THE ROLE OF DOMAIN EXPERTISE AND JUDGMENT IN DEALING WITH UNEXPECTED EVENTS

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Psychology
in the College of Arts and Sciences
at the University of Central Florida
Orlando, Florida

Summer Term
2005

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ABSTRACT

Unexpected events, particularly those creating surprise, interrupt ongoing mental and behavioral processes, creating an increased potential for unwanted outcomes to the situation. Human reactions to unexpected events vary. One can hypothesize a number of reasons for this variation, including level of domain expertise, previous experience with similar events, emotional connotation, and the contextual surround of the event. Whereas interrupting ongoing activities and focusing attention temporarily on a surprising event may be a useful evolutionary response to a threatening situation, the same process may be maladaptive in today's highly dynamic world.

The purpose of this study was to investigate how different aspects of expertise affected one's ability to detect and react to an unexpected event. It was hypothesized that there were two general types of expertise, domain expertise and judgment (Hammond, 2000), which influenced one's performance on dealing with an unexpected event. The goal of the research was to parse out the relative contribution of domain expertise, so the role of judgment could be revealed.

The research questions for this study were: (a) Can we identify specific knowledges and skills which enhance one's ability to deal with unexpected events? (b) Are these skills "automatically" included in *domain* expertise? (c) How does *domain* expertise improve or deter one's reaction and response to unexpected events? (d) What role does *judgment* play in responding to surprise? The general hypothesis was that good *judgment* would influence the process of surprise at different stages and in different ways than would *domain* expertise.

The conclusions from this research indicated that good *judgment* had a significant positive effect in helping pilots deal with unexpected events. This was most pronounced when *domain* expertise was low.

DEDICATION

For my mother,

Dr. Jo Ann King,

who dedicated her life to the practice of psychology and the happiness of others.

ACKNOWLEDGMENTS

This study was made possible by Mr. Michael Moskal of CUBRC and Mr. Jim Priest of Calspan through their Federal Aviation Administration funded Upset Recovery Training and Research. I wish to thank all of the pilots who have participated in this study and remember all of those who we have lost to tragic loss-of-control accidents. I would like to acknowledge all of my friends and family members who have supported my activities and tolerated my “need for cognition” for the past four years. My appreciation goes to ABXAir, Inc. pilot scheduler, Marta Craves, for her never-ending flexibility in trading flights so I could attend classes in between flying and ultimately complete this mission. I especially thank my dissertation committee members, Dr. Florian Jentsch, Dr. Clint Bowers, Dr. Valerie Sims, and Dr. Eleana Edens, for their time and dedication to this research project. Finally, this journey was orchestrated by one of the masters in our field, my mentor, Dr. Florian Jentsch and co-conducted by my husband, Captain Dennis Kochan. Their combined patience, understanding, and humor has made this time a wonderful part of my life.

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CHAPTER ONE: INTRODUCTION

Studies and discussions about the causes, responses, and outcomes of unexpected events span a wide array of domains and contexts. These range from the unexpected presence of a compound in the body impinging upon a cellular structure (Whitfield, Morley, & Willick, 1998) to the surprise at finding a new galaxy in space (Lyne, et al., 2004). Surprise and unexpectedness have been studied in medical applications, such as reactions to drug dosages, and events occurring during surgery or amongst operating team members (Woods & Patterson, 2001). For example, scientists were overwhelmingly surprised when they identified an unexpected mechanism that triggers increased blood flow to brain cells actively engaged in work, which may indeed open new doors to understanding many disease processes (Mintun, Vlassenko, Rundle, & Raichle, 2003).

Dealing with unexpected life events is a common thread in scientific, clinical, and popular psychology publications (e.g., Hammond, Keeney, & Raiffa, 1999; Watkins, & Bazerman, 2003). In the business arena, unexpected events occupy a strong presence in management training and corporate culture literature (Kylen, 1985; Weick & Sutcliffe, 2001). There is now a focus on unexpected events in national security and international relations as a result of the surprises of September 11, 2001, and countermeasures have begun to take shape. The American National Red Cross now teaches, through a brochure, that “there are things you can do to prepare for the unexpected and reduce the stress that you may feel now and later should another emergency arise. Taking preparatory action can reassure you and your children that you can exert a measure of control even in the face of such events” (American Red Cross, 2001, p.1).

Reactions to the unexpected have also been widely studied from an evolutionary perspective where the nature of the response was shown to be adaptive for animals and humans (Corbetta & Shulman, 2002; Inglis, 2000). For example, animal studies by Spinka, Newberry, and Bekoff (2001) demonstrated that animals' use of play enhances their ability to respond to unexpected events. Similarly, researchers (Bell & Wolfe, 2004; Hammond, 2000) investigated developmental changes in the emotion of surprise in infants and children exposed to unexpected events. The vast interest in unexpected events throughout the universe may indeed be generated by a desire for constancy (Hammond, 2000; Matsumoto & Tanaka, 2004); where any disruption to expectations results in a state of dissonance. Depending on the valance and degree of this dissonance, unexpected events have the potential to elicit joy or displeasure (Damasio, 1999; LeDoux, 2002) and produce associated cognitive and behavioral consequences (Meyer et. al., 1997) which may be categorized as manifestations of the emotion of surprise.

In aviation, unexpectedness and the associated pilots' reactions to it are major contributors to loss-of-control in flight, the largest category of fatal commercial air carrier accidents between 1994 and 2003 (Boeing Commercial Airplanes Group, 2004). Loss-of-control accidents were also the leading cause of general aviation accidents in the United States in 2003 (AOPA Air Safety Foundation, 2004), and these accidents have been on the constant increase for all categories of flight, including corporate aviation, for the past 25 years. Each year, millions of dollars are spent trying to train pilots to prepare for these "unexpected" events hoping to improve pilot performance in the event that they *might* occur. Thus, gaining insight into how one can best deal with the unexpected has important implications across a wide field of application areas.

Problem Statement

As the above examples illustrate, events perceived to be unexpected are those which “come without warning” or are “unforeseen” (American Heritage Dictionary, 1992, p. 1950). Unexpected events have the potential to induce varied reactions, ranging from surprise to behavioral “freezing.” In fact, unexpected events can trigger alterations in neurological, physiological, psychological, behavioral, and social processes.[1] Most importantly though, reactions to unexpected events involve processes whose associated cognitive and behavioral influences have wide spread implications to human performance in a wide variety of domains. I therefore believe that the study of pilots’ reactions to unexpected events is a topic which merits further investigation.

A good place to begin exploring this problem area is in how unexpected events have been dealt with in training protocols, specifically in aviation. Teaching people to deal with unexpected events has traditionally involved superficial exposure to all varieties and combinations of possible situations complete with examples of appropriate responses. In highly dynamic and/or ill-structured domains, where the unexpected is plentiful, however, trainers will find it impractical, if not impossible, to provide exposure to all possible surprising events. Most events in aviation are ill-structured (Orasanu & Connolly, 1993), such that one situation may resemble another, but it is unlikely to be identical. To train all possible events is an attempt to teach one to anticipate the unexpected and make it the “expected.” While this approach is believed to be beneficial, “unexpected” situations will remain, requiring pilots to respond in novel and creative ways.

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[1] Surprise is at once a verb; “to encounter suddenly or unexpectedly; take or catch unawares; to cause to feel wonder, astonishment or amazement, as at something unanticipated or out of the ordinary” and a noun; “the condition of being surprised” (American Heritage Dictionary, 1992, p. 1808)

Training for specific unexpected events as a reactive measure, however, likely will not inoculate pilots against the next new unexpected situation. An important aspect of training for unexpected events is its applicability beyond the specific event trained. Ultimately, the goal would be to marry cognitive skill (judgment) training with the requisite “stick and rudder” (domain) skills necessary to successfully perceive, process, and respond to any unexpected situation. In sum, aviation has attempted to address loss-of-control and other situations arising from unexpected events by targeting specific events with domain skill training. Unfortunately, aviation accident and incident statistics suggest this approach has not been completely successful (Boeing Commercial Airplanes Group, 2004; Federal Aviation Administration, 2001).

The purpose of this study was to identify the specific cognitive components active in reactions to unexpected events. Specifically, I investigated the influence of (a) *domain* expertise, (b) *judgment*[2], and (c) the interaction of the two, at various stages in a process model of the cognitive reactions to unexpected events The ultimate goal was to determine what specific knowledges, skills, and/or abilities are required to best respond to unexpected events, thus making it possible to provide specific training for the acquisition of these skill sets. Training in the target areas could be instrumental in contributing to the appropriate responses which result in successful outcomes, even in instances where there was no previous specific exposure or training to that particular unexpected event.

