility of missing a vital piece of

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<sup>107</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 3.

<sup>108</sup> Endsley, “The Role of Situation Awareness,” 271.

<sup>109</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 18.

information. According to a National Transportation Safety Board (NTSB) review of aircraft accident reports, limited attention accounted for 31 percent of accidents involving human error.<sup>110</sup>

Limited working memory capacity can inhibit the ability of the decision maker to perceive the elements (level 1 SA), comprehend the situation (level 2 SA), and construct future projections. A novice with limited working memory or an expert confronting a novel situation will experience the same frustrations concerning SA. Lacking previous experience, new information and current knowledge must be analyzed in working memory; because working memory has a limited capacity it is quickly exhausted, resulting in a decision-making process that may be seriously limited. The end result is an exorbitant amount of time devoted to conducting problem solving and Level 3 SA projections in working memory.<sup>111</sup>

## **2. Default Values**

Mental models often contain default values for decision makers in the form of information that is germane to the particular classification/domain. Default values assist the decision process by providing expected characterizations of an element — certain understandings that may be applied to the situation in a new manner. Default information is useful when the decision maker is dealing in areas of uncertainty while still possessing some background knowledge, allowing the expert to continue in situations that often stymie the novice. This is true, not because they are experts, but because they possess a relevant mental model developed through experience, explaining how a particular system works. Default information is helpful in situations where there is missing information or overload.<sup>112</sup> Consider the following example.

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<sup>110</sup> Endsley, “The Role of Situation Awareness,” 272.

<sup>111</sup> Ibid.

<sup>112</sup> Ibid.

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*When operating in domains of uncertainty, a specialist trained in hazardous material operations (expert) possesses technical knowledge that is germane or applicable to many hazardous material situations. At a hazardous material operation, this officer knows that chemicals contain particular characteristics (lighter or heavier than air). They may not be able to identify the exact agent right away; however, they may be able to tell you what it is not. This information leads to actions/options that may have stymied the novice or uninformed.*

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### **3. Automatic Action Selection**

Automatic action selection is based on the decision maker's use of templates (scripts) of prototypical situations when making decisions. When operating by using a template, less time is wasted on consideration of an alternative plan, thus freeing up memory space while allowing the decision maker to process larger chunks of information and make rapid decisions.<sup>113</sup> Because a response for a particular situation has been successful in the past, individuals do not have to search their memory bank. This is an example of Klein's, single-step "recognition-primed" decision model where the decision maker recognizes the situation based on comparing cues from the current situation with stored templates, and the appropriate response is recognized. The decision maker does not need to use the more time-consuming decision process that involves weighing of options and evaluating different courses of action.

While the automatic action selection mechanism provides good performance coupled with a low level of attention demand, there may be a down side. Namely, because the decision maker is on "automatic pilot," they may miss a novel situation that would normally be recognized. For example, would a person driving a familiar route suddenly recognize the insertion of a new stop sign? Probably not, because automatic

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<sup>113</sup> Endsley, "The Role of Situation Awareness," 276.

action selection often results in the decision maker acting on cues (stimulus), short-circuiting SA and decision making, and choosing a COA (response).<sup>114</sup>

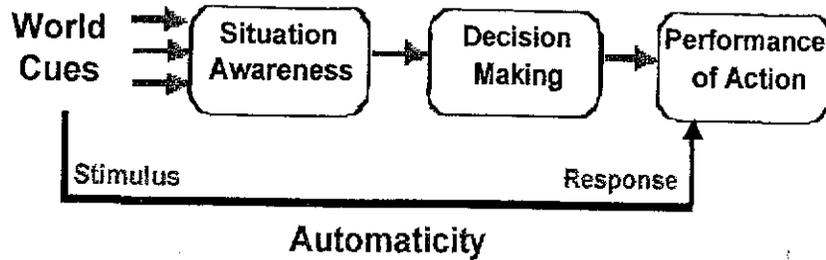


Figure 3. Automaticity (from<sup>115</sup>)

#### 4. Categorization of Information

“Chunking” data allows large amounts of related information to be grouped and stored under a single cue. The more developed mental models (as those belonging to the hazardous materials fire officer), the more fine-tuned the categorizing can be. In essence, if the decision maker possesses an extensive range of mental models, the amount of information about the environmental information can be small because it may be that only one cue is needed to generate response activity. For example, a small amount of information from the environment properly identified in the perception stage can trigger a mental model recalling similar situations.

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*While operating in the initial stages of a building fire on a lower floor, the roof team reports the roof-plumbing vent “hot to the touch” —a small piece of information. A seasoned chief, however, knows that plumbing vents are often located in shafts big enough to accommodate additional utilities. If fire has entered the shaft (causing the*

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<sup>114</sup> Endsley, “Theoretical Underpinnings of Situational Awareness,” 15.

<sup>115</sup> Ibid., 16.

*plumbing vent to become hot), it will spread vertically. When the fire reaches the top floor via the shaft, it will spread horizontally. Translation: the chief needs help!*

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A novice may struggle here because his or her mental model is not as well developed, while an expert, although possibly operating in a novel situation, has enough critical cues available to stimulate their mental model from past fires and SOPs.<sup>116</sup>

## **5. Data-Driven and Goal-Driven Processing**

Data-driven information sets in motion SA via a bottom-up decision-making process. Salient cues from the environment are instrumental in guiding the decision maker for deciding which portions of the environment are attended to (relevant) and those that can be ignored (irrelevant). The data-driven process is a bottom-up level 1 SA operation.<sup>117</sup> Conversely, the goal-driven progression is a top-down decision-making process. Goals and expectations determine which information is attended to. Synthesized data, information, and goals eventually result in the decision maker taking action based upon current understandings. A goal-driven process is a level 2 SA operation. Throughout SA development, there is a constant interaction between the dynamic and developing chain of events (bottom-up) that is indicative of an emergency-type response and goal-driven protecting of life and property that often dominates the decision making (top-down). While the top-down process will be predicated on existing expectations and goals, environmental cues (bottom-up) may require the decision maker to adjust plans or activate a new set of goals that align with the current situation.<sup>118</sup>

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*A fire chief supervising operations at an advanced fire has occupant removal and the fire's extinguishment as command objectives/goals. Because the building is structurally sound and still partially occupied, the decision is made to conduct search*

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<sup>116</sup> Endsley, "The Role of Situation Awareness," 276.

<sup>117</sup> Ibid.

<sup>118</sup> Ibid., 277.

*and rescue operations under the protection of an interior attack hose line. The chief is goal-driven, (top-down). A short time later, the chief receives reports that all occupants were safely removed from the building and the roof has partially collapsed into the top floor. Upon receipt of new information (bottom-up), the chief decides to adjust the extinguishment strategy. The chief's new goals now include a "risk vs reward" consideration; interior hose lines are removed and units prepare for an exterior operation.*

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## **6. Expectations**

Individuals' SA can be biased when they become predisposed to certain problem-solving outcomes based on standing expectations — the *if "X" then "Y"* mentality. There is a tendency to create a bias between information they are in agreement with while ignoring information in conflict with their expectations.<sup>119</sup> Klein calls this process a bending of the map.... believing what you want and explaining away any inconsistencies that conflict with your expectations. For example:

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*Fire extension is prevalent regarding certain types of building construction. While a row of attached wood frame buildings may be conducive to fire spread via a common cockloft (unobstructed open area between top-floor ceiling and underside of roof often connecting two or more buildings), a similar building known as a brownstone because it is brick construction is often considered a one building fire because brick firewalls extend into the cockloft separating one building from the next. Does this mean that fire cannot spread horizontally in a brownstone type building or that all row frame structures have common cocklofts? Now consider the receipt of information reporting fire in an adjoining building when it contradicts SOP and experience. What role does experience have in this situation?*

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<sup>119</sup> Endsley, "The Role of Situation Awareness," 276.

When the data conflicts with what you believe, you explain away the contradictions.<sup>120</sup> While it is true that individuals will process information faster if it is in agreement with their expectations — because they are predisposed in their SA exceptions and relying more on working memory — they are also less likely to notice miscalculations,<sup>121</sup> not unlike our driver who missed the stop sign because he was on “automatic pilot.”

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<sup>120</sup> Klein, *Power*, 148.

<sup>121</sup> Endsley, “The Role of Situation Awareness,” 276.

### III. NATURALISTIC DECISION MAKING

Decision making in its simplistic form occurs as follows: The individual experiences a situation and recognizes relevant cues while discarding those that are irrelevant. Recognized cues are processed into patterns that are verified by comparing them to mental models. If the pattern and the individual's stored experiences (mental models) are similar, and a "nano-second" mental rehearsal of the action (mental simulation) reveals a match, a decision/choice is implemented.

Research indicates that decision makers in time-compressed situations do not typically compare options;<sup>122</sup> there is no comparing of options, trying to decide if one choice is better than the other. If the decision or COA selection solves the immediate problem, it is implemented. Experience enables the decision maker to size-up the situation, determining if it is familiar or atypical, create a match, and implement a decision. This intuitive process is completed without deliberation, in a blink of the eye. Many first-responder decisions are made in this very manner. Time is a rare commodity at a fire scene; decisions are made under conditions of great time pressure, dynamic surroundings, and ill-defined goals.<sup>123</sup>

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*A fire chief is seldom the first unit to arrive on the scene of a developing fire. Chiefs are often dispatched upon the receipt of a preliminary report from initial units requesting the need for additional resources and command. When the chief arrives, drawing from his or her experience, via the use of stored mental models prompts anticipation that certain actions have already taken place; for example, hose lines stretched, ladders raised, searches in progress, etc. Data driven cues include changes in fire conditions as compared to those earlier detected. Namely, earlier reports regarding fire extension to floor above via the window is now receding; gray/black smoke is turning*

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<sup>122</sup> Endsley, "The Role of Situation Awareness," 17.

<sup>123</sup> Klein, *Sources*, 95.

*white; smoke is observed rising rapidly in a vertical column above the roof. A report informs the chief that all victims have been safely removed from the building.*

*The chief develops a pattern of cues that is familiar, based on recognized cues, while selecting a response that is conducive to an interior fire attack and extinguishment efforts based on mental models of past fires. Fire receding in conjunction with smoke turning white is indicative of water being applied to the fire; smoke observed rising rapidly from the roof of the fire building indicates that a ventilation hole has been cut to relieve upper floors of smoke and hot gases while limiting horizontal fire spread. Victim removal may no longer be a concern. These actions will make conditions on the upper floor favorable for final extinguishment. Cue recognition, pattern matching, and action script were all part of the pattern-recognition process behind intuitive decision making. There was very little deliberation involved in the decision selection.*

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Chapter III identifies four major components (cue recognition, pattern matching, mental models, and mental simulation) of a naturalistic decision-making process and recognition-primed decision model (RPD) and explains their relevance to a first-responder's problem-solving strategy in an asymmetrical threat environment of terrorism and natural disasters.

Naturalistic Decision Making (NDM) is an area of research within cognitive psychology that asks how experienced people, working as individuals or groups in dynamic, uncertain, and often fast-paced environments, identify and assess their situations, make decisions and take actions whose consequences are meaningful to them and to the larger organization in which they operate.<sup>124</sup>

The RPD model describes the way a decision maker is able to recognize a situation, by identifying typical events and cues and comparing pieces of data with stored templates, or schemas of previously experienced situations. Based on the response that worked during the previous experience, the decision maker attempts to recognize and

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<sup>124</sup> Caroline E. Zsombok, "Naturalistic Decision Making: Where Are We Now?" (eds) Gary Klein and Carline E. Zsombok, *Naturalistic Decision Making* (Mahwah, New Jersey: Lawrence Erlbaum Associates, 1997): 5.

evaluate a course of action by often relying on their intuition.<sup>125</sup> Klein defines intuition as the way experts translate experience into action.<sup>126</sup> Conversely, novice decision making or problem solving situations that are novel (such as asymmetric in nature) may require a more structured decision-making strategy, such as mentally rehearsing alternative options.

Chapter III explores this question via a comprehensive description of cue recognition, pattern matching, mental models, and mental simulation while supplying tangible real world examples (scenarios) that allow the reader to connect theory to reality. These scenarios are designed to enhance the reader’s comprehension of a NDM strategy through the identification of the recognition-primed decision model (RPD) benefits.

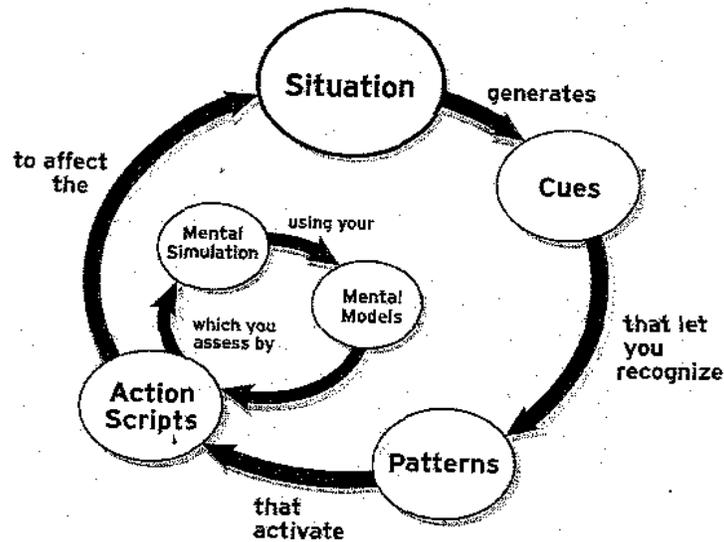


Figure 4. Recognition-Primed Decision Model.<sup>127</sup>

Prior to developing any plans or procedures for improving first responder decision-making skills in an asymmetric threat environment, it is important to define decision making terminology and relevance, thereby developing an understanding

<sup>125</sup> Klein, *Sources*, 24.

<sup>126</sup> Klein, *Power*, HIV.

<sup>127</sup> *Ibid.*, 26.

regarding where each component belongs in the decision-making process. For example, what is the difference between a mental model and a mental simulation? While mental simulation is defined as the process of mentally rehearsing the outcome of decisions, determining if an option is workable,<sup>128</sup> mental models are the decision maker's stored experiences, describing how things work.<sup>129</sup> Klein notes that a decision maker's mental model can be enhanced via exposure to numerous opportunities, as in rotating an individual through various jobs and duties within an organization until becoming familiar with the many functions.<sup>130</sup> Scenario-based training provides another method to build mental models.

Mental simulations are tangible activities in the sense that they involve some form of scrutinizing, measuring, and evaluation every time a decision maker weighs an option.<sup>131</sup> While mental simulations create a picture or scene within one's head and allow the scene to play out to determine its feasibility,<sup>132</sup> mental models are adaptive beliefs that help explain and predict situations.<sup>133</sup> Mental simulations and mental models help to explain why some problems can be solved intuitively while others need to be puzzled out.

The goal for this chapter is to develop the reader's mental model regarding how the decision-making process works and how it applies in everyday first-responder problem solving. This will be accomplished by providing related real-world examples for each discussed component. One of the main constituents of an effective decision-making strategy, regardless of the domain, is the acquisition and nurturing of real-life experiences to foster the decision makers' development of mental models. It is through the construct of mental models that the reader will understand the synthesis of the different SA levels

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<sup>128</sup> Klein, *Sources*, 89.

<sup>129</sup> *Ibid.*, 152.

<sup>130</sup> Klein, *Power*, 28.

<sup>131</sup> Klein et al., "Professional Judgments and 'Naturalistic Decision Making,'" 406.

<sup>132</sup> Klein, *Power*, 28.

<sup>133</sup> Brehmer et al., "How Professionals Make Decisions," 17.

of perception, comprehension, and projection.<sup>134</sup> By providing related examples, the learner may more readily see the relevance to his particular domain.

## A. CUE RECOGNITION

Effective cue recognition assists the decision-making process through the differentiation of relevant from irrelevant information, immediate from gradual transitions, and bottom-up data-driven vs. top-down goal-driven strategies. For example, the decision-maker's ability to discern cues that are relevant and requiring immediate action — while considering incident reports and goals — all begin with good cue recognition. Cues help the decision maker to construct patterns of behavior, building sense-making frames (data importance) that, in turn, activate corresponding mental models.

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*A neonatal nurse's intuition interprets an infant's crying pattern, feeding irregularities, distended stomach, and lethargic behavior as critical cues of sepsis, long before the ordered blood tests return. Recognizing cues that are relevant, requiring immediate action while influencing previous established objectives/goals, is a product of prior episodes comprising some or many of the same "tell-tale-signs." The nurse has "chunked" these cues into one universal warning sign. It takes only one symptom (cue) to activate a response.*

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A fire captain evaluates reports of creaking floors, sagging roof, and leaning walls, and determines that the building is in danger of collapse and needs to be evacuated. The captain does not require every critical cue to initiate a response; he probably made the decision upon the receipt of any one report. The aforementioned cues prompted the captain to intuitively calculate cue relevancy, action requirement, and strategy.