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[2] The use of the term “*judgment*” implies the same meaning as “cognitive judgment” rather than “perceptual judgment” as distinguished by Jensen (1995).

CHAPTER TWO: THEORETICAL BASIS AND PRACTICAL IMPLICATIONS

To facilitate understanding and minimize ambiguity of the theoretical and practical aspects of this study, brief definitions of the constructs of interest are included in each section. In cases where terms may have multiple meanings, the choice of definition selected for this study does not imply correctness. It is merely an attempt to clarify what is sought to be construed in this context.

Description of Responses to the Unexpected: Types and Manifestations

One of the first steps in this study was to determine what pilots find unexpected. The nature of surprise can be categorized in various ways. Two characterizations of the varieties and forms of unexpected events are offered as examples from the business world and aviation. It is interesting that the same themes were found in these two, rather diverse applications, as summarized in Table 1. As shown in the table, Kylen (1985) suggested the unexpected in business can come in five forms.

The first type is called “a bolt from the blue,” when something happens with no expectation, hint, or prior model of the event even being plausible. For example, someone is diagnosed with a disease for which there were no risk factors or predisposing conditions. The second type is when the event is known, but the direction of one’s expectation is incorrect. Here, one may expect to have very high cholesterol levels, based on diet and lifestyle, however, the level is unexpectedly low. The third form is when something is expected at a certain time and place, and it occurs at some other time and/or place. Another type of unexpected event is when something is expected to take a certain amount of time and unexpectedly takes longer or happens faster. “Duration events” are found often in the stock market or other investment entities where one expects the market to “turn around” and it does so, but very slowly. It is interesting to note, that the expectations of the investors are seldom modified to be in line with the fluctuations of the markets. The last type of unexpectedness, according to Kylen, is when a problem is expected, but its severity is not. In other words, one is aware of the problem, but the projected impact of the event is underestimated. This may have even been the case with the loss of space shuttle Columbia (National Aeronautics and Space Administration, 2003).

Table 1

Comparison of the Categorization of Unexpected Events in Two Domains

Domain	
Business (Kylen, 1985)	Aviation (Kochan, et. al., 2004)
(1) Event occurs with no prior expectation or cues ("bolt from the blue")	(1) Insidious events occur where the unexpected event unfolds over time
(2) Event is known, but expectation is in the wrong direction	(2) Subliminal appearance, where the event cues were neither overt nor blatant
(3) Event is expected, but occurs at some other time or place	(3) Events *perceived* as unexpected and causing surprise are not often rare or novel, rather, they are usual and routine
(4) Temporal expectation is wrong (event unfolds too fast or too slow)	(4) Events *perceived* as unexpected most often have cues available which, if used, would make the event less surprising
(5) Event is known, however the severity of the event is surprising	

In another study, Kochan, Breiter, and Jentsch (2004) showed that the nature of the reactions to the unexpected is governed by four principles, also displayed in Table 1. The unexpected can be insidious, subliminal, usual, or routine, and more often than not, there were cues available to suggest that the unexpected should have been expected.

The final interesting point from the review of actual accidents and incidents was the behavioral responses which arose from the unexpected events (Kochan et al., 2004). On a broad scale, regardless of the nature of the event or outcome severity, pilots either, (a) focused on the unexpected situation, addressed the condition, and returned to pre-event duties or; (b) focused on the unexpected situation and fixated on an aspect, without returning to the ongoing activities in a timely manner. The risk in this fixation would be particularly detrimental when piloting an aircraft where the ongoing task of flying must be attended to continuously. The investigation into aviation related accidents and incidents revealed that antecedents to unexpected events are often sublime, and do not typically emanate from highly unusual situations. More often than not, unwanted outcomes may have been preventable if information that was readily available had been noticed and considered. Given this, one can begin to look at the cognitive underpinnings that may help to explain the cognitive and behavioral effects of unexpected events and their associated consequences.

Description and Definition of Domain Expertise and Judgment

Are Domain Expertise and Judgment Separate Constructs?

The following brief discussion of expertise research and the concept of separate constructs of *domain* expertise and *judgment* abilities will be integral to the identification of the specific underlying skills necessary for responding to unexpected events. It is the tight integration of type, amount, frequency, and diversity of training, and experience, intertwined with other cognitive skills and abilities that I seek to separate in this study. In this case, I intend to parse out the relative contribution of domain expertise to one’s performance on the task of dealing with an unexpected event in order to identify the role of judgment. Conversely, other research has attempted to separate the judgment skills away from the domain expertise by minimizing the necessity of using judgment in the completion of tasks. Studies conducted in assessment centers (Kleinmann, 1993; Smith-Jentsch, 1996) indicated that revealing the nature of the domain task (making the dimensions of the task transparent to the applicant) improved the construct validity of the task.

My premise was that specific domain knowledge and expertise play one role in successful responses to surprise. However, ample evidence was presented to suggest other, more global and trainable judgment skills had at least some influence over many aspects and, in at least one part of the process, were key to a successful outcome in the process of surprise. In other words, I did not (and do not) believe that merely increasing one's level of domain expertise or domain knowledge is the most effective way to improve responses to unexpected events. Indeed, there was evidence for separate constructs of domain and judgment. There was also a significant interaction effect at certain times during the reaction to the event. The next section presents the details of the two separate constructs of expertise considered in this study.

Domain Expertise

In a review of the literature, there did not appear to be a universally accepted definition of what constitutes domain expertise. The prerequisite of possessing innate abilities in order to exhibit expertise in a particular domain, or in everyday living, has been successfully challenged by Ericsson and Charness (1994). Their research, and review of the literature, indicated the most salient features in becoming a domain expert, were extensive and sustained deliberate practice (about four hours per day) over an extended period of time (approximately 10 years or more) on a specific task or skill set from a chosen domain. The evidence showed a general predisposition to engage in deliberate practice appeared to be the most distinguishing individual difference, rather than an innate, domain specific or domain congruent ability as put forth by Gardner (1983). Therefore, it was argued that by means of practice over time, one was able to acquire and implement different forms of knowledge which constitute domain expertise. Consequently, the construct of domain expertise in this study was indicated by one's declarative, procedural, and structural knowledge as depicted in Figure 1. These domain factors are defined next in order to understand the role they play in domain expertise and to facilitate their manipulation in this study.

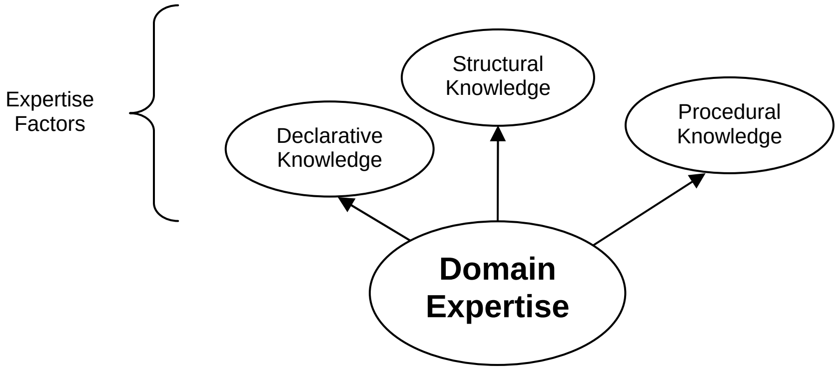

Figure 1. Domain specific factors involved in *domain* expertise.

Declarative Knowledge

Declarative knowledge (as used here) was simply the number and availability of facts to which one may have access.

Procedural Knowledge

Procedural knowledge (as used here) was the number and availability of procedures which may be used in domain specific tasks.

Structural Knowledge

In addition to exceptional knowledge of facts (declarative knowledge) and knowledge about how to accomplish a task (procedural knowledge), research suggested that people who had developed expertise in an area show differences from novices in how their knowledge is stored, structured, and retrieved (Chi, Glaser, & Farr, 1988). These differences were, in part, due to the depth, breadth, and number of schemata and action scripts available and used by an individual. Two main sub-components of structural knowledge were addressed in this study; schemata and action scripts.

Schemata

As part of structural knowledge, schemata are developed based on our past experiences with objects, scenes, and events, to create expectations as to what these objects, scenes, and events should resemble in the future (Hammond, 2000; Jones & Endsley, 2000; Meyer et al., 1997). Schemata guide our (a) comprehension of the current information, and (b) prediction of future events (Schützwohl, 1998). Schemata can be described in terms of three components: number, breadth, and depth. Schema number is the number of schemata activated for a given event. The number of schema activated depends on what information is perceived from the environment. If a given event is fairly simple, it may only require that one schema be activated to correctly understand the event. However, a more complex event may require several schemata to be activated in order to have a complete understanding. Schema breadth, on the other hand, can be defined as the “expanse of knowledge across system components” (Burke, 1999, p. 16). The greater the breadth, the more an individual is able to integrate the multiple constructs involved to better understand a complex or novel event.

Each schema also contains a number of interconnected variables. These interconnections combined with the number, breadth, and depths of variables determine the strength of a particular schema (Schützwohl, 1998). It is important to point out that schemata are initially formed through experience and training; therefore, they may or may not be accurate (Moray, 1996). Once formed, they are constantly monitored for evidence of contradictory incoming information. It is this monitoring and subsequent revision of schemata by way of incorporating new variables and/or modifying interconnections that improves the accuracy and therefore their usefulness for predicting future events. The predictive value of schema varies with the accuracy of its representation of true reality.

Generally, those with more expertise in a domain will have more, deeper, richer, and more accurate schemata relevant to their field than those with less expertise. As domain expertise increases, so does the breadth of one's schemata. The depth of the activated schemata, or its complexity and insightfulness, also depends on the individual's expertise and past experiences with similar events (Ceci & Liker, 1987). When people gain expertise and experience in a given situation, their schemata are redefined to incorporate relevant information that might have previously been seen as unimportant and irrelevant. This suggests the correct identification of discrepant events increases as domain expertise increases.

Action Scripts

Action scripts (Gioia & Manz, 1985; Klein, 2003) are also a component of structural knowledge. They are virtual cognitive structures consisting of our personal routines for responding in a given context. Script processing is the action that takes place when there is a situation generating cues and one recognizes the patterns formed by the cues. These patterns include routines and serve to activate the appropriate action script. Once activated the action script proceeds, but also affects, and can change the ongoing situation. The more patterns one has, the more action scripts will be available for use, and therefore more options will be available for decision making and responses. This functionality of structural knowledge through action scripts has important implications for dealing with unexpected events for individuals who posses different levels of domain expertise.

Klein (1997, 2003) stated that once a pattern is recognized (or matches close enough), we size up the situation, have a perspective on what cues are important and need to be monitored, the goals we wish to make, and what to expect next. If the situation is familiar, then one's reaction is intuitive and script processing runs essentially automatically. In an unfamiliar or ambiguous situation (e.g., not enough cues, conflicting cues, no pattern in memory), an option is selected, and a "mental simulation" is run through one's mental model of the situation which is then assessed by the action script. If it seems like the option will work, the script processing continues and a response is generated. If the option does not appear to be adequate, it is discarded, and another action script is run through the process.

Domain experts and those well trained at a skill possess a larger and more varied repertoire of candidate action scripts from which to choose in performing a task or responding to a situation. However, this is *not* to say that experts always choose the appropriate cues to use or ignore, nor do they necessarily know when it is necessary or prudent to change an action script. The expert pilot with a strong schema regarding certain weather radar patterns may be less likely to revise his course of action when evaluating weather than one with less weather experience and perhaps a weaker "weather" schema. In this case, the pilot with less expertise may not have the (perhaps erroneous) experience of flying through certain weather situations and although he has fewer action scripts from which to choose, he shifts scripts and modifies his flight path to completely avoid the area of weather. Therefore, just possessing expertise in a field may not be the only key to dealing successfully with the unexpected and indeed may at times be a hindrance to one's ability to shift the ongoing script.

Judgment Skills

The components of judgment skills which were considered in this study are presented in Figure 2.

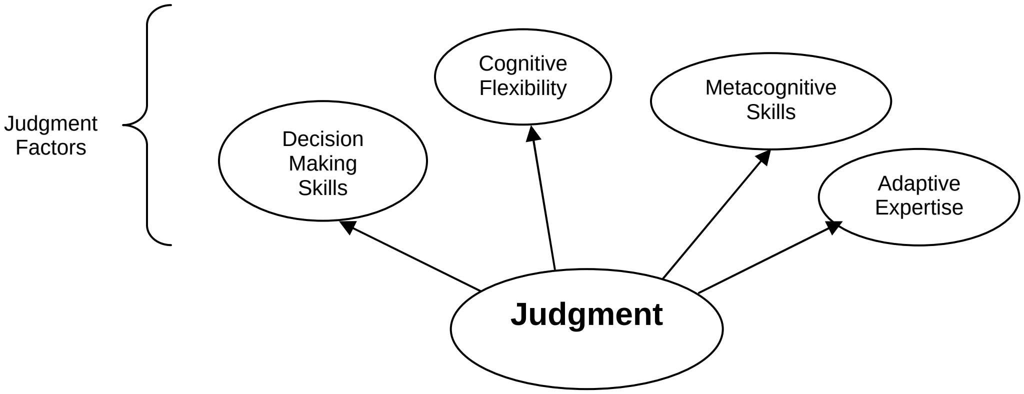

Figure 2. Domain-independent factors involved in judgment.

Decision Making Strategies

An in-depth review of information processing and decision making theory is beyond the scope of this paper. However, I briefly consider one pervasive idea found in judgment and decision making literature; that there are two pathways available in decision making; analytic versus intuitive. Often, the delineation between these modes of information processing and response is based on the amount of attention and cognitive energy required to make a judgment and respond to a given stimulus or situation. This short sidebar is necessary to the understanding of the process of surprise because cue (information) processing depends on task condition variables, such as time available, uncertainty in the information, level of expertise, and one's cognitive flexibility (Orasanu, Martin, & Davison, 2001).

In this light, Hammond's (2000) Cognitive Continuum Theory postulated that decisions are made in response to a disruption in constancy, and that optimally, one would move along a continuum from intuitive to analytic processes as the need arose due to the changing nature of the task. The properties of intuitive decision making are low cognitive control, fast processing, low attentional energy consumption, and low conscious awareness. Analysis incorporates high cognitive control, slower processing, high conscious awareness, is task specific and when errors occur, they are few, but large. Hammond also stated that it is often an unexpected event, which demands immediate decisions and responses that drive decision making toward the intuition end of the decision-making spectrum.

Cognitive Flexibility

Cognitive flexibility theory addresses the ability to quickly and accurately restructure the current action script to adaptively respond to dynamic situations and the inevitable unexpected event (Spiro, Coulson, Feltovich, & Anderson, 1988). Klein (2003) reiterated the need to be flexible in the business arena where one should expect to have to improvise and have flexible plans where "you can quickly jettison your planned sequence of actions and replace them with a more appropriate reaction" (p. 163). However, this skill will not necessarily be helpful in determining whether an event is indeed discrepant from the activated schema. One may have the "feeling" or "know" something is amiss, but be unable to identify the problem due to lack of domain expertise or knowledge. Therefore, the ability to verify an event as "unexpected" will not necessarily be affected by one's level of judgment.

Furthermore, in training for unexpected or novel events, there is a potential to over-proceduralize each training event. Research suggested there can be too much and too immersive mission planning, creating an illusion that an individual has already experienced a particular event and knows exactly the correct response (Weick & Sutcliffe, 2001). However, this is not necessarily the case. For example, airline pilots train specifically for any number of "unexpected events" such as windshear or wake turbulence. In reality, there are an infinite number of variants of each event, making it highly unlikely that the exact response has ever been practiced. Similar situations occur in business, where plans and procedures are often too specific to deal with the subtle differences encountered in each situation. The optimum situation would be to have adequate domain knowledge available, and to employ cognitive flexibility when evaluating the cues presented from the event.

Adaptive Expertise

A domain expert's knowledge, while organized around important ideas or concepts, is also "conditionalized" which means there are specific contexts in which the available cues may be useful (Fisher & Peterson, 2001). The variation, and at times deficiencies, in the flexible application of knowledge to new situations may be due, in part, to the lack of attention "experts" give to cues which are presented out-of-context. Alternatively, they may have such a strong schema about the situation that decisions are made automatically, without much analysis. In this case, a domain novice may find a workable solution from the cues available, regardless of context, as they usually reason backward, using a set of possible decisions to the problem description until the closest corresponding match is found. This gap in expert performance is addressed through the concept of adaptive expertise.