The more extensive and developed the background and domain-specific knowledge neonatal nurses have stored in long-term memory, the more efficient they

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<sup>134</sup> Endsley, "Expertise and Situation Awareness," 634.

become in responding to emergency situations. How do the previous two scenarios draw parallels between cue recognition, SA, and decision making? The nurse and fire captain's recognition of typical from atypical cues, while comprehending their relevance to the current environment and implications on future decisions, is a function of level 2 SA. The neonatal nurse first perceives the event (level 1 SA) and subsequently develops a strategy predicated on comprehension of cue significance relevant to goals and the decision maker's expectancies (level 2 SA). Recognized cues stimulate the recall of information from long-term to short-term memory while, at the same time, validating beliefs or expectancy.

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*While responding to an alarm, a fire chief is attentive to progress reports concerning a developing situation. The chief will listen to radio traffic trying to determine if the team is "winning or losing" at this fire. In this example, the radio traffic provides incident cues. Chiefs sense specific strategic and tactical operations because cues have stimulated prior experience or mental models; the chief has developed expectancies regarding this incident. Upon arrival at a fire scene, visual cues such as fire volume, smoke color, and direction of fire spread will validate whether the actions the chief had anticipated to take place were in fact performed and successful, thereby influencing subsequent practical decision making.*

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A novice and expert decision maker can view the same event, detect the same cues, and yet draw different conclusions. Studies indicate the difference between the way an expert and a novice utilize cues is often based more on the amount of weight a decision maker assigns to a cue and less on the number of cues considered.<sup>135</sup> They consider many of the same cues; however, when processing collected information, deciding relevant from irrelevant, the expert may assign a greater weight to one cue over the other. This reinforces the theory that experts and novices, when developing their perception of an incident (SA level 1), taking in all available information, are equal in

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<sup>135</sup> James Shanteau, "How Much Information Does An Expert Use? Is It Relevant?" *Acta Psychologica*, 81 (1992). [http://www.k-state.edu/psych/cws/pdf/acta\\_92.PDF](http://www.k-state.edu/psych/cws/pdf/acta_92.PDF). [Accessed July 16, 2007].

ability. The decision maker is taking the interpretation of cue importance to a new level; not only are relevant and irrelevant cues being separated, but relevant cues are further distinguished by level of importance or significance, thus helping to create a pattern and solve the current problem. Consider the following example.

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*An expert and a novice fire officer, conducting a size-up of the same situation, will extrapolate three to four significant cues to assist in their development of SA. However, the expert will assign a value to collected cues; in essence, the expert is beginning to reduce the complexity of the situation by deciding which cue/s is/are the most important. In contrast, the novice, with three to four significant cues collected in level 1 SA-perception, is often overwhelmed when trying to make sense of this information in level 2 SA-comprehension.*

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Kemper et al., comparing the decision-making abilities of experienced and novice pilots in time-sensitive situations, reveals that although their reasoning abilities were somewhat equal, the experienced pilots excelled because they possess greater domain-specific knowledge stored in their long-term memory.<sup>136</sup> Experienced pilots recognized relevant cues and developed patterns by comparing the current situation with schemas of past problem situations. In this study, both novice and expert pilots attempted to find a match in long-term memory, but only experienced pilots were able to match cues and recall patterns stored in long-term memory stores. Conversely, due to limited domain knowledge, novice pilots were forced to assimilate cues into short-term memory. Novice pilots needed to develop solutions to real-time problems from cues, while problem solving in time-pressured, stressful conditions.<sup>137</sup> Results from the Kemper et al., study also indicate that experienced pilots identified more cues that were relevant compared to novice pilots who reported fewer relevant clues and more irrelevant ones. Experienced

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<sup>136</sup> Kemper et al., "Aeronautical Decision Making," 184.

<sup>137</sup> Ibid., 191.

pilots were also more attentive to relevant cues. The best indicator of cue significance was probably the amount of time it took to make decisions based upon cue relevance.<sup>138</sup>

Shanteau's study asking third-year nursing students and faculty nurses to identify relevant cues in a nursing scenario revealed that the students' identification of relevant cues was 20 percent higher than the faculty nurses. However, upon taking a course on problem solving and decision making, the student nurses reduced their identification of relevant cues by 17 percent.<sup>139</sup> The results from this study are encouraging in several ways. First, these findings reinforce the critical idea that the difference between an expert and novice is not determined by the number of cues they considered, but by the relevance of those cues. Second, the fact that the student nurses' cue recognition skills could be improved by attending a problem-solving and decision-making course is inspirational to the author's hypothesis that decision-making skills can be learned by decision makers who lack experience.

This cue filtering process is performed in the Level 2 stage of SA-comprehension and demonstrates a critical thinking component of the decision-making progression. The decision maker is making assumptions and decisions based on intangible information, as compared to the corporeal information that can be visualized for authenticity. This critical thinking will help the decision maker to think more intuitively when confronting this same problem in the future.

The skills that help experts to solve problems in familiar situations, by utilizing cue recognition of similar events to develop pattern matching, are the same skills that will help them make good decisions in areas of uncertainty because expert decision makers will think more critically about novel situations. Cohen suggests that, because they are experts, they have the ability to think critically and, thereby, are more critical of their own assessment — and less likely to explain away situations. Because experts are so well tuned to cues that foster patterns, they may very well be aware, faster than a novice, that a

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<sup>138</sup> Shanteau, "How Much Information Does An Expert Use?" 4.

<sup>139</sup> Ibid.

piece of information is missing. <sup>140</sup> Cohen's statement regarding experts thinking more critically about novel situations is the foundation for this thesis. We know that experts may not have the knowledge/experience regarding asymmetric events, because these events are rare. Experts do, however, know how to think critically and, hopefully, that critical thinking can influence novice decision making.

The ultimate goal of cue collection and recognition is to take and use the information to build patterns of expected behavior while utilizing mental models to confirm beliefs. As vital as the collection of cues is to problem solving, if cues cannot be transformed and arranged into a coherent pattern of familiarity, they are of little use.

For example, imagine that while driving along a freeway there is a sudden buildup of traffic, with little or no traffic coming from the opposite direction. To an inexperienced driver concentrating on the minutia details of the road, staying attentive to their immediate surroundings, the pattern of recognition regarding the traffic congestion in one direction coupled with a lack of cars in opposing direction may never be comprehended. However, an experienced driver recognizes this sudden change in traffic as a potential problem ahead (some type of road condition/accident) in their direction of travel or possibly in the opposite direction, while observing little traffic coming from the opposite direction. These two situational cues help create a pattern of familiarity that is indicative of a road problem ahead; namely heavy traffic in one direction and little or no traffic in the opposite.

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*At this point, the expert's ability to distinguish between relevant and irrelevant information is critical. For example, the novice may consider incident location in their decision-making process, while the expert will not. Why? Because the information pertaining to incident location has no bearing on the problem at hand. Regardless of location, a decision needs to be made involving route selection. For the inexperienced*

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<sup>140</sup> Marvin S. Cohen and Bryan B. Thompson, "Training Teams to take Initiative: Critical Thinking In Novel Situations," *Cognitive Technologies, Inc.* (September 11, 1999) :5 <http://www.cog-tech.com/Publications/PubsRM.htm> [Accessed April 10, 2007]

*driver, time eventually runs out and they become part of the traffic jam, while the experienced driver, without deliberation, exits at the nearest egress and drives the service road until past the problem.*

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## **B. PATTERN MATCHING**

“Pattern matching, often performed intuitively, refers to the ability of the expert to detect typicality and notice events that did not happen and other anomalies that violate the pattern.”<sup>141</sup> Problem solving by the utilization of their pattern-matching skills, in conjunction with intuition and experience, is often a first responder’s decision-making modus operandi.

When dealing with uncertainty, decision makers begin to identify irregularities (via cue recognition) based on their expectations regarding previously experienced or known patterns of behavior. Developed recognition provides patterns for future decisions.<sup>142</sup> This is imperative because events are more easily recognized and re-created when their structure makes sense or a decision maker has domain-specific knowledge. The more expertise an individual has acquired in a particular domain, the more elaborate the portfolio of experience at their disposal for comparison and greater recognition. If they are not experts or experiencing a novel asymmetrical situation, they may recognize cues; they will struggle, however, in constructing and detecting typical patterns.

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*For example, when a group of chess masters was asked to re-create the positions of observed chess pieces on a board, they were better able to re-create those positions that followed a logical sequence of chess moves and positions than those that were randomly placed on the board.<sup>143</sup> What this tells us from an asymmetrical threat environment perspective is that while a fire chief can mentally recreate hose line*

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<sup>141</sup> Klein, Sources, 149.

<sup>142</sup> Cohen and Thompson, “Training Teams to take Initiative.”

<sup>143</sup> Kenneth Kemper et al., “Aeronautical Decision Making,” 188.

*positions, fire apparatus placement, and incident command post locations while responding to a particular type of fire, he may not be afforded this luxury at a hurricane or dirty bomb explosion. In addition, the individual will spend an excessive amount of time in working memory, creating meaning from knowledge of surroundings — solving problems but missing critical cues.*

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Ericsson et al., report that experts are only experts when solving problems in their own domain. For example, a seasoned urban fire commander may not be an expert when operating at a rural forest fire. The risks associated with experts operating in novel situations include the use of inappropriate patterns of recognition from past events. While pattern matching is designed to assist in the decision-making process, the decision maker may ignore inconsistencies to make the pattern fit.<sup>144</sup> This process was cited earlier as Klein's "bending of the map." The decision maker explains away inconsistencies to justify an initial pattern match with what has worked in the past. The rationalization of anomalies and inconsistent patterns in the decision-making process only compounds the situation, often reaching a point of no return.<sup>145</sup> Revisiting the neonatal nurse's decision-making scenario, consider the following regarding pattern matching, intuition, and experience.

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*The critical role of recognition in decision making came into sharper focus when Beth Crandall, 51, vice president of research operations at Klein Associates, got a contract from the National Institutes of Health to study how intensive-care nurses make decisions. In 1989, she interviewed nineteen nurses who worked in the neonatal ward of Miami Valley Hospital in Dayton, Ohio. The nurses cared for newborns in distress — some post mature, some premature. When premature babies develop a septic condition or an infection, it can rapidly spread throughout their bodies and kill them. Detecting sepsis quickly is critical. Crandall heard dozens of stories from nurses who would glance at an*

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<sup>144</sup> Endsley, "Expertise and Situational Awareness," 640.

<sup>145</sup> Klein, *Power*, 146.

*infant, instantly recognize that the baby was succumbing to an infection, and take emergency action to save the baby's life. How did they know whether to act? Almost always, Crandall got the same answer: "You just know."<sup>146</sup>*

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Crandall asked the nurses to recall the details that lead them to believe the infant was suffering from sepsis. Complexion fade from pink to gray, changes in feeding patterns, swollen abdomen, and a frequently crying baby that suddenly becomes listless and lethargic were among the symptoms that helped to develop a pattern. A novice nurse could easily explain each of these symptoms when they occur in isolation; however, an experienced nurse chunks symptom together to form a pattern, draws upon past events (experience) concerning infants diagnosed with sepsis who exhibited not all but many of the same symptoms, and intuitively creates a match. When infants display enough symptoms to develop a pattern indicative of sepsis, the nurses know what to do. Many times the baby is placed on antibiotics days before blood tests return confirming sepsis. "Each of these cues is extremely subtle but, taken together, they are a danger signal to an experienced nurse."<sup>147</sup> This is why the development of pattern recognition skills is so important to decision making.

Once the decision maker recognizes a pattern as familiar, intuition activates action scripts. We intuitively know what will work predicated on experience. While intuition has been described as a "gut feeling", it may be better described here as a not conscious thought process because the person has seen/experienced it before and they automatically recognize it and can act based on recognition of the situation. We sense what to expect next while recalling routines (action scripts) for responding. The more patterns/action scripts a decision maker has, and the more expertise they possess, the easier is to make decisions.<sup>148</sup> Consider the following examples of the pattern recognition process to intuitive decision making:

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<sup>146</sup>Bill Breen "What's Your Intuition," *Fast Company.com*. 38, August 2000, 290, <http://www.fastcompany.com/online/38/klein.html>. [Accessed July 20, 2007].

<sup>147</sup>Breen, "What's Your Intuition," 290.

<sup>148</sup> Klein, *Powers*, 23.

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*Fire ground commanders have different action scripts for each situation. One script may address search and rescue while another pertains to fire confinement and exposure protection. The fire commander constructs a set of patterns, generated from cues, organizing information particular to their domain. These patterns are stored in long-term memory.<sup>149</sup> The decision maker's experience level, pattern recognition skills, and developed associations between patterns and action scripts are all influential factors concerning a fire commander's decision making in a pressured environment.<sup>150</sup>*

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Using pattern recognition in critical time sensitive situations, matching situational cues and patterns with automated response actions appears to be the way that firefighters, nurses, and military commanders make split second decisions. Intuitive decision making is predicated on effective pattern matching.<sup>151</sup> However, when the data are conflicting and unreliable, when information is incomplete or ambiguous, how do these same individuals perform situational assessments?

### **C. MENTAL MODELS**

Experienced decision makers have internal representations of the system they are dealing with. They refer to these representations as mental models.<sup>152</sup> "Mental models are adaptive belief constructs used to describe, explain, and predict situations."<sup>153</sup> Developed from years of practice, a mental model can be viewed as a mental outline of

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<sup>149</sup> Crandall et al., "Training Decision Makers for the Real World," 314.

<sup>150</sup> Ibid., 312.

<sup>151</sup> Marvin S Cohen et al., "Critical Thinking Skills in Tactical Decision Making: A Model and a Training Strategy," *Making Decisions Under Stress* (eds). Janis A. Cannon-Bowers and Eduardo Salas, (Washington, DC: American Psychological Association, 1998): 156.

<sup>152</sup> Endsley, "The Role of Situation Awareness," 274.

<sup>153</sup> Kevin Burns. "Mental Models and Normal Errors," *How Professionals Make Decisions* (eds), Berndt Brehmer, Raanan Lipshitz, Henry Montgomery (Mahwah, New Jersey: Lawrence Erlbaum Associates, 2005): 17.

expected events for a dynamic situation.<sup>154</sup> Because a decision maker's working memory capacity is limited, mental models stored as long-term memory representations are retrieved to depict and predict how the world operates.<sup>155</sup> They allow the decision maker to use long-term memory stores to solve present day problems, attending to the dynamic unfolding circumstances of the event at hand.

A mental model's domain is comprised of features, functions, and applicability.<sup>156</sup> For example, an individual becomes familiar with a particular piece of equipment (tool). They know the tool's features, capabilities, and components. They know where and when the equipment is used and how the tool will react with the environment. When employing this piece of equipment, the decision maker compares the current situation with his mental model of the equipment's capabilities and predicts its effectiveness. In essence, a parallel is created, comparing the past (memory) with the present situation. If there is a match, the decision maker overlays the mental model on the situational model. If not, he takes additional steps (options) to solve the problem.

First responders working in similar domains for extended periods of time, responding to specific types of events, develop mental models depicting how certain events should evolve, the way things work — seeing inside the object or event. A hazardous material technician becomes an expert in the handling of hazardous material incidents because he specializes in responses of this type. Technicians are often summoned to mitigate hazardous material responses that are beyond the technical capability of operating first responders. By repeated exposure to domain-specific events, technicians develop and store experiences — mental models from previous operations. They become experts.

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<sup>154</sup>Andrew R. Dattel and Francis T. Durso, "Expertise and Transportation" (eds) Neil Charness et al., *The Cambridge Handbook of Expertise and Expert Performance* (New York: Cambridge University Press, 2006): 366.

<sup>155</sup> Klein, *Power*, 27.

<sup>156</sup> Endsley, "Expertise and Situational Awareness," 638.