One view of the conditionalization or adaptability of expert skills is the Constraint Attunement Hypothesis (Vicente & Wang, 1998). The researchers suggested that skill acquisition is related to one's adaptability to the constraints of the environment. They argued that their "product" theory considers not only the cognitive components of expertise (as in process theories), but the context of the performance as well. The purpose of their work was to investigate the influence of the context on expert performance with one goal to determine if experts are indeed more cognitively flexible (or inflexible) than novices. An interaction between domain expertise and strategies used, based on the context, was found.

The question remains, however, as to where in the decision making process judgment skills affect performance; and in what direction (helpful or hurtful). To answer this question may help explain why domain experts sometimes make fatal errors. For example, a pilot may successfully use a particular strategy (keeping the bank of the airliner shallow for passenger comfort) under a given circumstance, only to find it is woefully inadequate in another situation (needing to use all of the roll control of the airplane to recover from a wake turbulence encounter). According to Hammond (2000), cognitive competence is twofold; subject matter or domain competence and, separately, judgment and decision making competence. Domain competence is a function of learning, memory, and deduction, while decision making is the execution and application of the acquired domain knowledge. It is this idea of decision making competence, when coupled with domain expertise that gives rise to adaptive expertise.

One trait differentiating adaptive experts from routine experts (those with expertise in one area or lacking in judgment) is the ability of the former to perform well outside of their comfort zone. They are able to deal with ambiguity and understand how their current beliefs and assumptions may affect their understanding of a situation. Adaptive experts modify or invent new strategies in novel situations based on their current knowledge (Smith, Ford, & Kozlowski, 1997). To develop an adaptive expert, one must be taught to understand the underlying principles of a task at a deeper level. This training will allow them to recognize situations that have changed, or occur out of an expected context, and to select and combine various procedures in order to effectively solve a problem (Spiro, Feltovich, Jackson, & Coulson, 1991).

In order to be trained as an adaptive expert, one must first acquire at least requisite knowledge of the task domain (Smith, et al., 1997). Then, one must learn about themselves as thinkers and problem solvers. Experts know what *to do* as well as what *not* to do in a situation. In addition, *adaptive experts* not only use what they know, they monitor their current level of understanding of a situation, continue to learn, and strive to move to a higher level of functioning. They use each new situation as a challenge which provides a forum to facilitate additional expertise.

According to Fisher and Peterson (2001), adaptive expertise is comprised of four separate constructs; (a) multiple perspectives which is using more than one way of analyzing and solving a problem; (b) metacognition; (c) learning goals and belief in success; and (d) epistemology or one’s attitude toward gaining knowledge. That is to say, it takes a good measure of each of these constructs to be an adaptive expert. Furthermore, this decomposition of a complex term specifies measurable characteristics of an adaptive expert, such as metacognition.

Metacognition

Metacognition is the ability to monitor one's current level of understanding and decide when it is and when it is not adequate. In other words, it is the awareness of one’s knowledge and is a skill which can be used to control and manipulate cognitive processes. In order to develop adaptive expertise, pilots need to understand how they think, and how what they currently know can usually be helpful, but at times can be detrimental. Metacognitive training teaches decision makers to use general rather than specific strategies to optimize their judgment and decision making processes in both familiar and unfamiliar situations (Jentsch, 1997).

Metacognitive training typically involves improving metacognitive monitoring and control processes by teaching that (a) the meta-level exists and influences task processes, (b) describing strategies to improve meta-level processes, and (c) gives trainees an opportunity to practice thinking at this level. Metacognitive skills allow an individual to recognize novel or changing situations, select responses to the situation, monitor and evaluate their own progress; and to revise or create new strategies for responding to the task. One’s ability to script shift in response to an unexpected event should become significantly better as their level of judgment improves with the use of metacognitive skills. The next section will describe in detail the process model of surprise which will be used to test these hypotheses.

CHAPTER THREE: PREDICTING THE DIFFERENTIAL EFFECTS OF DOMAIN EXPERTISE AND JUDGMENT

It has been established that the unexpected is a complex problem (Chapter 1), and there are multiple skills (domain expertise and judgment) needed to best respond to the problem (Chapter 2). Now, I present evidence for the differential effects of domain expertise and judgment on the way unexpected events are processed using a highly modified model, originally developed by Meyer and colleagues (Meyer et al., 1997). Although this model has not been previously validated empirically as a whole, research has demonstrated that some individual components explain certain aspects of reactions to unexpected events (c.f. Meyer et al., 1997; Schützwohl, 1998). The approach of this study was to utilize the four main parts of this model (Parts A through D) as a test platform for hypotheses regarding which factors associated with domain expertise and judgment influence one's ability to respond to an unexpected event.

Framework for the Study of Unexpected Events

Although this model (Figure 3) is quite complex, I will present it here in detail only to provide necessary background information regarding the cognitive and behavioral aspects of the process. The model is then summarized into four working parts; Assessment of Situation (Part A), Schema Discrepancy Check (Part B), Discrepancy Verification (Part C), and Script Switching Process (Part D). One must keep several key points in mind when considering the process model of surprise used here. First, although portrayed sequentially, most of the steps in the model are taking place simultaneously. In addition, most likely, more than one "event" is being processed at the same time.

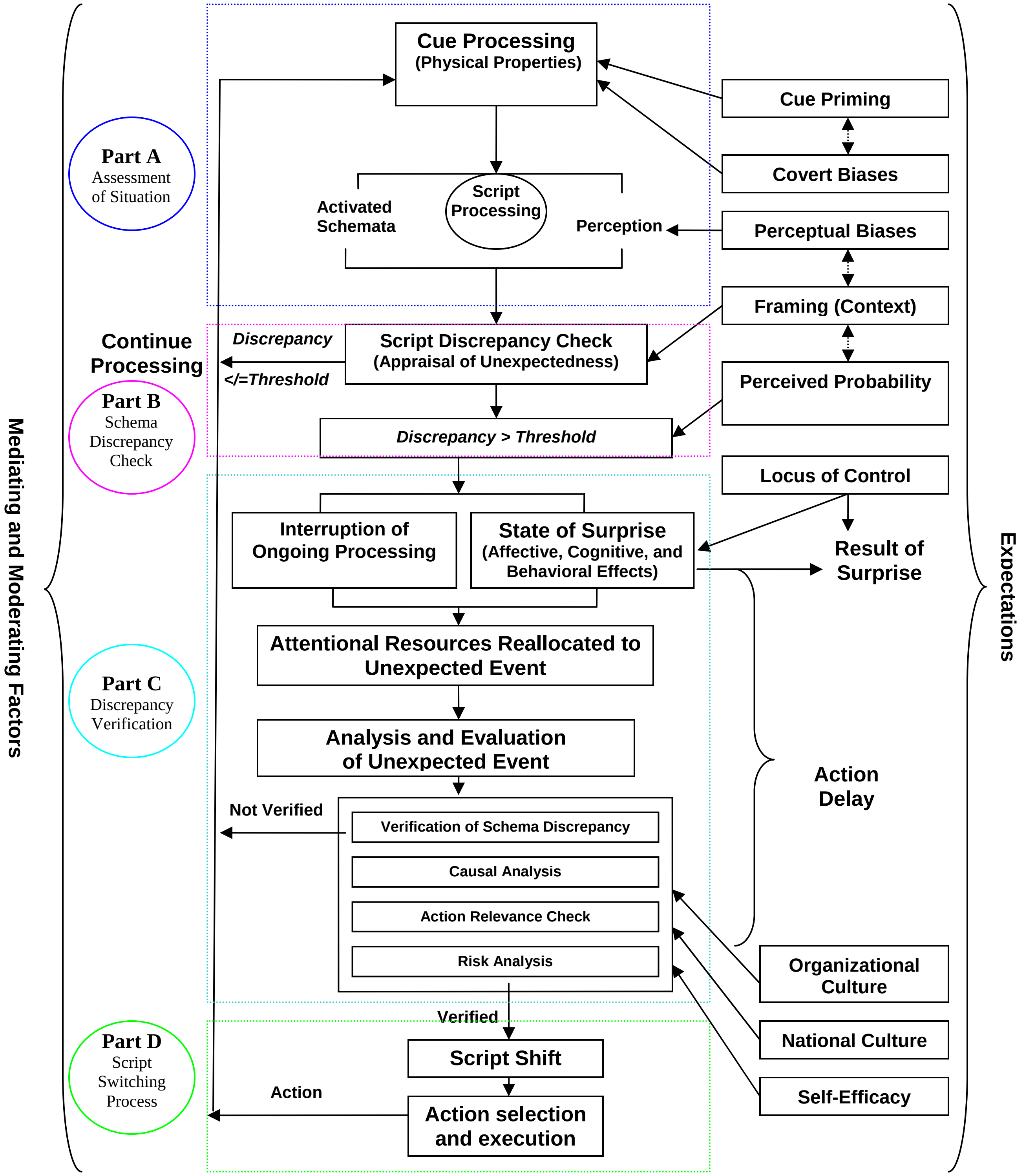

Figure 3. Process model adapted from Meyer, Reisenzein, & Schützwohl (1997).

Second, a host of interpersonal, social, and environmental factors such as training, experience, expertise, attention, motivation, heuristics, framing (context), biases, (cue processing) influence the process from beginning to end (Mauro, Barshi, Pederson, & Bruininks, 2001). For example, one’s state and trait personality factors such as risk perception, risk assessment, and risk taking behaviors influence the process at many junctures (Lubner, Hellman, Struening, & Hwoschinsky, 1999; Orasanu et al., 2001). Finally, national, organizational, and industry cultural norms also affect how one deals with an unexpected event (Helmreich & Wilhelm, 1997).

The Process Model – Part A

Assessment of Situation

The first section (Part A) of this conceptual process model deals with the physical properties and the perception of the cues available in the environment. During this input phase, humans continuously perceive internal and external cues in the environment relating to objects, scenes, and events.

Cue (Information) Processing

Cues in the environment are initially processed for their physical properties. The physical properties of the cues (salience, number, placement, color, brightness, tone, etc.) and many psychophysiological aspects of sensory processing, affect one’s ability to *detect* discrepant events. Cue processing is subtly influenced by learned and innate covert biases which will be discussed in detail as components of expectation.

One particularly important factor in this first stage of the process, as reported by Kochan et al. (2004) and others (Rickard & Bajic, 2004; Spratling & Johnson, 2004; Weick & Stucliffe, 2001; Wickens, 2003) was that more often than not, there *were* cues available which, if considered, would have provided sufficient information to preclude a situation from being perceived as unexpected. The question then arises as to what might be the deciding factor in whether a cue is noticed and brought into the decision making process or discarded as irrelevant information. If domain experts have a wider selection of patterns suitable to an appropriate action script, then their recognition of a changed situation should be faster than with less domain expertise. However, experience in a field would also tend to strengthen the schemata germane to the domain tasks (Schützwohl, 1998). Therefore, subtle or weak cues may be discarded as irrelevant noise because there was a "close enough" fit to an existing, known pattern, and a close scrutiny of all information was not forthcoming (Klein, 1997, 2003).

Perception

Returning to Part A of the model, we will next consider the concept of perception which I consider becoming aware of something via the senses. All internal and external sensory input (cue processing) is perceived through the filter of one's current physical state, mental state, mental model (Klein, 2003), and currently activated schemata (Meyer et al., 1997). Perception will be tempered by perceptual biases and other expectations. Neuroscientific studies (Kagan, 2002) have also demonstrated that people with more experience in a certain domain and therefore people more likely to have diverse experiences, may not have the same type of reaction (e.g., surprise) to an event as those with no exposure to the same situation.

Currently Activated Schemata

This process model is based on the premise that humans maintain a set of schemata which are personal, informal knowledge structures representing internal and external, events, objects, or situations. Currently activated schemata would be those which pertain to the ongoing situation or task. When an unexpected event is encountered, this activated schema (or schemata) is the benchmark to which an evaluation of the event is made as to whether it fits with the situation. During this evaluation, one's training, experience, and the strength of the activated schema dictates which cues are considered useful information or disregarded as non-essential (Orasanu, et al., 2001).

Script Processing

Script processing activities are continuous and based on the current, ongoing state of a situation. If an unexpected stimulus has been presented, the ongoing script processing is temporarily interrupted while the new cues are perceived and processed. Although not necessarily conscious at this point, there are significant changes taking place in the cognitive activities of the script processing (Damasio, 1999; Kagan, 2002). Again, depending on training, priming, emotional state, and other biasing factors, the unexpected event which is sufficiently discrepant from the currently activated schema will allow the process to continue. Otherwise, the feedback loop will be activated and "routine" processing will continue.

Expertise and Assessment of the Situation Hypotheses

The most salient features of this part of the model are one's perception, recognition, and utilization of the cues available in the environment. Based on the evidence of one's response to surprise at this stage, the following hypotheses regarding the differential effects of domain expertise and judgment on the assessment of the situation are depicted in Figure 4 and were put forth:

Hypothesis 1a: One's ability to assess the unexpected situation covaries with one's level of *domain* expertise. This was predicted because of the increased availability of facts and organization of facts in memory should allow for better cue recognition and cue usage.

Hypothesis 1b: Judgment has no significant influence or may negatively influence one's assessment of a situation. If one possesses exceptional adaptive expertise (a component of *judgment*), but does not have the requisite *domain* knowledge, there may be a tendency to overlook important cues.

Hypothesis 1c: There will be *no* significant interaction between the effects of *domain* expertise and *judgment* on one's assessment of the situation.

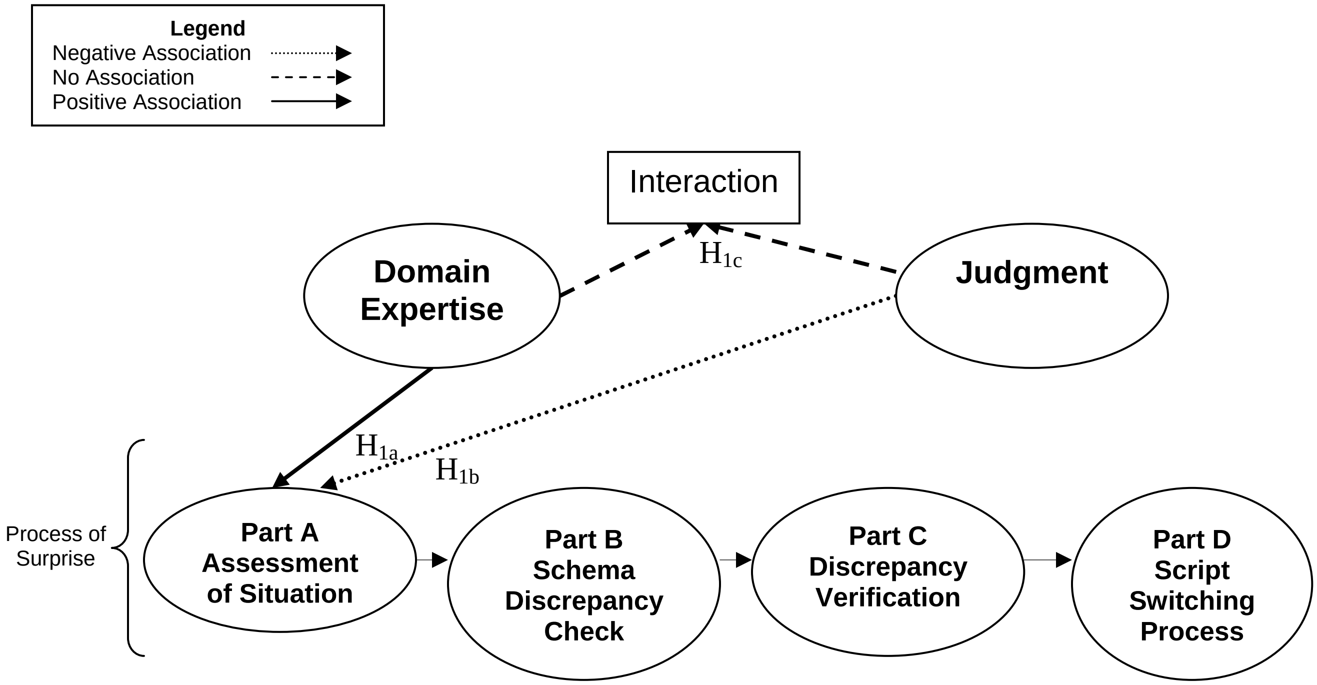

Figure 4. Hypotheses regarding the effects of domain expertise and judgment on the assessment of an unexpected event.