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*A fire chief assigned to a high-rise building district for an extended period of time should begin to develop mental models to aid in strategic planning and decision making when responding and operating at high-rise building fires. How well these buildings resist vertical and horizontal fire spread, along with their vulnerability to collapse, will become the subject of numerous after-action reports and fire critiques. The chief's success stories, failures, and near misses will be fodder for mental model development. Decisions that worked, fell short, or were classified as last option choices will be filed away for future retrieval. The chief becomes sensitive to any information that may trigger a response action. His mental models are extensive enough to filter information, deciding relevant from irrelevant, identifying which information needs his immediate attention. When confronting incidents of a similar type, the fire chief relies on prior knowledge or mental models of how the world operates according to prior experience.*

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It would seem logical to assume that the more time individuals spend in particular domains, the more numerous and extensive their mental models will become. In essence, they are becoming experts in their domains. Conversely, Klein suggests the rotation of employees through the different jobs of a corporation, exposing them to new and challenging situations and job requirements, thereby enhancing their mental models. When required to work with the different entities of a corporation, each employee will have greater knowledge concerning job characteristics. Consider the following example of mental model building.

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*In an attempt to expand a firefighter's experience/knowledge base concerning the wide-range of building construction and fire related scenarios a firefighter might confront, the Fire Department City of New York (FDNY) established a training program requiring newly promoted firefighters to work in several firehouses and locals throughout their first three years of service. The average rotation time spent in each firehouse was approximately one year. This was groundbreaking considering the fact that many firefighters work their entire career in one firehouse, becoming resident experts*

*regarding buildings or area oddities specific to their response district. For instance, firefighters dedicating their entire career to a low-rise building district, becoming quite proficient concerning fire operations in buildings germane to their district, may be at a distinct disadvantage if they suddenly find themselves working in mid-town Manhattan amongst the forty- or fifty-story office buildings. By rotating through several firehouses scattered throughout the city, the firefighters have the opportunity to experience fires and emergencies that are not predicated on a particular domain. The goal was to produce a more rounded firefighter with varied mental models.*

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Mental models assist decision making in two distinct ways. First, when we use mental simulations to puzzle out problems, mental models help to predict outcomes. Second, mental models help the decision maker to recognize inconsistencies when pattern matching the present to the past, recognizing what is typical and what is out of the norm. Mental models are a type of story building; they give us a casual account of how things work while helping us make educated guesses and spot inconsistencies.<sup>157</sup>

Klein et al., take the mental model theory to the next level by identifying and distinguishing the difference between comprehensive models and just-in-time (JIT) models. Comprehensive models belong to individuals who possess thorough knowledge in a particular domain. For example, mechanics who work primarily on diagnosing and repairing automobile transmissions would possess comprehensive models in transmission repair. A transmission-related problem activates long-term memory stores that retrieve mental models of past transmission repair work. When the job is successfully completed, the results are stored in long-term memory for future use.

“In complex and open systems, a comprehensive mental model is unrealistic.”<sup>158</sup> While the comprehensive mental model is static, first responders often need dynamic, fragmentary knowledge to help make sense of a situation. This sense making is the prelude to JIT mental models.<sup>159</sup>

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<sup>157</sup> Klein, *Power*, 314.

<sup>158</sup> Klein et al., “A Data-Frame,” 151.

<sup>159</sup> *Ibid.*, 130.

JIT mental models rely on the belief that fragmentary knowledge from one domain can be applied to problem solving in another domain. When decision makers discover themselves troubleshooting, working with limited knowledge, considering choices without a complete understanding about what is going on, they often utilize JIT mental models as an additional method to problem solving. The concept of JIT is in no way related to time constraints, as if the JIT model was devised at the last possible second. Instead, it is a theory whereby the decision maker, because there is no comprehensive mental model, will construct a mental model at the time it is needed.<sup>160</sup> A dividend of the JIT mental model process may be the attainment and storage of new knowledge in long-term memory.

There are domains where the need for a comprehensive type of mental model exists; for example, a cardiac system is somewhat closed and refined as science progresses. However, compare this to the fire chief standing in front of a burning building, developing and creating multiple JIT models to make effective decisions.

A fire officer will rely on knowledge/experiences acquired from similar situations and develop a COA based on what has worked in the past. For example, in an earlier scenario, while processing reports of sagging floors within the building, the fire captain recalls a similar situation from long-term memory when reports of sagging floors were followed by a building collapse. Imagine the fire captain receiving relevant information regarding individual safety but minus the mental model that provides a COA or the ability to construct a JIT mental model. Translation: The fire officer does not need to be a building engineer to possess enough fragmentary knowledge regarding indications of building collapse.

Experts are making better on-the-spot decisions because they have a greater fragmentary knowledge base, a more thorough cause-and-effect relationship than their counterpart who is considered a novice. Klein et al., suggests that we train people by expanding their “repertoire and depth of casual relationships, rather than trying to teach

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<sup>160</sup> Klein et al., “A Data-Frame,” 131.

fully worked out mental models within a domain.”<sup>161</sup> This statement is encouraging and reinforces the belief that SA, decision making, and critical thinking templates can be developed for today’s asymmetrical threat environment. Consider the example and how mental models contributed to an intuitive decision-making scenario.

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*It is a simple house fire in a one-story house in a residential neighborhood. The fire is in the back, in the kitchen area. The lieutenant leads his hose crew into the building, to the back, to spray water on the fire, but the fire just roars back at them. “Odd,” he thinks. The water should have more of an impact. They try dousing it again, and get the same results. They retreat a few steps to regroup. Then the lieutenant starts to feel as if something is not right. He does not have any clues; he just does not feel right about being in that house, so he orders his men out of the building — a perfectly standard building with nothing out of the ordinary. As soon as his men leave the building, the floor where they had been standing collapses. Had they still been inside, they would have plunged into the fire below.<sup>162</sup> Table 3 identifies and connects the different RPD components of the simple house fire scenario.*

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<sup>161</sup> Klein et al., “A Data-Frame,” 132.

<sup>162</sup> Klein, *Sources*, 32.

Table 3. Simple House Fire

Cues recognition	Pattern matching	Mental models
One-story house in a residential neighborhood	Bedrooms/living areas on first floor or basement	Extinguishing fire allowed units to search the first floor/basement bedrooms
Fire is in the back, in the kitchen area.	Food on stove, gas-fueled fire, oven fire, electrical fire, grease fire	Food on stove became 2 <sup>nd</sup> alarm fire — there are NO routine fires
The water should have more of an impact	Water extinguishes fire and reduces heat; black smoke turns white	Gas fueled fire required the gas to be turned off before final extinguishments. Kitchen fire that was an extension of a basement fire. Voids provide undetected extension of fire from basement
Dousing it again, and get the same results.	Additional water should accomplish final extinguishment	Accelerant fire with inadequate water pressure.
Perfectly standard building with nothing out of the ordinary	Sound buildings not subject to collapse	Basement fire burned undetected, and caused first floor to collapse; water did not reach seat of fire.

When dealing with an asymmetrical threat environment, first responders will often not possess a mental model for the situation at hand, nor the capacity for engaging in pattern recognition, and must therefore have a contingency plan. Mental simulations, rehearsing mentally how a selected option may play out and comparing different courses of action, is one such step.

#### D. MENTAL SIMULATION:

Mental simulation is defined by Klein as “the ability to imagine people and objects consciously and to transform those people or objects through several transitions finally picturing them in a different way than at the start.”<sup>163</sup>

Mental simulation comes into play when the “simple-match RPD model” fails to intuitively recognize a solution. Teaching the art of mental simulations involves mentally rehearsing options to determine workability for current problem solving, inputting, or adjusting as warranted. The development of good mental simulation skills will improve accuracy and save time in critical situations.

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<sup>163</sup> Klein, *Sources*, 43.

By rehearsing a COA, mental simulation helps the decision maker to make sense of events that are void of the critical cues and patterns that activate intuition.<sup>164</sup> The decision maker will play out options in their mind's eye, making use of mental models, analyzing actions that must be taken, and results of implementation, while identifying problems with selected courses of action/options and their solution.<sup>165</sup> “When we use mental simulation to derive a plausible explanation, we feel that we have diagnosed the situation the way a physician might diagnosis a disease or an auto mechanic might diagnose an engine problem.”<sup>166</sup>

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*A fire commander responding to an early morning alarm for an advanced fire in a newly constructed commercial building must decide between an interior or exterior attack. Among the many cues the commander will consider in his size up, two or three are critical and are immediately apparent; the amount and volume of fire, time of day, and building stability. Before making a choice, the commander will consider relevant cues, recognize patterns, and compare and contrast the patterns to mental models of previous fires. If time permits or patterns are not making sense, the commander may mentally rehearse a series of actions predicated on cues. For example, the volume of fire could indicate how long the building has been burning or if the fire is perhaps arson related; commercial buildings are normally unoccupied after business hours; and newly constructed buildings are not built to burn, while those in the state of disrepair are prone to collapse earlier than expected.*

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Regarding the commercial building fire scenario, remove any information indicating that the fire is in the advanced stage. For some fire commanders (experts) the remaining two critical cues (time of day and construction) may still be enough to make an

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<sup>164</sup> Klein, *Sources*, 89.

<sup>165</sup> Raanan Lipshitz, “Converging Themes in the Study of Decision Making in Realistic Settings,” *Decision Making In Action: Models And Methods*. (eds) Roberta Calderwood et al., (Norwood, New Jersey: Ablex Publishing Corporation, 1993): 109.

<sup>166</sup> *Ibid.*, 89.

intuitive decision in favor of an exterior attack. The commander's mental simulations concerning decisions made can be cognitively processed in numerous ways. First, if time permits in an intuitive setting, the commander may mentally rehearse the decisions to identify any unforeseen problems before implementing action. He may modify or reject an option or possibly explore another action.<sup>167</sup> Second, when a problem or a decision-making opportunity does not provide enough familiarity to be solved intuitively, the commander will decide on a COA by mentally playing out identified options to determine their feasibility for success. If one works, he will implement the decision; if not, he will choose another course of action and repeat the simulation steps.

Continuing with the previous scenario, imagine that the commander is considering suggestions to implement an interior attack. Because there are no mental models available for pattern matching, he will mentally play out how the process will unfold. He may envision the following:

- Optimum apparatus placement for unit safety. Is it available?
- Proximity of command post to building for adequate communication with interior operations. Can communication be maintained?
- Resources on hand if plan needs to be changed. How fast can they go to an exterior attack if needed?

By mentally rehearsing options, the commander will validate or disprove their COA. Agreed upon decisions are not necessarily the best choice, although they are a workable solution. This is because, in many highly time-compressed decision-making situations such as firefighting, there is not time to come up with the optimal solution. Instead, decision makers use a "satisficing" strategy to arrive at a workable solution given the time constraints.<sup>168</sup>

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<sup>167</sup> Gary A Klein, "A Recognition-Primed Decision (RPD) Model of Rapid Decision Making," *Decision Making In Action: Models And Methods*. (ed) Roberta Calderwood et al, (Norwood, New Jersey: Ablex Publishing Corporation, 1993) 140.

<sup>168</sup> Stanley C. Collyer and Gerald S. Malecki, "Tactical Decision Making Under Stress: History and Overview," (eds) Janis A. Cannon-Bower and Eduardo Salas, *Making Decisions Under Stress* (Washington, DC: American Psychological Association, 1998): 7.

A word of caution concerning mental simulation: The person constructing the mental simulation needs to be familiar with the particular task, thinking at the right level of abstraction. You cannot mentally simulate an option foreign to your domain of expertise. For example, a fire chief has no background knowledge regarding the mental cognitions of a neonatal nurse rehearsing emergency interventions of a newborn in distress.

Mental simulations do not need to be elaborate. Due to the limits of our working memory, six steps should be the limit. If there are too many transitions, the decision maker will lose track.<sup>169</sup> When span of control becomes an issue, the decision maker can “chunk” several transitions into one unit. If the simulation is too detailed, it will take up critical working memory space. The decision maker can assume certain steps being taken without actually thinking it out. This presumption is a good example of SA automatic action selection. A simulation comprised of intangibles cannot be measured, therefore a certain amount of domain knowledge is necessary to separate fact from fiction.<sup>170</sup>

The decision maker must keep in mind that simulations can be wrong; “they are a means of creating explanations, not for generating proofs.”<sup>171</sup> While mental simulation is effective when the decision maker is not quite sure what is happening, trying to puzzle out the problem; time-pressure, and too many moving parts can complicate their puzzle and affect the quality of mental simulation.<sup>172</sup>

In summary, filtered information from the environment activates the mental model, creating numerous situational models designed to assist decision making. Selective cues help the decision maker to recognize patterns, activating action scripts in the form of mental simulations. Mental simulations rely on stored mental models to

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<sup>169</sup> Klein, *Sources*, 52.

<sup>170</sup> *Ibid.*, 53.

<sup>171</sup> *Ibid.*, 68.

<sup>172</sup> *Ibid.*, 69.

mentally rehearse different scenarios to determine if the decision maker's choice will be effective. "In order to build an effective mental simulation, we need to have good mental models of how things work."<sup>173</sup>

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<sup>173</sup> Klein, *Power*. 27.

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## IV. DECISION-MAKING STRATAGEM

Chapter IV outlines a stratagem to transform first responders into better decision makers when confronting uncertainty. Earlier chapters described SA and the RPD model strategies of cue recognition, pattern matching, mental models, and mental simulations. Chapter IV, however, identifies the characteristics that constitute an effective decision-making strategy in the following ways: first, through identification and evaluation of the mechanisms of NDM and expertise; second, by categorizing trainable decision-making skills and the methods for training them; and finally, by suggesting a scenario-based experiment to determine if first-responder decision-making performance in an asymmetrical threat environment can be enhanced.

NDM strategies enhance an individual's intuitive decision-making skills, while SA fast tracks proficiency and expertise development for a novice decision maker's training. While training has been and will continue to be considered the educational methodology of choice, intended to enhance decision making, it may not be the appropriate word to describe this process. Two issues are paramount regarding a person becoming more skilled in their domain: First, educators may want to consider the process more of an education than training regimen; "training provides specific skills, whereas education provides the basis for further skill acquisition."<sup>174</sup> Second, Klein tells us that training a novice to think like an expert is too time-consuming and expensive. However, maybe we can get a novice to learn like an expert.<sup>175</sup> As discussed earlier, a novice can learn like an expert by engaging in deliberate practice, compiling an extensive experience bank, and obtaining accurate feedback on decisions made.<sup>176</sup>

Before beginning an educational undertaking designed to prepare novice decision makers to learn like experts in asymmetrical threat environments, the "end to the means" regarding the characteristics that underlie effective decision making must be determined.

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<sup>174</sup> Stoney A. Trent, "Team Cognition in intelligence analysis training," *Dissertation* (Ohio State University, 2007): 21.

<sup>175</sup> Klein, *Sources*, 104.

<sup>176</sup> *Ibid.*

In other words, what should they be able to do? While there are numerous skills and training methods for enhancing decision-making effectiveness, the following table outlines the characteristics (knowledge and skill) and mechanisms of NDM that enhance decision-making performance in an asymmetrical environment — those decision-making skills and methods specific to this study. By doing so, educators will be better prepared to make the transition from “what to train” (skills) to “how to train it” (methods).

Table 4. NDM Characteristic and Mechanism/Expertise

<b>Characteristics</b>	<b>Mechanism/Expertise</b>
<ul style="list-style-type: none"> <li>• Flexibility/adaptability</li> <li>• Quick/resilient</li> <li>• Risk-taker/accurate</li> </ul>	<ul style="list-style-type: none"> <li>• Situational-Awareness skills</li> <li>• Organized knowledge structure</li> <li>• Mental simulation, models, cue/pattern recognition</li> <li>• Reasoning skills</li> </ul>

## A WHAT TO TRAIN (SKILLS)

### Situational Awareness Skills

- Ability to conduct a rapid accurate assessment; synthesis of perception, comprehension, and projection SA Levels.

### Cue recognition/pattern-matching skills.

- Trusting intuitive decision making

### Mental Simulation Skills

- The art of rehearsing a solution

### Mental Models

- Selecting the right model for the right situation/constructing templates

### Domain-Specific Problem-Solving Skills

- Problem solving in domain of expertise, not generic

### Reasoning

- Critical thinking and creative problem solving/improvising

## B. HOW TO TRAIN (METHODS)

Design scenario based training, i.e., computer based simulations, paper/pencil decision skill training, tabletop exercises...

- Domain-specific scenarios allow the trainee to buy into the hypothesis of the situation. If individuals can see the relevance of the training to their job, learning will take place. “The most important criteria concerning simulations are whether the decision maker takes the scenarios seriously.”<sup>177</sup>
- Scenario-based training can be the conduit for exposing individuals to the type of situations they will confront in real-world settings. Unlike real world events, however, and full-scale exercises, scenarios can be stopped, paused, and rewound. Mastered skills can be fast-forwarded, while remedial training can be conducted on those skills not yet perfected. For example, scenario simulations are safer than full-scale exercises, not exposing individuals to unnecessary risks.
- Scenario-based simulations provide more practice trials; the very problem-solving skills that the trainer is trying to enhance — namely situational awareness, cue recognition, pattern match, mental models, and mental simulation — are strategically included in the scenario. These skills can be enhanced through repeated exposure (deliberate practice) and designing scenarios around training objectives. For example, displaying cues with associated patterns will help to develop templates (mental models) for future use.<sup>178</sup> Because opportunities to develop decision-making expertise via real-world events are limited, scenario-based training provides a chance to acquire skills that real-world events may not have the opportunity provide.

When considering “what to train,” educators need to make certain the instructional design is context-specific domain knowledge. To make training truly effective, individuals need to work within their area of expertise. For example, if the goal

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<sup>177</sup> Gary A. Klein and David D. Woods, “Conclusion: Decision Making In Action” (eds) Roberta Calderwood et al., *Decision Making In Action: Models And Methods* (Norwood, New Jersey: Ablex Publishing Corporation, 1993): 410.

<sup>178</sup> Canon-Bowers, “Training Decision Makers for Complex Environments: Implications of the Naturalistic Decision Making Perspective.” 105.

is to enhance a fire officer's decision-making capabilities while operating in areas of uncertainty, scenario-based instructions should begin by introducing the officer to an environment comprised of familiarities, one in which they feel somewhat comfortable regarding incident problem solving. Then, once familiarity is established, strategically tweak the scenario with situational injects that develop uncertainty. This is an ideal opportunity to evaluate JIT mental models — the use of fragmentary knowledge to activate good mental models.<sup>179</sup> Do novice officers possess enough domain knowledge to enable them to piece together a good synopsis regarding the uncertainty? Chapter V explains the scenario-based training methodology, while describing the thesis experiment in detail.

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<sup>179</sup> Klein et al., "A Data-Frame," 130.

## V. SCENARIO-BASED LEARNING AND EXPERIMENTAL DESIGN

We have discussed scenario-based examples as a means to provide exposure to asymmetric scenarios that first responders do not experience in their normal jobs. Scenario-based training provides an effective way to expose practitioners to events and let them respond when there are not opportunities in every day practice. The author's goal here is to reinforce the decision maker's thought process by creating a skill and application connection.

Scenario-Based Training (SBT) entails the development of cue-driven exercises. The objective is to expose trainees to response environments similar to those in their professional lives, while providing feedback on responses. According to Cannon-Bowers et al., SBT helps accelerate the learning process for the decision maker from novice to expert status by providing deliberate practice with a series of task-related episodes. Deliberate practice builds familiarity. SBT also provides trainees with an opportunity to work with equipment that is often not readily available in a controlled laboratory setting.<sup>180</sup>

According to Ayers et al., SBT follows a performance-based imperative. It is different from traditional training because scenarios incorporate a specific decision-making component.<sup>181</sup> SBT must focus on the outcome and how it can be improved, rather than on the transfer of skills or the acquisition of knowledge. While skills are imperative to SBT, they are attained via traditional training and through experience. Scenario-based exercises immerse the decision maker in situations requiring performance.

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<sup>180</sup> John J. Burns, Janis A. Cannon-Bowers, Eduardo Salas, John S. Pruitt. "Advanced Technology in Scenario-Based Training" (eds) Janis A. Cannon, Eduardo Salas, *Making Decisions Under Stress*. (Washington, D.C.:American Psychological Association, 2006): 365.

<sup>181</sup> Frank Ayers, MS, Thomas Connolly, Ed.D, Charles Robertson, Ph.D. Michele M. Summers, MS "Managing Risk through Scenario Based Training, Single Pilot Resource Management, and Learner Centered Grading" (September 2007): 8. [http://www.faa.gov/education\\_research/training/fits/guidance/media/RM\\_thorough\\_SBT.pdf](http://www.faa.gov/education_research/training/fits/guidance/media/RM_thorough_SBT.pdf). [Accessed December 23, 2007].

SBT is the next best thing to reality; “Reality is the ultimate learning situation and scenario-based training attempts to get as close as possible to this ideal.”<sup>182</sup> SBT incorporates effective real-life scenarios coupled with expert feedback, providing an opportunity for a novice to learn like an expert. “In other words, we learn better the more realistic the situation is, and the more we are counted on to perform.”<sup>183</sup> Washington State homeland security stakeholders, when asked for their suggestions on improving training materials, cited real life and recent examples wherever possible.<sup>184</sup> According to the *Homeland Security Institute Report to the WA State Committee on Homeland Security*, the most difficult challenge regarding training is relating knowledge from training to “real life.” Real-life scenarios help participants apply what they know; two by-products of this application are the use of judgment and skill.

#### **A. EXPERIMENT HYPOTHESIS**

Through the utilization of scenario-based instruction, this experiment attempted to determine whether the decision-making skills of newly promoted fire officers could be enhanced through specific training designed to develop those skills. The training consisted of practice with asymmetric terrorist and natural disaster scenarios, expert feedback, and a brief lecture on SA / RPD model strategies.

By manipulation of the independent variables (SA / RPD brief and expert feedback), the author attempted to achieve the desired outcome of improving novice decision-making skills (dependent variable). In other words, feedback and SA / RPD reinforcement (independent variables) should have improved novice decision makers’ problem-solving and decision-making skills in the final scenario. The end goal was to determine if novice decision-making skills could be enhanced, thereby training them to learn like an expert.

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<sup>182</sup> Ayers et al., “Managing Risk through Scenario Based Training.”

<sup>183</sup> Ibid.

<sup>184</sup> “Emergency Responder Training Assessment and Recommendations,” Homeland Security Institute Report to the WA State Committee on Homeland Security (December 2005):14. <http://www.metrokc.gov/prepare/docs/2006-02-23%20001%20Emergency%20Responder%20Training%20Assessment%20and%20Recommendations.pdf>. [Accessed December 23, 2007].

## **B. GROUP DESIGN**

Three groups were assembled: control, expert, and experimental. The experts were fourteen New York City Fire Department officers with extensive job knowledge and decision-making experience, identified by their current rank, years of service, and self-reported domain expertise. The experts had a minimum of fifteen years of fire department experience and at least one year in their current rank. The experimental and control groups consisted of twenty-nine New York State Fire Officers promoted within the past twelve months. While the use of a random lot selection would ensure that both groups were of equal distribution, group designation (experimental/control) was determined by the availability of participants. The control group consisted of fifteen officers from various fire departments located throughout New York State, excluding the FDNY. The experimental group was fourteen recently promoted FDNY lieutenants. While the period of time spent in previous rank (firefighter) varied, officer field-experience for the experimental and control groups was limited or in some cases non-existent.

## **C. PRE-EXPERIMENT QUESTIONNAIRE**

Prior to exercise commencement, each group completed a brief questionnaire giving greater insight into their fire service experience and additional domain-specific job knowledge. The expert's mean score of years of service with the fire department (25) was two times more than the experimental (9) and control (12) groups, while experts years in current rank (5) was five times higher. In addition to confirming their status as an expert or novice, information was collected on their familiarity with SOPs. The pre-experiment questionnaire asked groups to rate their knowledge regarding fire department standard operating procedures (SOP) at certain types of responses, while avoiding the risk of predisposing subjects to certain assumptions, namely a terrorist attack. For example, a terrorist-related scenario depicts an explosion at a subway station, the questionnaire asked about subway/transit SOPs and not about an explosives or terrorism-related response. The experts rated themselves higher than the experimental and control groups in the five-knowledge/experience categories. The below average scores of the experimental and control group solidifies their status as novice decision makers (see Appendix A).

#### **D. THESIS EXPERIMENT**

The experiment began by providing the expert group with the one-page brief describing SA and RPD strategies. This description established a connection between decision-making theory and expert practical application by providing real world analogies (see Appendix B). Next, a written practice scenario depicting an emergency response to a novel situation, i.e., a terrorist scenario, was distributed to each member of the expert group. The researcher read the scenario passage aloud to a selected decision point (participants could read along silently). At each decision point, the experts were asked one to three questions in several different formats. For example, one format asked the expert group to prioritize from a list of possible options, while another format asked the group to provide a yes or no response. The lists of possible actions/options to decision point questions were developed from five pre-experiment scenario pilot sessions with other peer experts.<sup>185</sup>

A scenario response key was developed by considering the experts' most common responses as correct answers to decision point questions. For example, if twelve out of fifteen experts provided the same response to a question, that response was considered correct. For responses requiring experts to prioritize from a list of six to seven actions, the top three prioritized responses became the answer key. The experts were also asked to explain their decision-making process and problem-solving strategies in the context of SA and RPD, the why behind their decision making and prioritization. These responses provided the foundation for developing feedback for the experimental group. For example, an underlining theme throughout the scenario readings was the protection of first responding, making sure they do not become part of the problem by becoming victims themselves. One expert provided the following analogy to reinforce the need to protect first responders first:

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<sup>185</sup> At the pre-experiment sessions, the scenarios were read to other experts in the same fashion. Their responses were captured, summarized, and studied for commonalities between group members. Common responses were developed into actions or decision-making option lists unique to each scenario decision point questions. These pilot-sessions turned out to be invaluable during the actual experiment because the groups were given 2.5 minutes to make decisions and provide explanations when asked. By asking the individuals to prioritize from a list of responses designed solely to that specific passage, all three groups were considering the same information and suitable responses.

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*Part of an airline pre-flight safety plan prior to take-off includes instructions regarding the donning of individual breathing masks — in case cabin pressure is lost while the plane is in the air. Individuals with a child are told to don their mask first and then the child's. Why? Because, if conditions require supplementary oxygen, you may be overcome while trying to outfit your child. In which case, what good would you be to your child? The same analogue goes for firefighting. Managers need to make decisions ensuring their personnel are properly equipped before sending them into danger ... we must protect ourselves first ... and this involves decision making ... possibly unlike those of the past because of prior knowledge/experience.*

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This procedure continued until all the scenario passages were read and scenario decision points completed. A total of four asymmetric type scenarios (tanker on bridge, subway explosion, radiological attack, and earthquake) were read to the expert group, with three practice and one actual experimental test scenario (see Appendix C, D, E, F)

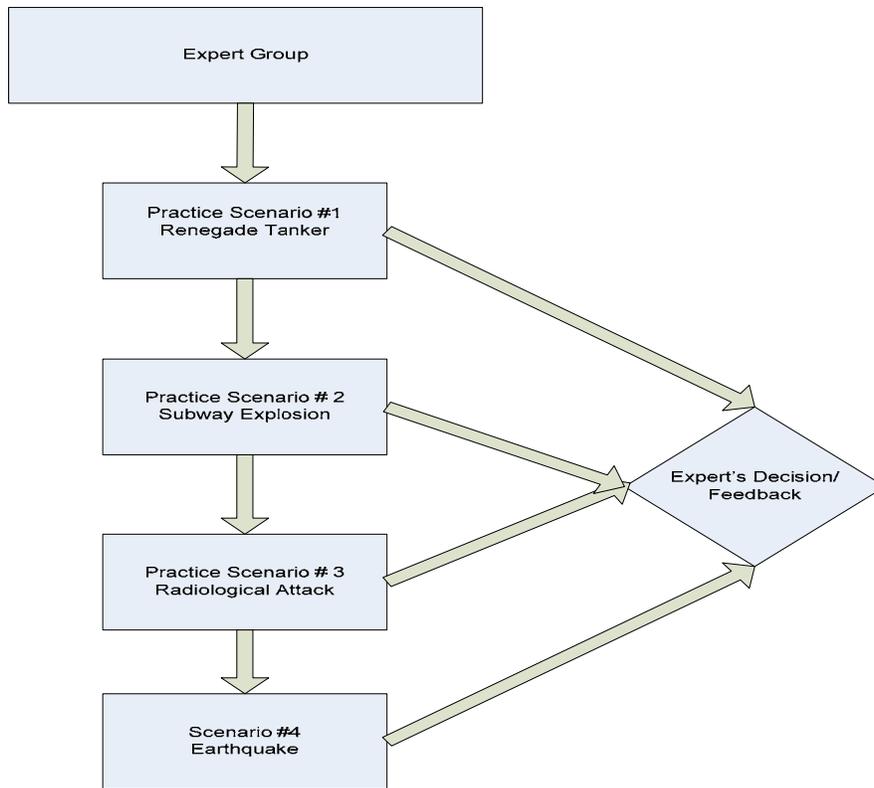


Figure 5. Expert Group Experiment Matrix

The same scenarios were distributed to the control and experimental groups. Each scenario passage was read aloud to the decision point (participants could read along silently). At each decision point, the researcher asked one to three questions and then gave participants 2.5 minutes to provide a response. This procedure continued until all the scenario passages were read and scenario decision points completed.

Upon completion of each scenario decision point, the experimental group was exposed to the independent variables (SA / RPD brief and experts' feedback). The control group was not exposed to the independent variables. The goal of expert feedback was to improve the decision making of the experimental group at subsequent scenario decision points based on providing examples of how experts responded to other scenarios. The hypothesis was that providing examples of the way experts responded to similar types of scenarios would persuade the experimental group to learn and make decisions like the experts, considering and weighing options/actions they may not have in the past.

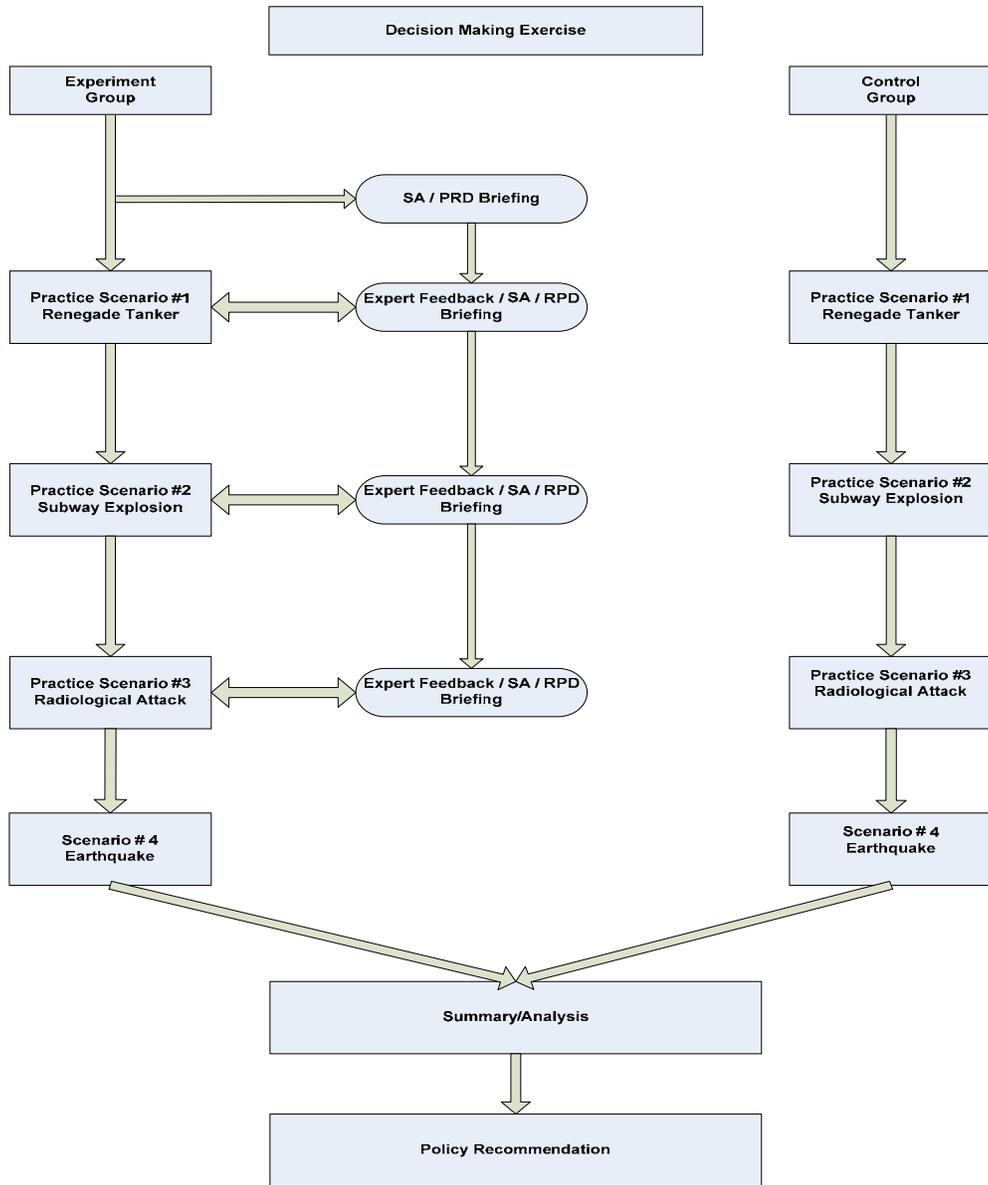


Figure 6. Experiment / Control Group Experiment Matrix

At selected decision points (one per scenario), the experimental group completed a decision point questionnaire regarding decisions made (see Appendix G). These decision points were selected because they provided the opportunity for researchers to capture the effects of expert feedback and the SA / RPD model brief on groups' decision making in real time, during the scenario. On a scale of 1-5, with 1 being low and 5 high, the experimental group rated the following: The decision difficulty and level of confidence regarding the selected decision point. The role that experience (mental models), rehearsal (simulation), and pattern matching/cue recognition played in decision making and problem solving. Additionally, the three levels of situation awareness, perception (size-up), comprehension (making sense) and projection (predicting what will happen next) were also rated. The control group did not complete this questionnaire since they did not receive the independent variables treatment.