The Process Model – Part B

Schema Discrepancy Check

As in all decision making and information processing models, the process is influenced by a multitude of environmental and individual differences variables. Some of these influences, such as covert and perceptual biases serve to change the process of surprise through an interaction effect as it evolves (moderates) (Friedman, Cycowicz, & Gaeta, 2001). Other variables, such as contextual surrounds and perceived probabilities, can have an indirect effect on the outcome, but do not materially change the internal cognitive processes (mediators) (Fletcher, et al, 2001). Variables associated with one's expectations have the potential to impact reactions to surprise at every stage of processing as they serve to bias one's perception and understanding of the information available.

Expectations

Expectations are a part of the planning, predicting, and decision making processes used by all individuals in everyday life. Some scientists (e.g., Kagan, 2002) even purport that one feature distinguishing humans from other primates is the ability to formulate predications about future events based on desired goals in the distant future. Expectations are embedded in the cognitive networks formed by semantic representations, schemata (personally held views about how things should be), and action scripts (the dynamic ongoing process about how situations *should* unfold) used in assessing risk, formulating predictions, and choosing responses to an event.

The degree of expectedness is determined, in part, by how congruent or incongruent an event is with one's view of what should be. When situations do not proceed as one expects, a chain of physiological, emotional, and sociological events take place (Hammond, 2000, Jones & Endsley, 2000; Meyer et al., 1997). The resultant condition is a state of surprise which, depending on the valance and strength, can be extremely disruptive in virtually any domain. I will next consider the specific factors comprising expectations.

Cue Priming

Cue priming deals with the bottom-up processing of the sensory information presented in the unexpected event (Spratling & Johnson, 2004). Cue priming increases the sensitivity of a cue by improving the perceptual discrimination of the object (Colagrosso, Mozer & Huber, 2004).

Covert Biases

Depending on the strength of the activated schema and current ongoing action script, the discrepant information may or may not be interpreted as unexpected or even worthy of consideration. This initial, nonconscious processing has been shown to a priori influence the accurate processing of sensory information. The research team of Bechura, Damasio, Tranel, and Damasio (1997) has demonstrated a covert biasing effect which influences decision making in much the same way as other learned or innate biases. These covert biases work to influence the facts, options for decisions, projection of future outcomes, and reasoning strategies due to an individual's past emotional experience in similar situations. For example, a pilot's negative emotional experience with an event (e.g. rejected landing) can inflate how unexpected an event may appear. This causes the mechanism of surprise to become activated when it may not, in fact, be a particularly discrepant event for the ongoing situation. An abundance of good *judgment* could help mitigate this type of reaction by use of one's cognitive flexibility.

Perceptual Biases

Perceptual biases interact with covert biases to influence cue processing. Behavioral evidence of perceptual biases was presented by Kahneman (2003), who addressed *how* and *why* certain informational cues are noticed and others are not by considering accessibility. The dual-process (intuition versus reasoning) model of decision making proposed by Kahneman and

Tversky (1984) and revised by Kahneman (2003) revealed the core concept of accessibility. Accessibility determines how easily a thought comes to mind and is “determined jointly by the characteristics of the cognitive mechanisms that produce it and by the characteristics of the stimuli and events that evoke it” (p. 699). The accessibility dimension (more or less accessible) can be applied to the attributes of an object, the different objects in a scene, and the different aspects and cues available in a situation. The concept of accessibility includes the influences of heuristics (e.g., availability, representativeness), cue features, associative activation, priming, selective attention, and specific training which have all been demonstrated to affect both intuitive and analytical decision making (Connolly, Arkes, & Hammond, 2000; Jensen, 1995; Kahneman, 2003; Kahneman & Tversky, 1984; Klein, Orasanu, Calderwood, & Zsambok, 1993).

This study approached the cognitive difficulties apparent in responding to the unexpected keeping in mind that two, possibly competing, pathways leading to a decision are active at the same time as summarized by Kahneman (2003). He concluded his discussion on accessibility with the proposition that most judgments and preferences are initiated by intuitive action, based on the accessibility of information; unless that action is deliberately modified, corrected, or overridden by analytic reasoning. Domain experts should have access to more information than non-experts should, however in the case of the unexpected, intuitive reasoning may not serve to be the best process. Perhaps those less expert in a domain must analyze the situation more carefully as they do not have enough background facts and experiences to get a “feel” for the situation. This analysis of the event may indeed lead them to an appropriate change of plans (script shift); whereas the intuitive path may not indicate that, the ongoing script is no longer useful.

Framing

Contextual priming is based on a top-down, attention dependent bias toward information that is believed to be most relevant to the desired behavior. Spratling and Johnson (2004) explained the biasing effects generated by feedback mechanisms from cognitive processes on contextually primed target locations or objects. Features in a congruent context caused a stronger neural response and the resulting feedback mechanism increased the strength of the perceptual processing bottom-up signal resulting in a faster recognition. A response delay was also observed when one feature of a cue was as expected (as framed), and another was unexpected; for example, an air traffic controller may expect a target in a certain location (latitude and longitude), however the aircraft’s altitude may not be as expected (Handy, Green, Klein, & Mangun, 2001). Contextual expectations will naturally be strengthen by repeated experience in a domain, perhaps causing a higher degree of surprise when an event occurs out of the expected context.

Perceived Probability of Event

One’s expectation of an event is assumed to be a function of the perceived probability of an event occurring at any time and the *average* probability of that event occurring. The level of expectation is also assumed to be mediated by the base rate of the event. Consequently, when the perceived probability of an event occurring is greater than or equal to the average perceived probability of that event as mediated by the base rate, one would consider the event “unexpected”. Domain expertise will again have an influence on the perceived probability of an event; however, one’s perception of probabilities will not necessarily be statistically correct (‘it will never happen to me’ syndrome). This will also potentially skew one’s perception of the unexpectedness of an event.

Appraisal of Unexpectedness

Meyer et al. (1997) stated that as long as the activated schemata and the events (cues) perceived are congruent (enough), one interprets the event and automatically executes the appropriate action scripts and continues ongoing processing.

Threshold for Discrepancy

Events are measured against an individual's threshold for discrepancy as determined by their personal schema for the situation. When a discrepancy of sufficient strength is detected between the currently activated schemata and one's perception of the situational cues, the process continues.

Expertise and Schema Discrepancy Check Hypotheses

Expectations, framing, and priming will all contribute to one's analysis of whether an event is sufficiently discrepant from the ongoing situation. The hypotheses, displayed in Figure 5, were based on the previously presented evidence regarding the mechanisms involved in estimating the likelihood of an event and one's schema strength.

Hypothesis 2a: The correct identification of an event as discrepant may decrease as *domain* expertise increases due to a stronger schema and erroneous probability estimate.

Hypothesis 2b: *Judgment* will have no significant influence on the correct identification of an event as discrepant as the ability to determine whether an event is surprising is based on *domain* expertise factors of probability estimates and schema strength.

Hypothesis 2c: There will be *no* significant interaction between the effects of domain expertise and *judgment* on one's identifying an event as discrepant.

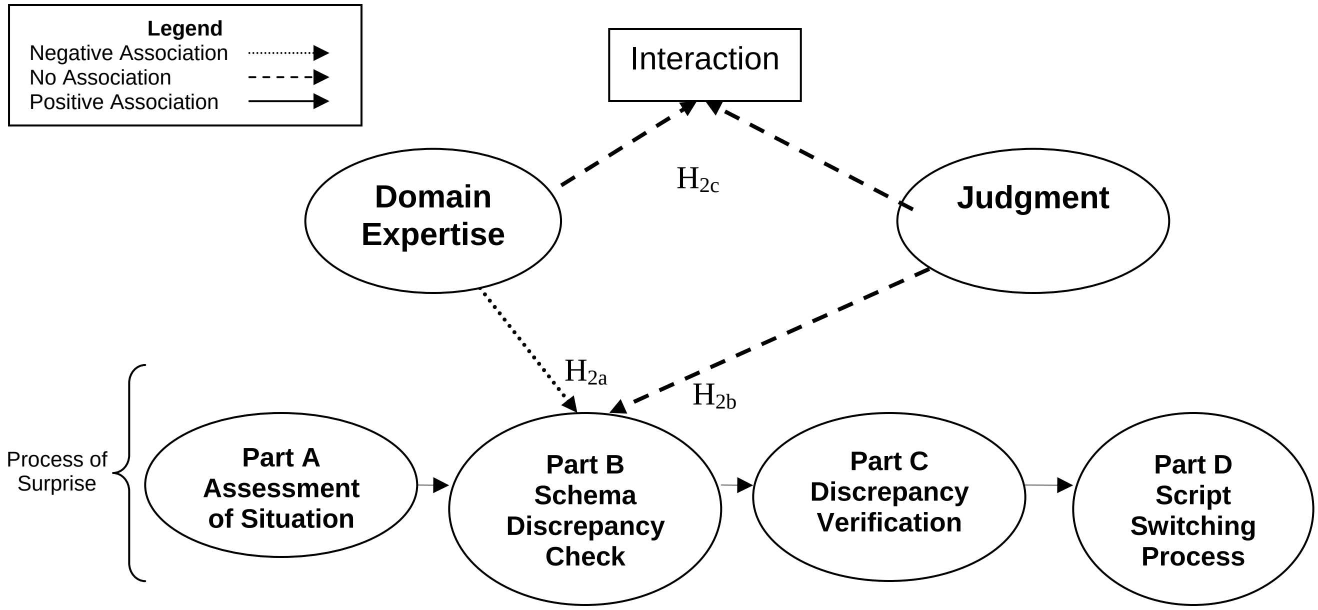

Figure 5. Hypotheses regarding the effects of domain expertise and judgment on the schema discrepancy check.

Process Model – Part C

Discrepancy Verification

State of Surprise

When situations do not meet one's expectations, a chain of physiological, emotional, and sociological events take place (Damasio, et al, 2000; Hammond, 2000; Jones & Endsley, 2000; Meyer et al., 1997), known generally as the emotion of surprise. Some researchers hypothesized that unexpected events are viewed as unpleasant experiences because they reduce the predictability of the environment, and one feels less control over the given situation (Weick & Sutcliffe, 2001), or destabilizes the homeostasis of the organism (Hammond, 2000). Other neuroscientists (e.g., Damasio, 1999; LeDoux, 2002) described the interdependence of emotions (including surprise) and cognition as having the ability to be considered in a positive or negative light, based on the impact of the situation to the survival of the organism.

This view was supported by empirical evidence provided by Schützwohl (1998) who found that the resultant feeling of the emotion of surprise, can have either a motivating (positive) or petrifying (negative) effect, depending on the extent of the discrepancy of the event with what is expected based on the currently activated schema. Additionally, the research team of Mauro, Barshi, Pederson, and Bruininks (2001), has suggested that the degree of unexpectedness elicits different affective and cognitive reactions. It appears that mildly discrepant events are viewed as pleasantly surprising, while excessively discrepant and novel events cause unpleasantness thus creating the possibility for more severe or longer lasting interruptions of ongoing processes. For example, most pilots tend to enjoy a moderate challenge of their skills and knowledge, and will find a minor surprise a welcome challenge. However, a major disaster, extreme inflight upset, or novel unexpected event will often be met with fear reactions including the lack of immediate response.

Interruption of Ongoing Activities

The duration of one's fixation on an unexpected event resulting in an interruption of ongoing activities will play a large part in the outcome of the event (Handy et al., 2001). The time spent focusing on the event may be influenced by the strength of the schemata pertaining to the situation (Schützwohl, 1998) where it may take longer to process a discrepant piece of information (cue), with increasingly strong schemata. An event with a smaller expected probability may also result in a longer fixation. For example, a previously unnoticed target on an air traffic controller's radar screen may elicit a state of fixation and while their focus is on this intruder, the rest of the screen is neglected. If, in addition, this is a target type with a very low probability of showing on the radar screen, the neglect of the ongoing processes may be even longer.

Reallocation of Attentional Resources

Wickens (2003) suggested many aviation accidents are triggered by highly unusual, and therefore, unexpected events. The unwanted outcomes are often the result of misallocation of attentional resources due to the response mechanisms associated with an unexpected event. Another factor, discussed by Woods and Patterson (2001), is that unexpected events often occur due to the mismanagement of automated functions in the aircraft. Once the event has occurred, there is an increasing escalation of cognitive activity, and coordination demands, leading to the likelihood of even more errors. It was expected that unique and separate contributions from domain and judgment abilities will be found to influence the level of interruption of ongoing processes.

Responses to Unexpected Events

Action Delay

Differences in response selection may be related to the ability of a pilot to modify or change schemata (or switch action scripts) based on the new situation. According to Meyer, et al. (1997), this would result in a longer action delay for dealing with the event and returning to other duties. The length of this delay may influence the ultimate outcome of an event, and once again, it may be controlled by one’s level of domain expertise and/or judgment skills.

Analysis and Evaluation of Unexpected Event

Once an event is perceived as unexpected, four additional sub-processes occur: (a) schema discrepancy verification to determine that the discrepancy is real; (b) analysis as to the cause of the event; (c) assessment of the relevance of the event to determine its effect for ongoing action; and (d) risk assessment and analysis. This analysis and evaluation portion of the model correlates with the analysis side of the intuition/analysis decision making dichotomy

(Hammond, 2000; Kahneman, 2003). The next step in the process model depends on the outcome of these sub-process analyses, combined with any other pertinent assessment of the situation, such as company values and cultural norms. Indeed, even at this stage, the discrepant cues may be deemed irrelevant or not applicable to the current situation and therefore disregarded; at which point normal processing continues.

Expertise and Discrepancy Verification Hypotheses

Once an event has been determined to be unexpected, an interruption of ongoing processes of some duration will be displayed. The benefits of high levels and good structure to one's domain knowledge will assist in this stage of the process. Those with less domain expertise may create a length of action delay that contributes to an unwanted outcome due to inattention to the ongoing task. High levels of judgment are not expected to assist significantly at this juncture, although some evidence of an interaction effect may be found as shown in Figure 6.

Hypothesis 3a: Discrepant event verification will be less disruptive to ongoing processes as *domain* expertise increases due to the increasing levels of automaticity for ongoing skills and the familiarity with possible alternatives.

Hypothesis 3b: Discrepant event verification will improve significantly with increased *judgment* due to the increasing ability to search for alternatives which may not be obvious.

Hypothesis 3c: There will be a significant interaction between the effects of *domain* expertise and *judgment* on one's verification of a discrepancy. High levels of *judgment* will assist those with low levels of *domain* expertise more than those with high levels of *domain* expertise in event verification through the increased ability to search for and consider different alternatives.

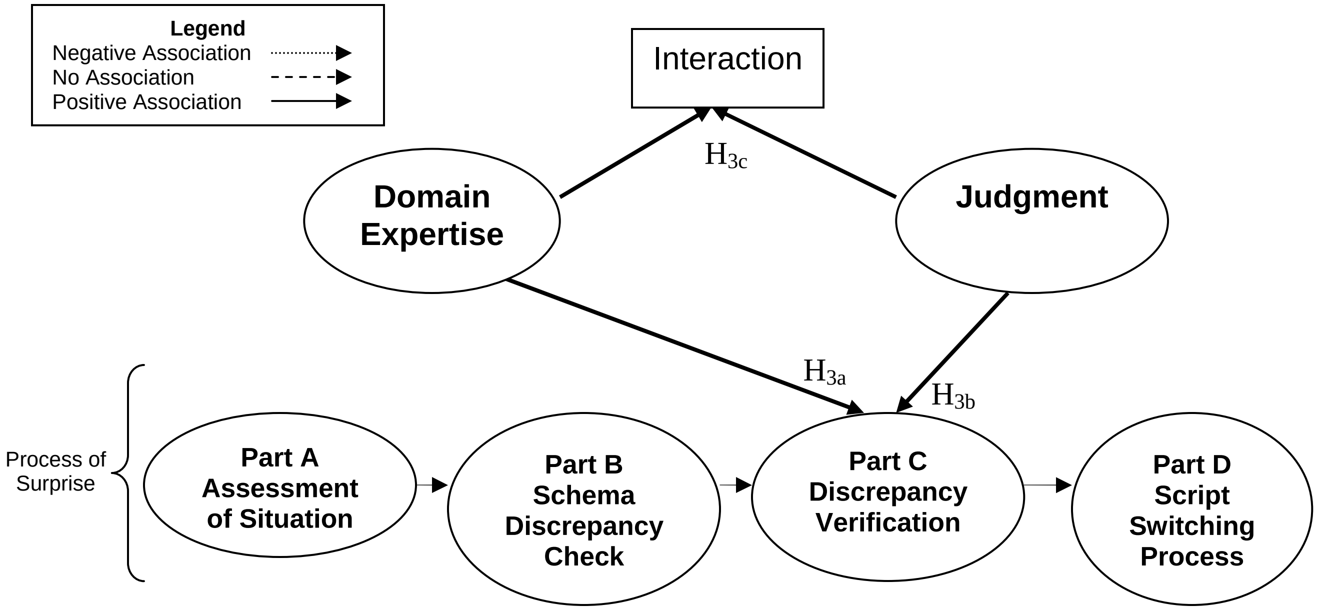

Figure 6. Hypotheses regarding the effects of domain expertise and judgment on discrepancy verification.