#### **E. EXPERIMENTAL / CONTROL GROUP SCORING**

First responders often multi-task at emergency incidents, making several decisions simultaneously or in consecutive fashion, therefore, when prioritizing from a list of potential actions, the individual's top three responses that agreed with the expert response key regardless of order/ranking were scored as correct. For example, an individual might select the same three responses as the expert group but rank them in a different top order. The response will be considered correct and they will receive full credit. However, if the individual's response matches only two of the three answer key response, they received partial credit for that decision point. Table 4 was taken from the earthquake scenario decision point # 4.6. At this decision point, the experimental and control group members were read the following passage and asked to prioritize a list of six possible actions. When compared against the expert response key, both members received partial credit for their responses.

Table 5. Sample Earthquake Scenario Passage

<b>Scenario: Earthquake</b>		<b>4</b>								
<p>Upon arrival you observe someone lying face down in front of the station with two men running from the location, opposite your approach.</p> <ul style="list-style-type: none"> <li>• The streets in and around the station are crowded with people either requesting help or seeking information about the initial earthquake.</li> <li>• Incident size-up reveals gasoline leaking from several fuel pumps with fuel pooling in and around the station and street.</li> <li>• Gasoline has also been discovered coming up through the ground in the rear of the station. This fuel is flowing down the street adjacent to the curb line and smoke is venting under pressure from the front cornice of the station.</li> </ul>										
<p><b>Scenario Decision Point # 4.6:</b></p> <ul style="list-style-type: none"> <li>• Prioritize your decision-making. What problems do you address first, second, third...? Explain your first three decisions.</li> </ul> <p> <input type="checkbox"/> Fuel coming from rear of station and flowing down the street  <input type="checkbox"/> Person lying face down  <input type="checkbox"/> Smoke from cornice  <input type="checkbox"/> Fuel pooling in front of station  <input type="checkbox"/> People requesting help/information  <input type="checkbox"/> Lack of resources (foam/EMS)         </p>										
<p><b>Expert group’s prioritization response key</b></p> <table border="1"> <thead> <tr> <th style="text-align: center;">Ranking</th> <th style="text-align: center;">Prioritize Decision Making</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td>Person lying face down</td> </tr> <tr> <td style="text-align: center;">2</td> <td>Fuel coming from rear of station and flowing down the street</td> </tr> <tr> <td style="text-align: center;">3</td> <td>Smoke from cornice</td> </tr> </tbody> </table>			Ranking	Prioritize Decision Making	1	Person lying face down	2	Fuel coming from rear of station and flowing down the street	3	Smoke from cornice
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<p><b>Experimental group member</b></p> <table border="1"> <thead> <tr> <th style="text-align: center;">Ranking</th> <th style="text-align: center;">Prioritize Decision Making</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">1</td> <td>Person lying face down</td> </tr> <tr> <td style="text-align: center;">2</td> <td>Lack of resources (foam/EMS)</td> </tr> <tr> <td style="text-align: center;">3</td> <td>Smoke from cornice</td> </tr> </tbody> </table>			Ranking	Prioritize Decision Making	1	Person lying face down	2	Lack of resources (foam/EMS)	3	Smoke from cornice
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2	Smoke from cornice									
3	Person lying face down									

### **Expert Feedback**

Person lying face down is a known life hazard (visual confirmation) and addressing life is a # 1 priority before property. Unit can make quick assessment and determine viability of victim removal. The person lying down may possibly be victim of robbery and requiring immediate help.

Fuel coming from rear of station and flowing down the street needs to be controlled. If flow cannot be stopped, units must make an attempt to contain or divert flow from reaching an ignition source. Leaking fuel is largest threat to life/property, if ignited it will intensify an already dynamic and developing situation.

Extinguishing the fire eliminates a major problem. For example, smoke from the fire has potential to expose hospital and apartment building. Investigating the source of smoke will reveal fire intensity, determining if a quick stop of fire can be accomplished or whether operating personnel should be moved to a safer area

The earthquake scenario had eight-scenario decision points that added up to 100 percent. Therefore, each decision point was worth between ten and fifteen points. The researcher determined decision point weight by considering the difficulty of the response, impact on the scenario outcome, and number of decision point questions. Scenario decision point # 4.6 was worth fifteen percent of total earthquake scenario score; therefore both individuals received credit for ten percent because they were correct in two of the three responses.

### **F. SUMMARY**

Upon completion of the four scenarios, the experimental and control groups provided feedback by completing the post-experiment questionnaire (see Appendix H). The goal of this experiment was to determine if the decision-making and problem-solving skills of newly promoted fire officers, when operating in an asymmetric threat environment and without experience, could be enhanced through specific training designed to develop those skills. If it can be enhanced through training, then the analysis

of scenario decision making amongst the three groups, comparing the experimental and control group's scenario responses with those of the expert groups should indicate a significant difference. While this experiment provided greater insight into the hypothesis on improving first responder decision making in an asymmetric environment, Chapter VI analyzes group response data while making recommendations based on experiment findings.

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## VI. ANALYSIS AND RECOMMENDATIONS

To determine the impact of the independent variables (expert feedback and SA / RPD briefing), a one-way ANOVA was used to compare the earthquake scenario scores of the experimental and control groups (see Appendix I). Contrary to its namesake, an ANOVA is concerned with differences between mean scores and not between variances. A one-way ANOVA looks to see if there is a variation between group means.<sup>186</sup> When the difference is larger than would normally be expected, you have a significant difference.<sup>187</sup> The ANOVA “F” value of 14.087 yielded a “p” value of .001 (the significance is greater than .05). Therefore, we can say with confidence that there was a significant difference between the experimental and control groups’ mean scores for the final asymmetrical scenario (earthquake), or the two groups are statistically different from each other (see Appendix J).

Furthermore, since the distinction between the two groups throughout the course of the four scenario readings was the experimental group’s receipt of independent variables SA / RPD briefing and expert feedback, one concludes that the inclusion of the independent variables helped to achieve the dependent variable, namely, improving first-responder decision making in an asymmetrical threat environment.

### A. RECOMMENDATION

Experiment findings indicated that novice decision making was influenced by external factors. When comparing the control and experimental groups’ scores on the earthquake scenario, novices in the experimental groups were beginning to respond like experts. Expert feedback that was provided during practice scenarios was paying dividends, an exchange of knowledge had taken place; novice and expert were considering the same cues in their decision making, coming to similar conclusions.

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<sup>186</sup>Will G Hopkins, “T-Test and One- Way ANOVA,” *A New View of Statistics*, 2000. <http://www.sportsci.org/resource/stats/ttest.html>.

<sup>187</sup>Susan Archambault, “One-way ANOVA,” *Psych 205 Review Site*, Psychology Department, Wellesley College. 2002. <http://www.wellesley.edu/Psychology/Psych205/anova.html>.

Several questions surface regarding the thesis hypothesis and experiment finding. First and foremost, “How can first responder agencies use experiment findings to improve personnel decision making?” In other words, how can they get their novices to learn like experts?” There is no need to re-invent the training wheel here. The training level of application, however, may need to be elevated. For example, whereas classroom instruction often involves the more traditional instructor-led discussions, experience and naturalistic decision-making expertise may be best conveyed to the novice via scenario-based exercises that provide expert feedback regarding decisions made.

While designers of scenario-based exercises should strive to focus on domain-specific situations that pair expert and novice decision makers together in unfamiliar circumstances and have them problem solve; this is not always a requisite of an effective scenario. For example, the premise that drove the earthquake scenario was inconsequential. It could have easily been a hurricane- or flood-driven scenario and still have been effective. Although decision-making situations should be domain-specific whenever possible, scenarios merely provide a reason for the decision makers to be there, and they should not always be designed with the sole purpose of testing subject matter experts. In the case of the earthquake scenario, observing the exchange of information between experts and novices — with the intent of developing better decision makers by having experts explain the why behind decisions made — was a primary objective.

For example, scenario-based exercises need to emphasize not only what experts consider relevant, but also why. In other words, show the math. If the experts provide the answer without explanation, will the learning be short-term? When developing scenario-based exercises, designers must be certain that experts expand upon their response by describing in detail the cues, patterns, and experiences (mental models) they considered when making connections. Did they mentally puzzle out a COA before coming to a decision? What was considered in their SA analysis? Otherwise, minus expert guidance, the novice gains no advantage when confronting an unfamiliar situation. The scenario should drive the exercise, not the decision making. Because, in reality, there may be no real experts.

So, if there are no or few bona fide experts when situations are novel, how does the expert get by? The complexities that constitute an asymmetrical threat environment often turn experts into novices for that particular situation, and yet experts can make sound decisions. This statement was corroborated when experts, who rated their natural disaster knowledge/experience levels barely above average, puzzled out the unfamiliar. That capacity — solving a novel situation when information is limited — is what experts need to convey to novices. There are several schemes for designing this higher first-responder decision-making training curriculums.

As a fire officer advances through the various promotional ranks, he is often required to attend officer training before moving to a subsequent level. One objective of this orientation is to familiarize officers with the decision-making and problem-solving responsibilities of the new rank. For larger departments, promotional courses may be conducted simultaneously, with newly promoted lieutenants, captains, and chiefs each attending individual orientation training courses. Experienced fire officers are leaving familiar roles regarding decision-making responsibilities, and preparing to assume new roles with novel decision-making opportunities. How can departments harness this expert knowledge before it leaves the rank?

Scenario-based simulation exercises, bringing officers of different ranks together, may be one answer. This would involve having senior incumbent members preparing to leave their current rank work through scenario-based exercises with less experienced officers filling the created vacancy. This process is cyclical because, as the “tricks of the trade” are conveyed between incoming and outgoing, the officer is both beneficiary and benefactor of vital decision-making information. Imagine a group of captains preparing for their new rank by working alongside a group of senior chiefs managing a large-scale hazardous materials incident via a three-hour scenario-based simulation, and then have those same captains school a group of lieutenants regarding the company commander responsibilities inherited when assuming the captains’ rank.

Decision making in today’s asymmetrical environment is as much a concern for the newly promoted first-line supervisor responding as a boss to an incident with terrorist implications as it is for a three-star chief with over twenty-five years of service assuming

command of an escalating incident with no known cause or conclusion. Maybe there are no “real technical experts” for asymmetrical incidents just yet, but rather individuals with good SA / decision-making skills. Individuals with the ability to make sense of their surroundings, using what little cues and patterns the environment offers. Individuals that can route decisions through mental rehearsals of plausible COA, project future events, and provide expert feedback on decisions made. Sounds insurmountable? Well it is not.

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*While participating as an expert in the subway explosion scenario, a well-respected FDNY battalion chief with more than thirty years of fire department service needed to make a decision regarding the stopping of trains while operating at a suspected terrorist attack upon a subway platform. Having no mental models with subway incidents, he created an analogy with high-rise building fires, with which he had a fair amount of firefighting experience. Sounds far-fetched? Not really. The issue with the subway incident involved the movement of air; trains provide 90 percent of subway ventilation. Train movement could be beneficial and it could also be catastrophic. Are there reports of additional attacks? Are people on the platform? If a chemical agent is involved, has it been identified? The chief needed more information.*

*Before firefighters provide ventilation at a high-rise building fire, they often go to a floor above the fire and open windows, trying to re-create the same conditions units will experience on the fire floor should they decide to ventilate the fire floor. The firefighter is determining the benefits of ventilation. If a strong wind blows into the building, ventilation right now is not a good idea. The fire fighter required additional information, not unlike the chief operating at the subway incident.*

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This example epitomizes how experts use domain-specific experience from a different scenario to create JIT mental models while employing mental simulation to puzzle out a COA. The chief was no expert regarding subway incidents, yet he acted expertly. This chief problem solved by comparing the workings of a subway system encompassing a myriad of underground tunnels and a high-rise building that scraps the

sky. By creating this analogy, he decided that the effects of a train moving air, much like the wind blowing into the building, was not beneficial to the operation. Imagine the benefits of getting a novice to think at this level.

The New York City Fire Department, along with many other first-responder agencies is comprised of individuals with these very talents. They are the experts. How long they remain as members of their respective departments in another matter. While they still are, we need to learn from them.

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*A well-known golf instructor commenting on the art of teaching the motions of his golf swing to a novice, comments there is little an expert can do regarding teaching a swing. The learning needs to be experiential and feedback based. This golf analogy goes for SBT... "It's about learning, not about golf."<sup>188</sup>*

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<sup>188</sup> Ayers, et al., "Managing Risk through Scenario Based Training."

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## APPENDIX A

### Pre-experiment questionnaire mean scores

In addition to asking the three groups to provide their years of service with the fire department and current rank, the pre-experiment questionnaire also asked the groups to rate their experience/knowledge level in five emergency response categories. On a scale of 1-5, with 5 indicating a high level of experience, the experimental group rated their natural disasters experience/knowledge level with a mean rating of 1.8, indicating the least experience regarding the five categories. The control groups' ratings for natural disasters were 2.7, while the experts' was a 3.

Groups Experts: (10) Chiefs (5) Captains Experimental: (14) Lieutenants Control: (5) Captains (10) Lieutenants	Expert (14)	Experimental (14)	Control (15)
Years of service with the Fire Department	25	9	12
Years of service in current rank	5	0	1
<b>On a scale of 1-5, with 1 indicating little experience and 5 indicating extensive experience, rate your fire department knowledge/experience in the following response categories</b>			
	Expert	Experimental	Control
Knowledge/experience with high-rise building firefighting	3	2.4	2.3
Knowledge/experience with subway related incidents. (i.e.) fires/emergencies	4	2.8	1.3
Knowledge/experience with CBRNE related incidents	3	2	2.5
Knowledge/experience with hazardous material incidents	3	2.1	2.9
Knowledge/experience with natural disasters	3	1.8	2.7

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## APPENDIX B

### Pre Exercise SA / RPD Group Briefing

<b>Situational Awareness (SA):</b> Simply stated, SA is the art of being aware of your surroundings via SA perception, comprehension, and projection levels.	
<b>Level 1 SA Perception:</b> <i>(initial size-up)</i>	Knowledge of surroundings, recognizing familiarities along with inconsistencies.
<b>Level 2 SA Comprehension:</b> <i>(making sense of surroundings)</i>	Understanding/comprehending what you perceive along with its significance to incident goals and objectives
<b>Level 3 SA Projection:</b> <i>(predicting what will happen next and take appropriate actions)</i>	Projection of future events (what will you do with the information), governed by the synthesis of perception and comprehension.
<b>Recognition-Primed Decision Model (RPD):</b> The recognition-primed decision model describes the way a decision-maker is able to recognize a situation and make a decision by comparing current events to stored experiences.	
<b>Cue recognition:</b> <i>(Color of smoke; volume of fire)</i>	Identification and evaluation of incident cues. Cues result in patterns; patterns are compared to stored experiences. (mental models)
<b>Pattern matching:</b> <i>(water normally cools &amp; extinguishes fire)</i>	“Pattern matching refers to our ability to detect typicality and notice events that did not happen and other anomalies that violate the pattern.” <sup>189</sup>
<b>Mental models:</b> <i>(private dwelling attic fires often originate in the basement)</i>	Mental models explain the way things work! They are our stored experiences that help us describe, explain, and predict situations. <sup>190</sup>
<b>Mental simulations:</b> <i>(mentally rehearsing the steps of a roof rope rescue moments before initiating)</i>	We evaluate a course of action by consciously imagining what would happen if we carried it out. <sup>191</sup>

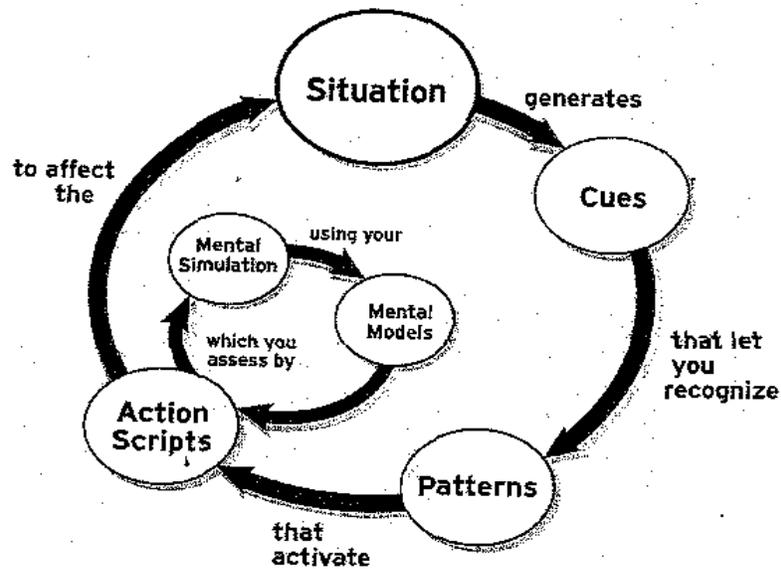
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<sup>189</sup> Gary Klein, *Sources of Power*, 149.

<sup>190</sup> Kevin Burns, “Mental Models and Normal Errors,” (eds) Berndt Brehmer, Raanan Lipshitz, Henry Montgomery, *How Professionals Make Decisions* (Mahwah, New Jersey: Lawrence Erlbaum Associates, 2005): 17.

<sup>191</sup> Klein, *Power of Intuition*, 26.

- Cues let us recognize patterns
- Patterns activate action scripts
- Action scripts are assessed through mental simulation
- Mental simulation is driven by mental models <sup>192</sup>



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<sup>192</sup> Klein, *Power of Intuition*, 28.

## APPENDIX C

### Renegade tanker on bridge scenario

<b>Scenario: Renegade tanker on bridge</b>	<b>1</b>
<p>As the first engine company (pumper) officer to arrive at the scene of a 911-generated response for a truck fire on a suspension bridge during evening rush hour, you receive the following information from police stationed at the foot of the bridge:</p> <ul style="list-style-type: none"><li>• A tanker with a capacity of 5,000 gallons disregarded police instructions and attempted to use the bridge's lower level that is restricted to passenger traffic only. A police vehicle immediately pursued the tanker.</li><li>• While attempting to stop the tanker before reaching mid-span, the police car crashed into the center divider and flipped over, while causing the tanker to sideswipe a passenger bus traveling in the same direction.</li><li>• The bus swerved before coming to an abrupt stop, as the tanker crashed into the side rail with the driver of the tanker fleeing the scene.</li><li>• Bridge police are diverting traffic on the bridge while attempting to contact the police officer involved in the chase.</li></ul> <p>Upon receipt of the preceding information, you establish command at the bridge.</p>	

#### Scenario Decision Point #1.1:

- **In regards to the preceding scenario, prioritize the following list of actions. Explain your first three actions**

- \_\_\_ ID product leaking from tanker
- \_\_\_ Life hazards to occupants of bus and police car
- \_\_\_ Whereabouts of driver leaving scene
- \_\_\_ Protecting first responders /risk vs. reward
- \_\_\_ Communication w/units and dispatcher/ request additional alarms/resources
- \_\_\_ Security of scene/ isolation of area against additional tankers/explosions (terrorism)
- \_\_\_ Prevent contamination
- \_\_\_ Notify additional agencies

### Expert group's response key

Ranking	Actions
1	Comm. w/units and dispatcher/request additional alarms/resources
2	Protecting 1 <sup>st</sup> responders / risk vs. reward
3	Life hazard to occupants of bus and police car

### Expert Feedback:

Communication with units and the fire dispatcher was a common thread among expert decision makers. The experts overwhelmingly believed that incoming units needed to be alerted regarding the magnitude of the event. Such an alert would be helpful to responding units regarding possible staging locations while ensuring units don't do the proper protection equipment (PPE). Operating units also needed to request, via the dispatcher, the response of specialized units and resources. For example, a hazardous material unit may be needed to confirm the identification of the tanker's contents and mitigate the leak; a foam unit may be required to extinguish burning fuel, and EMS to address medical needs.

At an incident of this type, the incident commanders must consider the "risk vs. reward" factor. Will rescues endanger first responder personnel? Protecting first responders, preventing them from becoming part of the problem is the most important consideration in the size-up. If first responders are not safe, they cannot help those they are entrusted to protect. For example, first responders may be conducting operations amongst an unidentified leaking product; therefore, they must consider possible exposure to and contamination from a hazardous material and take appropriate protective actions.

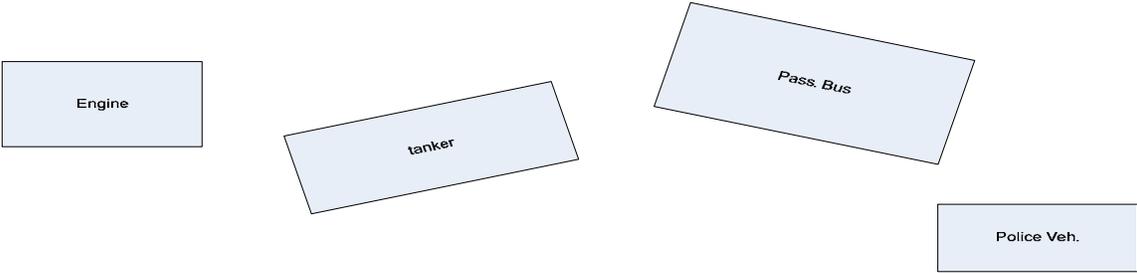
The life hazards to the police vehicle and occupants of the bus is paramount. An initial size-up of the two vehicles will generate a resources list. For example, ambulatory victims will be immediately removed while non-ambulatory and those pinned/trapped will require special resources. The number of injured bus passengers and status of police officer will determine the EMS's commitment of resources.

<b>Scenario: Renegade tanker on bridge</b>	<b>1</b>
<p>Approaching the incident, you observe the following conditions:</p> <ul style="list-style-type: none"> <li>• The engine compartment/cab section of the tanker is involved in fire while exposing the passenger bus</li> <li>• A steady flow of liquid coming from the rear compartment of the tanker</li> <li>• An occupied passenger bus stopped about 25 feet beyond the tanker</li> <li>• A police vehicle lying on its side about 25 feet in front of the bus</li> <li>• The product has been identified as # 2 fuel oil</li> </ul> <p>Because bridge traffic is now at a standstill in both directions, additional units will be delayed in gaining access to the immediate area.</p>	

**Scenario Decision Point # 1.2:**

- **What will you address first? Prioritize and explain the following decision-making options (1, 2, 3, 4):**

- \_\_\_ Police vehicle lying on its side
- \_\_\_ Fuel tanker involved in fire
- \_\_\_ Liquid coming from the rear compartment of the tanker
- \_\_\_ Occupied passenger bus



**Expert group’s response key**

Ranking	Decision making options
1	Fuel tanker involved in fire
2	Occupied passenger bus
3	Police vehicle lying on side

## **Expert Feedback**

Addressing the burning fuel tanker was an overwhelming concern of most experts. Extinguishing the fire solves numerous problems and has the greatest impact regarding the protection of life and property. If total extinguishment of the fire cannot be attained due to the contents burning, then at least containment can be achieved. If the fire is not addressed, the incident can expand. Additionally, because the fire exposes the passenger bus, containment would assist the rescue effort while reducing panic among bus passengers.

The bus is occupied, and therefore a top priority. It is severely exposed to fire, with a good possibility of containing injured passengers. The police vehicle lying on its side is the furthest from the incident and may possibly require a technical rescue (extraction), and has the least impact upon the incident. Although the liquid leaking from rear of tanker is a concern, most first responders are not trained to the level required to mitigate the leak that is both time consuming and requiring special equipment.

## APPENDIX D

### Explosion on subway platform scenario

<b>Scenario: Explosion on subway platform</b>	2
<p>You are a newly promoted lieutenant working a day tour in a mid-town engine company (pumper).</p> <ul style="list-style-type: none"> <li>• At 5:00 pm, your company responds to a 911-generated dispatch, reporting a loud noise on a subway platform within your first-alarm district.</li> <li>• The response to this alarm consists of (2) two engine companies and (1) one ladder company; The Battalion Chief normally assigned is operating at another incident and is unavailable.</li> <li>• Your company normally arrives second at this location, however, while in route you receive notification that you are now arriving first and that other loud noises have been reported at subway platforms serviced by the same subway line.</li> </ul>	

#### Scenario Decision Point # 2.1:

- **Does the receipt of additional information influence your decision-making? Yes / No. Explain.**

Group	Yes / No	Percentage
Experts	Yes	100 %

#### Expert Feedback

The receipt of additional information influenced experts' decision making in the following ways: First, an isolated incident on a subway platform could be the result of an electrical fire, derailed train car, or possibly a trash can fire, just to name a few. While these events are not everyday occurrences, they do happen from time to time and typically are isolated events. Multiple incidents, however, on the same platform or at more than one location and you begin to recognize a pattern. Given the location (mass transit platform) and the history of past attacks on similar locations (Madrid and Tokyo), first responders need to think terrorism or premeditated planning. For example, several loud noises equate to explosions and explosions equate to terrorism. Additional reports of explosions confirm an ongoing event and verify a consistency in information received while lending credibility to earlier reports whether terrorist related or not.

Second, your unit's responsibilities change because of additional information. Because you will now arrive first on the scene, you will assume the role of incident commander (until relieved by a higher rank) and be responsible for transmitting a preliminary report regarding initial size up. Depending on rank structure and arrival order of responding units, your initial role/responsibilities may be more strategically (directing operations) and less tactical.

**Scenario Decision Point # 2.2:**

- **Prioritize the following concerns. Explain your first three concerns.**

- \_\_\_ Evaluate status of victims and evacuation in progress
- \_\_\_ Establish communication with the transit authority for additional information
- \_\_\_ Recognize Incident Commander responsibilities
- \_\_\_ Conduct environmental size up (smoke, fire, readings)
- \_\_\_ Adequate resources on scene

**Expert group's response key**

<b>Ranking</b>	<b>Concerns</b>
<b>1</b>	Recognize Incident Commander responsibilities
<b>2</b>	Conduct environmental size up (smoke, fire, readings)
<b>3</b>	Evaluate status of victims and evacuation in progress

**Expert Feedback**

The first officer assuming command at an incident of this type needs to recognize that early establishment of command and control is imperative for the safety of operating personnel. Standard firefighting operating procedures, often predicated on an aggressive attack of the fire to protect life and property may not be applicable here. Instead, more time than usual is required in initial size-up. While your unit's initial duties may have included the stretching of hose lines or identification of the hazard, you are now responsible for the overall management of the incident.

As the incident commander, you need to conduct a size up, provide direction (leadership), and prioritize actions (what needs to be done first). Two primary concerns include unit deployment and the transmission of preliminary reports to notifying higher command of a developing situation, while alerting incoming units regarding the magnitude of the event.

An environmental size-up regarding smoke, fire and monitoring of the immediate vicinity for hazardous material release will determine future actions. At an incident of this type, units cannot continue operations without additional information. There are too many unknowns. For example, reports of loud noises on a subway platform are not unusual; however, they do need to be investigated. A visual size-up of the subway air vents at street level may indicate conditions down on the subway platform. Where there is smoke there is fire! Units need to create patterns from cues, reports received, and expectations developed from past events.

Life is a #1 priority. At an incident of this type, the incident commander must evaluate the status of victims and evacuation in progress. Signs and symptoms of evacuating passengers provide information regarding the type of event. What symptoms do victims normally exhibit when evacuating a fire related environment? Are the passengers exhibiting signs/symptoms that would normally be expected, or are they displaying signs and symptoms that are atypical? The evacuation status also provides valuable information regarding first responder commitment. For example, our mental models / expectations regarding rush hour at a subway platform tells us to expect a large number of passengers using the subway station. Therefore, while responding, we anticipate or expect to find a mass exodus up the subway platform stairs to the street above.

<b>Scenario: Explosion on subway platform</b>	<b>2</b>
<p>Upon arrival at the street-level entrance to the subway platform, you observe several people with minor injuries complaining of breathing difficulties; there is a light to medium smoke condition coming from the subway vents.</p> <ul style="list-style-type: none"> <li>• On-scene transportation personnel inform you that there have been a total of three loud noises, “The first noise occurred immediately after the train left the station and shortly after two subsequent noises were heard—first one then the other.”</li> <li>• A surveillance camera located at the far end of the station reveals two people overcome on the platform as several small fires burn. Numerous backpacks and bags are scattered throughout.</li> <li>• Presently there is no one exiting the subway via the street entrance where you are located. It is now 5:15 pm and the remaining assigned units are arriving.</li> </ul>	

**Scenario Decision Point # 2.3:**

- **Are you committing personnel to the subway platform? Yes / No. Explain.**

<b>Group</b>	<b>Yes</b>	<b>No</b>
<b>Experts</b>	60%	40%

**Expert Feedback**

Sixty percent of experts committed personnel to the platform. The common thread amongst the experts was the now confirmed life hazard. The signs/symptoms that evacuating passengers displayed were also instrumental in the IC decision to commit units to the platform. For example, people complaining of breathing difficulties while serious, is a common fire related symptom (mental models from experience). The smoke could be the result of a malicious trash can fire, with the noise being the sound of a heated aerosol container exploding. A majority of the experts believed that a limited commitment of resources outfitted with full protective equipment to rescue victims, extinguish fires and conduct a reconnaissance of the immediate area was a justifiable risk considering the rewards.

Conversely, forty percent of the experts decided against committing personnel to the platform without additional information. The common thread amongst this group of experts was that further investigation of the scene was required, identifying hazards before committing personnel. This incident could involve an improvised explosive device

with possible chemical or nerve gas components. Experts made this observation by considering the history of past incidents (sarin gas attack on Tokyo subway system). The limited evacuation of subway platform does not match patterns and expectations for rush-hour time of day and reinforces reluctances to commit personnel to an unknown environment. Additionally, the use of first responder radios could detonate secondary explosive devices designed to harm first responders operating at the scene (Madrid train bombings).

**Scenario Decision Point # 2.4:**

- **At this point, are you stopping train movement? Yes / No. Explain.**

Group	Yes	
Experts	90 %	

**Expert Feedback**

Ninety percent of the experts agreed that train movement should be stopped. The moving trains provide subway tunnel ventilation; therefore stopping trains reduces air movement and contamination of adjoining stations. Additional reasons for stopping trains included the following: Isolating trains at previous station prevents trains from entering the station and exposing passengers to a possible secondary explosive device; passengers may have entered the track area because station was uninhabitable or exited stranded trains in tunnel between stations; the incident commander may need to commit units to the track area and confirmation of power removal takes time.

<b>Scenario: Explosion on subway platform</b>	<b>2</b>
<p>From an adjacent subway entrance that serves the same platform but not within your line of sight, units report that they are operating at street level assisting in a mass evacuation of subway passengers.</p> <ul style="list-style-type: none"> <li>• There are some minor injuries and complaints of difficulty with breathing, however for the most part passengers appear to be ambulatory.</li> <li>• Evacuating passengers inform assisting units that there was a loud noise just as the train pulled out of the station and then everything went black.</li> </ul>	

**Scenario Decision Point # 2.5:**

- **Does the receipt of this information change your current decision-making (committing personnel to platform / train movement)? Yes / No. Explain.**

<b>Group</b>	<b>No</b>	
<b>Experts</b>	70%	

**Expert Feedback**

Seventy percent of the experts stayed with initial decision-making. Reasons for staying with initial plans include that the new information (regardless of their prior decisions to commit or not commit personnel to platform or stop trains) does not significantly influence their strategies regarding decision to commit or not commit units to platform and stopping train movement. For those who decided to commit personnel to platform the new information reinforces the initial objectives, namely that victims are endangered and need to be rescued. Also, the new information is consistent with their original assessment and expectations of explosive situation and decision to commit has already been initiated. For the experts deciding against the commitment of personnel, the situation still remained undefined and a good assessment needs to be made before committing personnel.

**Scenario Decision Point # 2.5:**

- **Prioritize the following actions. Explain your first three actions.**

- \_\_\_ Ensure adequate resources on hand
- \_\_\_ Transmit information to dispatch (progress report)
- \_\_\_ Guard against secondary devices/terrorism
- \_\_\_ Need additional information from TA
- \_\_\_ Consider gross/mass decontamination of passengers
- \_\_\_ Limited search of subway w/PPE ensuring responder safety

\_\_\_Monitor immediate environment

**Expert group’s response key**

<b>Ranking</b>	<b>Actions</b>
<b>1</b>	Limited search of subway w/PPE ensuring responder safety
<b>2</b>	Guard against secondary devices/terrorism
<b>3</b>	Transmit information to dispatch (progress report)

**Expert Feedback**

Because life is a # 1 priority, a risk vs. reward evaluation warrants a limited search of subway platform. Adhering to PPE recommendations allows first responders to achieve goals of rescue and reconnaissance while at the same time retaining a level of safety.

Other than a visual inspection, initial units do not have the capability to detect the presence of an explosive device. With this in mind, units need to guard against secondary devices designed to kill first responders, while recognizing their limits when operating at the scene of initial explosion. If units consider this incident to be terrorist related, they must recognize that the use of secondary explosives devices is a pattern of past terrorist attacks (Madrid) and guard against complacency and request additional resources.

Special first responder resources are required at this incident. Their use should be recognized and requested as early as possible in the incident. For example, victims on the platform and evacuating passengers requiring medical attention will require a greater commitment of EMS resources besides those normally assigned on the initial response. The immediate environment must be monitored by special equipment not normally assigned to first responder units. Lastly, higher levels of command need a size up-this incident is part of larger problem

<b>Scenario: Explosion on subway platform</b>	<b>2</b>
A few minutes later, several evacuated passengers are exhibiting signs of weakness and confusion and complaining of headaches, dizziness, and nausea. Three victims become incapacitated and require immediate medical attention.	

**Scenario Decision Point # 2.6:**

- **On a scale of 1-5, with 1 being very low and 5 being very high, how confident are you that this incident is terrorist related? Explain.**

<b>Group</b>	<b>Scored a 4 or higher</b>
<b>Expert</b>	<b>70%</b>

**Expert Feedback**

Seventy percent of the experts scored a 4 or greater regarding their level of confidence that this incident is terrorist related. Location, multiple explosions, and medical symptoms all point to terrorism. Similarities can be drawn between this attack and past attack on comparable locations (Madrid train bombing). For example, terrorist groups are known for attacks on critical infrastructure (transit) along with the time of day (rush-hour) and the large number of passengers. Reports from evacuating passengers that an explosion occurred immediately after the train left the station coupled with delayed physical symptoms and victim incapacitation are indicative of a chemical type attack reinforcing beliefs that this incident is terrorism related.

**Scenario Decision Point # 2.7:**

- **If this incident is terrorist related, what type of attack might the scenario information indicate?**

<b>Type of attack</b>	<b>Chemical</b>	<b>Explosive</b>	<b>Dirty bomb</b>	<b>Incendiary</b>
<b>Experts</b>	7 (50%)	4	2	1

**Scenario Decision Point # 2.8:**

- **Prioritize the following decision-making actions. Explain your first three actions:**

- \_\_\_ Safety full PPE
- \_\_\_ Request additional resources for decontamination
- \_\_\_ Make necessary notifications

- \_\_\_ Ensure passenger evacuation continues
- \_\_\_ Isolate and confine access to area
- \_\_\_ Extinguish fires burning
- \_\_\_ Triage of victims
- \_\_\_ Re-examine monitoring of environment

**Expert group's response key**

<b>Ranking</b>	<b>Actions</b>
<b>1</b>	Safety full PPE
<b>2</b>	Make necessary notifications
<b>3</b>	Isolate and confine access to area

**Expert Feedback:**

Experts agreed that in addition to ensuring that all members adhere to PPE recommendation and notifications regarding incident dynamics continue to be transmitted, the immediate area must be isolated. The latest information regarding several evacuated passengers exhibiting signs of weakness, confusion, and complaining of headaches, dizziness, and nausea, along with victims becoming incapacitated and requiring immediate medical attention necessitates that the area be sealed. Intrusion from the exterior and containment of those contaminated / injured until further evaluation in the form of decontamination and triage can be administered is paramount. If isolation measures are not taken, the incident has the capability of expanding beyond immediate area.

## APPENDIX E

### Radiological response scenario

Scenario: Radiological response	3
<p>A highly publicized and controversial meeting scheduled for the United Nations building has resulting in several credible threats from dissent groups vowing to take unspecified action if the meetings are not canceled.</p> <ul style="list-style-type: none"><li>• Due to the seriousness of these threats, along with the importance of these meetings taking place, all affected first responders have increased their awareness levels. In addition to their normal security precautions, the police are spot searching vans/trucks entering Manhattan, while fire department units have been reminded of the importance to activate and monitor all CBRNE-related equipment while out of quarters.</li><li>• Although all threats are taken seriously, precautions of this nature are not unusual for units that work in this area. More times than not, these threats are unsubstantiated, the awareness level is reduced, and units go back to business as usual.</li><li>• Throughout the first two days of the United Nations meetings, no unusual occurrences have been reported; however, your unit's false-alarm rate during this two-day period has increased by more than 100 percent.</li></ul>	

#### Scenario Decision Point # 3.1:

- **Given the following information, how do you prepare for your upcoming tour of duty on the final day of the United Nation's meeting? Prioritize the following actions. Explain your first three actions.**

- \_\_\_\_\_ Check pass along book regarding responses from previous tours
- \_\_\_\_\_ Remind members to guard against complacency due to the unusually high false alarm rate
- \_\_\_\_\_ Ensure all equipment is operational and members are knowledgeable with equipment use
- \_\_\_\_\_ Contact surrounding companies for additional information
- \_\_\_\_\_ Contact Police Department for update
- \_\_\_\_\_ Prepare Drill on CBRNE type attack
- \_\_\_\_\_ Conduct briefing stressing the type of threats units could encounter

### Expert group's response key

Ranking	Actions
1	Ensure all equipment is operational and members are knowledgeable with equipment use
2	Check pass along book regarding responses from previous tours
3	Remind members to guard against complacency due to the unusually high false alarm rate

### Expert Feedback

The experts agreed that ensuring all equipment is operational and members are knowledgeable with equipment use was a top action. Understanding that predicting what might happen on any given tour is impossible and that other than signs / symptoms, the only way to detect the presence of radiation is through the monitoring of the environment, working equipment and knowledge of its use is imperative.

The placing of equipment in or out of service is just one of the many entries that may be found in a unit's pass along book. Experts believed that one of the first steps in preparation for the upcoming tour was to check unit's pass along book entries recorded since their last tour of duty. Entries will capture any unusual events that have occurred on prior tours creating patterns regarding specific types of response. For example, a unit may record notifying the next level of command regarding the unusually high false alarm response rate to a specific location.

Pattern of high false alarm rate with no explanation reinforces the need to remind members to guard against complacency due to the unusually high false alarm rate. For example, terrorist may be monitoring response patterns to certain locations, waiting for apathy to sets in, resulting in firefighter complacency followed by terrorist strike

<b>Scenario: Radiological response</b>	<b>3</b>
<p>At 11:00 am on the third and final day of the meetings, while responding first due to a street-box alarm that requires you to pass within one block of the United Nations building, your unit receives a reading of (1mr/hr) on their radiological detector. This is the first radiological reading units have received since the meetings commenced. The alarm location you are responding to has been one of your recent chronic false alarms boxes.</p>	

**Scenario Decision Point # 3.2:**

- **Do you stop to investigate or proceed to original response location? Stop / Proceed. Explain.**

<b>Groups</b>	<b>Proceed</b>	<b>Stop</b>
<b>Experts</b>	60 %	40 %

**Expert Feedback**

Sixty percent of the experts believed that unit must continue to original response location. No known life hazards along with radiological readings too low or not unusually high (possibly background readings) were among reasons for proceeding to original location and not stopping to investigate. Units did notified the dispatcher regarding readings (location/rate) while passing along information to units responding to original alarm and requested the response of nearest available unit or hazardous material unit with sophisticated equipment to verify readings.

Forty percent of the experts believed readings were high enough to warrant investigation for verification and that some type of radiological event has taken place. A reading of 1 mr/hr on apparatus may indicate higher reading closer to source and units may be approaching an area with higher readings. Unit notified dispatcher of readings and that they are stopping to investigate while requesting an additional unit to verify readings with a second meter. Additional units can continue to original alarm location that has been chronic false alarm box.

<b>Scenario: Radiological response</b>	<b>3</b>
<p>A few moments later your unit is redirected to a reported traffic accident one block north of the United Nations. While entering the block of the reported location, your apparatus narrowly avoids a head-on collision with a car driving against oncoming traffic. The car comes to an abrupt halt with two men exiting and running away from the scene. You continue to monitor your readings that have increased and are now holding steady at (10mr/hr). Sizing-up the accident scene you observe the following:</p> <ul style="list-style-type: none"> <li>• A traffic accident involving a van and a small bus transporting about 10 passengers. Writings on the side and front of the bus are in English and Hebrew</li> <li>• The van has crashed into the side of the bus pinning the bus driver to his seat and blocking the only exit door on the bus</li> <li>• A small fire burns under the van</li> <li>• You are now receiving a reading of (5r/hr) on your radiological detector</li> </ul>	

**Scenario Decision Point # 3.3:**

- **Considering the “risk vs. reward” commitment of resources, what will you address first? Prioritize the following decision-making options. Explain your first three decision-making options.**

- \_\_\_ Address life hazard on the bus
- \_\_\_ Transmit size-up and resource request
- \_\_\_ Extinguish the fire
- \_\_\_ Identify hazards and monitor environment
- \_\_\_ Ensure all members wear full PPE
- \_\_\_ Isolate the area due to confirmed radiological threat (hot zone)

**Expert group response key:**

<b>Ranking</b>	<b>Options</b>
<b>1</b>	Ensure all members wear full PPE
<b>2</b>	Transmit size-up and resource request
<b>3</b>	Address life hazard on the bus /Isolate the area

**Expert Feedback**

Ensuring that all personnel wear full PPE protects firefighters so they can protect life. Keeping firefighters from becoming victims themselves is an incident commander’s

primary concern. At this incident, the inhalation of contaminants is an immediate threat to firefighters. The verified radiological readings (5 r/h) in immediate area of bus and van dictate that firefighter don PPE, providing sufficient protection for short-term exposure (alpha / beta).

This incident is beyond the capabilities of a single unit response, necessitating that units transmit a size-up alerting incoming units regarding the magnitude of the incident while requesting additional resource. A size up alerts higher command to escalating incident while providing valuable information to responding units. For example, incoming units need to know location of contamination controls zones. A resource request gets specialized units and equipment on the scene (Haz-Mat unit/decontamination) or at least on the road, additional manpower affords the incident commander the ability to rotate personnel.

Isolation of immediate area is required pending further size up while protecting members from additional exposure. Reading of 5 r/h confirms a radiological threat and necessitates the evacuation of immediate area and establishment of contamination control zones to identify areas requiring special equipment and personal protection levels. Life hazard on the bus is a #1 priority. There is a medium risk (exposure) for high reward (life). Units can make rescues, evacuating ambulatory passengers first and rotating personnel for technical rescues limiting exposure to radiation.

<b>Scenario: Radiological response</b>	<b>3</b>
While sizing-up the incident, your chauffeur informs you that additional units are being assigned to this location and that similar incidents are being reported throughout the area.	

**Scenario Decision Point # 3.4:**

- **Does this new information change your decision making process regarding your unit’s commitment? Yes / No. Explain.**

<b>Group</b>	<b>No</b>	
<b>Experts</b>	80 %	

## **Expert Feedback**

Eighty percent of the experts were already treating this as a terrorist related incident, taking the necessary precautions and actions to ensure firefighter safety (PPE, isolation, notifications). They were committed to incident and recognized immediate problems i.e., life, fire, hazardous materials, etc...The additional information confirms assumptions regarding terrorism and heightens the likelihood that this is a terrorist related event, however it does not change decision making process — objectives regarding the incident remains the same , a radiological attack w/victims.

## APPENDIX F

### Earthquake scenario

<b>Scenario: Earthquake</b>	<b>4</b>
<p>It is January 2, 2008, and you are working a day-tour in Ladder Company 999 located in Queens, New York.</p> <ul style="list-style-type: none"> <li>• Ladder 999's response area is mainly residents consisting of private dwelling wood-frame buildings that are two to three stories in height. Although the neighborhood is composed of several ethnicities, most of the local residents are Hispanic.</li> <li>• While in the process of completing your 0900 roll call and familiarizing yourself with apparatus tools and equipment, the ground beneath you begins to shake causing you to momentarily lose your balance, as breaking glasses/dishes can be heard from the kitchen area.</li> <li>• The shaking lasts no more than twenty seconds; however, it is immediately followed by two additional tremors that are shorter in length and less severe. The distinguishable error/failure tone emitting from the house watch computer is drowned-out by the high-pitched sound of car and house alarms heard up and down the street of the firehouse.</li> </ul>	

#### Decision Point # 4.1:

- **From the information received up to this point, prioritize the following list of decision-making actions and explain your first three actions.**

- \_\_\_ Monitor media for additional information (television/radio)
- \_\_\_ Establish communications w/dispatcher
- \_\_\_ Prepare for emergency type responses (gas and water mains, downed trees/power lines)
- \_\_\_ Assessment of members/firehouse
- \_\_\_ Prepare for verbal alarms received at firehouse
- \_\_\_ Establish communications with immediate supervisor

#### Expert group's response key

<b>Ranking</b>	<b>Action</b>
<b>1</b>	Assessment of members/firehouse
<b>2</b>	Establish communications w/dispatcher
<b>3</b>	Establish communications with immediate supervisor

## **Expert Feedback**

The condition of personnel and structural stability of firehouse is the primary concern. Firefighters cannot help civilians if they are unable to respond because of personal injuries or structural damage to firehouse (utilities, apparatus doors, apparatus floor, and apparatus). Understanding that few fire officers are structural engineers, a visual inspection of the firehouse building needs to be conducting nonetheless. Among the questions that need to be answered include: Can the building withstand a similar tremor? Does unit need to evacuate due to structural damage to firehouse?

By contacting dispatcher, unit establishing a reliable communication link while notifying the dispatcher of unit's availability for response. For example, if units cannot open the firehouse apparatus doors, they cannot respond. Units can also determine extent of earthquake damage outside of their immediate response area. Is it widespread or limited in scope? This is important because unit will know how much support it can expect from surrounding units. Communication with dispatcher will also help to appraise next actions.

In addition to establishing communication with dispatcher, units also need to contact the next level of command. The chief will be gathering additional information to determine safest response matrix, therefore they need to know unit status and availability. For example, if a unit is in-service but responding undermanned, the chief's priorities may need to change regarding the protection of life and property, they may not be able to perform both.

<b>Scenario: Earthquake</b>	<b>4</b>
<p>You find out that at approximately 8:58 am, the New York City area experienced an earthquake with a reported 5.5 to 6.0-magnitude range. Tremors have been reported for up to 100 miles of the epicenter located just north of the city with additional aftershocks reported throughout your area.</p> <ul style="list-style-type: none"> <li>• At 9:10am, you are dispatched via department radio to a reported explosion and fire at a gas station located within two blocks of the firehouse.</li> <li>• Before leaving quarters, you receive information regarding a possible robbery in progress at your response location. Additional fire units have been assigned to the alarm and the police are in route.</li> <li>• While responding you are flagged down by neighbors telling you that their child is hurt and needs medical care. Although you are able to understand bits and pieces of the conversation, the language barrier prevents you from obtaining any additional information regarding the extent and circumstances surrounding the child's injuries.</li> </ul>	

**Scenario Decision Point # 4.2**

- **Does this new information regarding a possible robbery in progress and verbal alarm for injured child change your response procedures? Yes / No. Explain.**

**Expert group's response key**

<b>Group</b>	<b>Yes / No</b>	<b>Percentage</b>
<b>Experts</b>	Yes	100 %

**Expert Feedback**

Experts overwhelming agreed that the child was an immediate life threat and must be addressed. Personal contact with civilian (verbal alarm) confirms an incident that may require prompt action if life threaten. Prioritizing this incident will influence next decision regarding unit remaining on the scene or proceeding to original alarm. If injuries are not life threatening, the officer may consider leaving one firefighter with child until arrival of EMS.

<b>Scenario: Earthquake</b>	<b>4</b>
You stop and discover the child's injuries to be minor and already under the care of EMS. In the meantime, the dispatcher has received several calls reporting smoke and a street collapse in the same vicinity of the gas station. The police are also reporting widespread looting throughout the area.	

**Scenario Decision Pt # 4.3:**

- **Place a check next to the following decision-making actions/options you agree with and rank which actions/options are most important. Explain your first three actions.**

- Proceed to original alarm but wait for police before investigating
- Advise chauffeur to slow down and proceed with caution
- Inform members of additional information regarding reports of a robbery in progress and street conditions
- Use of heavy caliber streams from a distance
- Wait for remaining alarm assignment before continuing into immediate area
- Consider hydrant system to be compromised
- Due to reports of civil disturbance, maintain unit integrity when operating

**Expert group's actions/options response key**

<b>Ranking</b>	<b>Actions / Options</b>
<b>1</b>	Inform members of additional information regarding reports of a robbery in progress and street conditions
<b>2</b>	Advise chauffeur to slow down and proceed with caution
<b>3</b>	Due to reports of civil disturbance, maintain unit integrity when operating

**Expert Feedback**

Upon arrival at the scene, operating units need to be on same page regarding operations. By informing members of additional information regarding reports of a robbery in progress and street conditions, members will understand circumstances of response before arrival

Anticipating the infrastructure to be compromised (traffic lights, gas, electric), along with the possibility of further street collapse occurring due to weight of apparatus and undermined street from water main breaks, necessitates that the officer and chauffer communicate regarding response.

Do not allow members to become victims of civil disturbance/robbery. Operating as a team (no member operates alone) maintains unit integrity, allowing officers to assess the “big picture” before committing members to individual tasks

<b>Scenario: Earthquake</b>	<b>4</b>
<p>Because your response route is obstructed, you have to navigate around several displaced vehicles and assorted debris.</p> <ul style="list-style-type: none"> <li>You observe numerous small fires burning in the distance, but no significant damage, other than a few downed trees and electrical wires detected within your immediate vicinity.</li> <li>Your chauffeur informs you that this gas station is situated in an area comprised of two ten-story residential buildings and a two-story hospital.</li> <li>Monitoring the department radio, you are aware that fire/EMS units are overwhelmed with medical, gas odors, electrical, water pressure problems, etc.,...types of emergencies.</li> </ul>	

**Scenario Decision Point # 4.4:**

- Do you anticipate that the hospital or residential buildings will be an immediate concern? Yes / No.**

<b>Group</b>	<b>Yes / No</b>	<b>Percentage</b>
<b>Experts</b>	Yes	100 %

**Scenario Decision Point # 4.5:**

- Prioritize the following list of decision-making situations you might encounter. (1 being the most important and 9 the least). Explain your first three decision-making situations.

- \_\_\_ Stuck elevators at both locations
- \_\_\_ Exposure problems from possible falling glass (ten-story buildings)
- \_\_\_ Extension of fire from gas station
- \_\_\_ Possibility of multiple high-pressure gas leaks at location
- \_\_\_ Movement of patients may become an issue (evacuation or shelter in place)
- \_\_\_ Limited emergency -type resources available to assist
- \_\_\_ Smoke (hydrocarbons) from fire may affect hospital and apartment complex
- \_\_\_ No electrical power in area
- \_\_\_ Request for assistance from hospital staff or apartment residents

**Expert group’s response key**

<b>Ranking</b>	<b>Decision-making situations</b>
<b>1</b>	Extension of fire from gas station
<b>2</b>	Possibility of multiple high-pressure gas leaks at location
<b>3</b>	Limited emergency type resources available to assist

**Expert Feedback**

Extension of fire from the gas station presents an immediate hazard with greatest potential to threaten life/property. Although units are already overwhelmed, by addressing the fire, they have the opportunity to impact and influence the situation. Because resources are limited and water source questionable, fire must be contained and prevented from extending (not necessarily extinguished). The situation will get worse if fire extends — do not allow fire extension to add to problem.

Not unlike the fire, gas leaks, if not controlled, have the potential to significantly impact the incident. The availability of multiple ignition sources throughout area (fires, downed electrical lines), along with the potential of ignited gas leaks under pressure leading to a fast-moving fire, necessitates units consider such actions as building evacuation and gas dispersion.

Due to limited availability of emergency-type resources, the magnitude of incident will overwhelm resources. If the incident is widespread, numerous events will have taken place, and requests for additional resources will be a priority and prevalent throughout city. The strain on personnel to do many things will be great. Units must prepare to be self-sufficient while recognizing their limits.

<b>Scenario: Earthquake</b>	<b>4</b>
<p>Upon arrival, you observe someone lying face down in front of the station with two men running from the location, opposite your approach.</p> <ul style="list-style-type: none"> <li>• The streets in and around the station are crowded with people either requesting help or seeking information about the initial earthquake.</li> <li>• Incident size-up reveals gasoline leaking from several fuel pumps with fuel pooling in and around the station and street.</li> <li>• Gasoline has also been discovered coming up through the ground in the rear of the station. This fuel is flowing down the street adjacent to the curb line and smoke is venting under pressure from the front cornice of the station.</li> </ul>	

**Scenario Decision Point # 4.6:**

- **Prioritize your decision making. What problems do you address first, second, third...? Explain your first three decisions.**

- \_\_\_ Fuel coming from rear of station and flowing down the street
- \_\_\_ Person lying face down
- \_\_\_ Smoke from cornice
- \_\_\_ Fuel pooling in front of station
- \_\_\_ People requesting help/information
- \_\_\_ Lack of resources (foam/EMS)

**Expert group's response key**

<b>Ranking</b>	<b>Prioritized Decision-Making</b>
<b>1</b>	Person lying face down
<b>2</b>	Fuel coming from rear of station and flowing down the street
<b>3</b>	Smoke from cornice

**Expert Feedback**

Person lying face down is a known life hazard (visual confirmation) and addressing life is a # 1 priority before property. Unit can make quick assessment and determine viability of victim removal. The person lying down may possibly be victim of robbery and requiring immediate help.

Fuel coming from rear of station and flowing down the street needs to be controlled. If flow cannot be stopped, units must make an attempt to contain or divert flow from reaching an ignition source. Leaking fuel is largest threat to life/property, if ignited it will intensify an already dynamic and developing situation.

Extinguishing the fire eliminates a major problem. For example, smoke from the fire has potential to expose hospital and apartment building. Investigating the source of smoke will reveal fire intensity, determining if a quick stop of fire can be accomplished or whether operating personnel should be moved to a safer area

<b>Scenario: Earthquake</b>	<b>4</b>
Members conducting a perimeter size-up report water under pressure (along with dirt and sand) coming from several large cracks in the street that separates the gas station from the hospital. This condition also appears to be undermining the sidewalk that leads directly into the apartment complex.	

**Scenario Decision Point # 4.7:**

- **What decisions need to be made regarding street management? List your concerns and explain your first three concerns.**

**Expert group's response key:**

<b>Ranking</b>	<b>Concerns</b>
<b>1</b>	Position apparatus out of collapse area.
<b>2</b>	Establish safe access / egress from apartment building
<b>3</b>	Ensure operating and incoming units are aware of conditions

**Expert Feedback**

Due to the structural integrity of the street, apparatus must be positioned outside of a potential street collapse area. The weight of apparatus and already undermined street/sink holes are conducive to further collapse. Secondary access points to and from hospital/apartment complex also need to be identified. If hospital/apartment buildings need to be accessed/evacuated, undermined street/sidewalks will limit availability of safe access and egress routes.

Officers must ensure that both operating and incoming units are aware of conditions. Do not assume that everyone knows what you know and see. Individuals operate at different situational awareness levels and may not share the same comprehension/understanding of the incident as you do. In all likelihood, the stopping of unnecessary traffic has already been initiated; however, current conditions may require that the isolation zone be expanded, limiting apparatus and excessive pedestrian traffic in the area.

<b>Scenario: Earthquake</b>	<b>4</b>
At approximately 9:30 a.m. you begin to notice the ground shaking in your area. The sidewalk and street has now caved in, cutting off your access to the apartment complex and hospital. There is a distinct smell of natural gas throughout the area and people are beginning to exit the surrounding buildings and hospital, reporting odors of gas/fuel.	

**Scenario Decision Point # 4.8:**

- **Regarding the hospital and ten-story residential buildings, a decision may need to be made concerning evacuating or sheltering in place. List those points that must be considered first before any action can be taken. Explain your first three points**

**Expert group’s response key**

<b>Ranking</b>	<b>Points to be considered</b>
<b>1</b>	Can gas leaks be controlled?
<b>2</b>	Available of resources
<b>3</b>	Are you evacuating people to a safer location?

**Expert Feedback**

Can units determine if reports of natural gas odors are from high pressure/low pressure main? This information will be invaluable to specialized fire units and utility companies that have the capability of shutting down leaks and can be useful to these units while in route. If gas leaks are within a hospital or surrounding building, can the leaks be located, stopped, or controlled? If leak can be stopped, conditions improve (evacuation may not be required). If gas leaks are from an exterior source, shelter in place may be preferred option

Availability of resources will dictate what units can and cannot do. Does the incident commander have enough resources (fire / civilians) to conduct an evacuation? Due to limited resources, can ambulatory patients be moved and non-ambulatory sheltered in place? The incident commander must ascertain available resources in the form of hospital staff and civilians.

Regarding the evacuation or sheltering in place of hospital or apartment complex, several questions must be addressed. Are apartment and hospital residents in immediate danger? Where will you evacuate people and are you exposing them to greater danger (street conditions) by evacuating? How safe are access and egress routes from hospital and apartment buildings?

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## APPENDIX G

### Experimental group’s decision point questionnaire

Upon the completion of each scenario, the experimental group completed a decision point questionnaire. This questionnaire was designed to capture decision-making responses in real time; immediately after they were made. A review of this questionnaire revealed the SA / RPD model briefing components received an above-average rating regarding usefulness. Although there was no pre-experiment data to compare these ratings against, the results are nevertheless encouraging for several reasons. First, the experimental group members received a minimal SA / RPD model briefing regarding a complex topic, and yet the group’s awareness level was above average. Second, the impetus for identifying methods for improving first-responder decision making by raising their situation awareness levels is strengthened. The control group did not complete this questionnaire

<b>On a scale of 1-5, with 1 being very low and 5 being very high, rate the following:</b>	<b>Tanker DP # 1. 2</b>	<b>Subway DP # 2 .3</b>	<b>Radiological DP # 3. 3</b>	<b>Earthquake DP # 4. 6</b>
How difficult was this particular decisions? 1 2 3 4 5 (low) (high)	2	3.4	2.9	3.1
How much confidence do you have with the decisions you made? 1 2 3 4 5 (low) (high)	4.3	3.2	3.9	3.6
How much did you rely on experience in your decision-making process? ( <b>mental models</b> ) 1 2 3 4 5 (low) (high)	3.1	2.9	2.9	3.2
How often did you mentally rehearse a course of actions prior to making a decision? ( <b>mental simulation</b> ) 1 2 3 4 5 (low) (high)	4.1	3.5	3.6	3.3
How successful were you in creating patterns from identified cues and using those patterns to recognize familiarities and inconsistencies? ( <b>cues + patterns = decisions</b> ) 1 2 3 4 5 (low) (high)	3.7	3.3	3.6	3.5
<b>Perception: (initial size-up)</b>	3.6	3.6	3.7	3.9



## APPENDIX H

### **Post-experiment questionnaire**

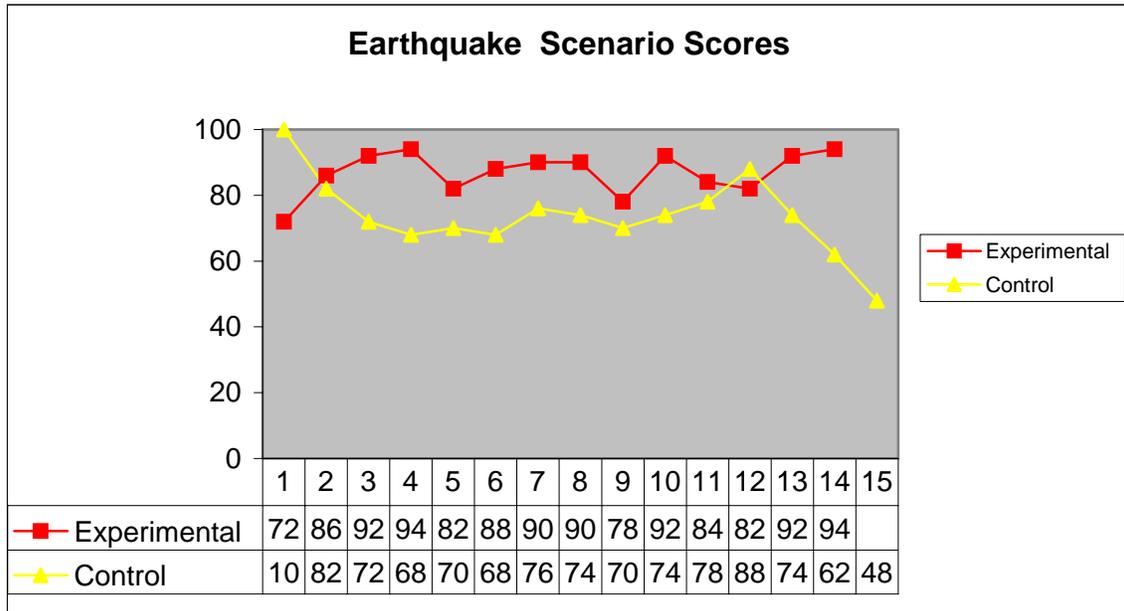
Both the control and experimental groups completed a post-experiment questionnaire designed to evaluate scenario difficulty, decision-making confidence, and influence of the independent variables. The experimental group rated the influence of expert feedback on their overall decision making with a mean rating of 4.1 on a scale of 1-5 and the helpfulness of the SA/RPD model theory briefing with a mean rating of 3.4. These above-average scores, when coupled with the experimental groups' high scores during the actual earthquake scenario, add credibility to research findings, showing that expert feedback made a difference. The credibility of research findings are further reinforced when compared to the control group that received no feedback and scored noticeably lower on the earthquake scenario responses.

When responding to the post experiment questionnaire, the control group members were unaware that the experimental group received any additional treatment. Therefore, their ratings were not skewed, biased, or pre-disposed toward additional training. Yet, the group rated how influential the receipt of expert feedback would have been with a mean rating of 4.5 on a scale from 1-5. The group also rated how helpful a pre-scenario decision-making skills/theory training would have been to their decision-making with a mean rating of 4.5.

<b>On a scale of 1-5, rate the preceding exercise</b>								
<b>Regarding decision making, how difficult were these scenarios?</b>					<b>Experimental</b>	<b>Control</b>		
Renegade Tanker	1	2	3	4	5	3.4	2.9	
	(low)				(high)			
Subway	1	2	3	4	5	3.5	3.7	
	(low)				(high)			
Radiological Attack	1	2	3	4	5	3.9	3.5	
	(low)				(high)			
Earthquake	1	2	3	4	5	4.1	3.6	
	(low)				(high)			
<b>How confident were you with your decision making?</b>					<b>Experimental</b>	<b>Control</b>		
Renegade Tanker	1	2	3	4	5	3.7	3.9	
	(low)				(high)			
Subway	1	2	3	4	5	3.4	3.4	
	(low)				(high)			
Radiological Attack	1	2	3	4	5	3.1	3.1	
	(low)				(high)			
Earthquake	1	2	3	4	5	3.1	3.1	
	(low)				(high)			
How influential was the receipt of expert feedback after each scenario decision point on subsequent decision making?								
1	2	3	4	5	4.1			
(low)				(high)				
How helpful was the SA/RPD model theory briefing on your decision making? (pattern and cue recognition, mental models, mental simulation, SA levels-perception, comprehension, projection )								
1	2	3	4	5	3.4			
(low)				(high)				
How influential do you believe the receipt of expert feedback after each scenario decision point would have been on subsequent decision making?							4.5	
1	2	3	4	5				
(low)				(high)				
How helpful do you believe the pre-scenario decision-making skills/theory training would have been to your decision making?							4.5	
1	2	3	4	5				
(low)				(high)				

# APPENDIX I

## Earthquake scenario score



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## APPENDIX J

### Earthquake Scenario One-way ANOVA

Dependent (Experiment and Control Combined)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Experiment	14	86.8571	6.54989	1.75053	83.0753	90.6389	72.00	94.00
Control	15	73.6000	11.59310	2.99333	67.1800	80.0200	48.00	100.00
Total	29	80.0000	11.51397	2.13809	75.6203	84.3797	48.00	100.00

ANOVA Dependent (Experiment and Control Combined)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1272.686	1	1272.686	14.087	.001
Within Groups	2439.314	27	90.345		
Total	3712.000	28			

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