Process Model – Part D

Script Switching Process

Script Shift

According to Schützwohl (1998), the strength of the activated schemata and the degree of perceived unexpectedness interact to initiate a transformation of the schema or to reject the input. However, modification of a schema would, in theory, require many instances of the same event, whereas updating or creating a new script for the situation would be more likely. Maintaining the ability to continually evaluate a situation and modify or change action scripts as necessary is key to dealing with unexpected events. It is also critical in situations with degraded information, too much noise, or ill-structured problem domains that the most relevant available cues are utilized to determine if a script shift is indeed warranted.

Response Selection and Execution

Response selection is selecting the choice of response from the candidate actions. The decision to take action or decline any immediate action results in the selected response. This response follows a feedback loop to continue processing, which is essentially the sub-process of evaluating the choice and execution of the response.

Expertise and Script Switching Process Hypotheses

This is the most critical stage of the process model for the effect of *judgment* (Figure 7). Here, the highest levels of *domain* expertise may only serve to bias one into thinking the situation does not need to be addressed, while possessing cognitive flexibility and adaptive expertise skills (*judgment*) brings to light the need for a shift in the action script.

Hypothesis 4a: One's ability to script shift will be unrelated, or may even be negatively related to their level of *domain* expertise due to their stronger schemas and higher use of intuitive decision making styles.

Hypothesis 4b: One's ability to script shift will be significantly better as their level of *judgment* increases as this task is primarily a cognitive task and domain non-specific.

Hypothesis 4c: There will be a significant interaction between the effects of *domain* expertise and *judgment* on one's ability to script shift. High levels of *judgment* are expected to mitigate the potential negative effects of high *domain* expertise and enhance the ability to script shift for those with low levels of *domain* expertise through the application of cognitive flexibility and metacognitive skills.

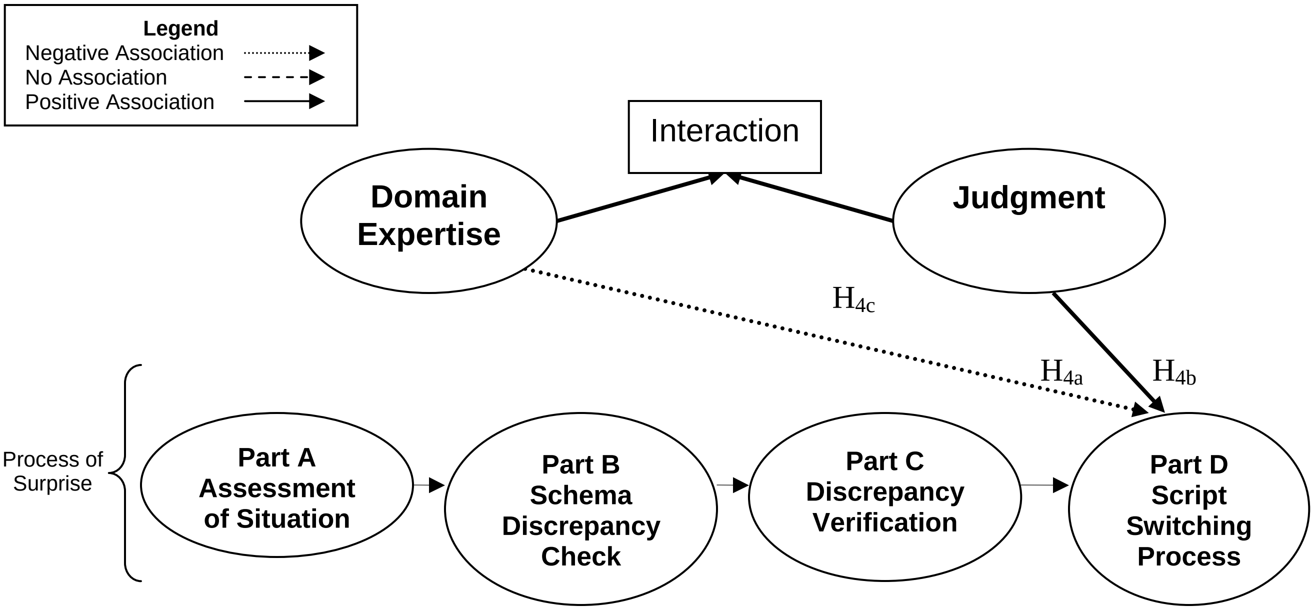

Figure 7. Hypotheses regarding the effects of domain expertise and judgment on the script switching process.

Summary

It is apparent that the effects of unexpected or novel events can be detrimental to an individual's cognitive and behavioral processes. Of greatest consequence appears to be the action delay that takes time and attention away from ongoing tasks, potentially leading to an unwanted and likely dangerous outcome. However, relatively little research exists on the specific effects of unexpected on cognitive or behavioral processes. Research such as this study was needed to determine the effects of dealing with the unexpected on human performance and the potential for improving responses to unexpected events. The main theme of this investigation was that training involving *judgment* skills such as cognitive flexibility, metacognitive skills, and adaptability may be the first step to addressing the underlying skills necessary to be able to better respond to the unexpected.

Hypotheses

Four sets of hypotheses were proposed, each describing how *domain* expertise and/or *judgment* play a part in the steps of the processes generated by an unexpected event. It was through the empirical testing of these hypotheses that I attempted to answer the research questions posed in this study. Can we identify specific knowledges and skills which enhanced one's ability to deal with unexpected events? Furthermore, were these skills included in *domain* expertise and/or *judgment*? Did *domain* expertise improve or deter one's reaction and response to unexpected events? What role did *judgment* play in responding to the event? The specific hypotheses are reiterated below.

Hypothesis 1a: One's ability to assess the unexpected situation covaries with one's level of *domain* expertise. This was predicted because of the increased availability of facts and organization of facts in memory should allow for better cue recognition and cue usage.

Hypothesis 1b: *Judgment* has no significant influence or may negatively influence one's assessment of a situation. If one possesses exceptional adaptive expertise (a component of *judgment*), but does not have the requisite *domain* knowledge, there may be a tendency to overlook important cues.

Hypothesis 1c: There will be *no* significant interaction between the effects of *domain* expertise and *judgment* on one's assessment of the situation.

Hypothesis 2a: The correct identification of an event as discrepant may decrease as *domain* expertise increases due to a stronger schema and erroneous probability estimate.

Hypothesis 2b: *Judgment* will have no significant influence on the correct identification of an event as discrepant as the ability to determine whether an event is surprising is based on *domain* expertise factors of probability estimates and schema strength.

Hypothesis 2c: There will be *no* significant interaction between the effects of domain expertise and *judgment* on one's identifying an event as discrepant.

Hypothesis 3a: Discrepant event verification will be less disruptive to ongoing processes as *domain* expertise increases due to the increasing levels of automaticity for ongoing skills and the familiarity with possible alternatives.

Hypothesis 3b: Discrepant event verification will improve significantly with increased *judgment* due to the increasing ability to search for alternatives which may not be obvious.

Hypothesis 3c: There will be a significant interaction between the effects of *domain* expertise and *judgment* on one's verification of a discrepancy. High levels of *judgment* will assist those with low levels of *domain* expertise more than those with high levels of *domain* expertise in event verification through the increased ability to search for and consider different alternatives.

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Hypothesis 4c: There will be a significant interaction between the effects of *domain* expertise and *judgment* on one's ability to script shift. High levels of *judgment* are expected to mitigate the potential negative effects of high *domain* expertise and enhance the ability to script shift for those with low levels of *domain* expertise through the application of cognitive flexibility and metacognitive skills.

CHAPTER FOUR: METHOD

Overview of Research Protocol

This study was conducted in an aviation context, as it represents a highly complex domain replete with innumerable unexpected and surprising events. The data collection and analyses were part of an ongoing training and research study on pilots' reactions to unexpected events. As part of an FAA-sponsored program performed by the Calspan Corporation, pilots participated in a three-day upset recovery training program in Roswell, NM. Questionnaires, knowledge tests, and interviews were administered to determine expertise levels. Each pilot participant also flew a sortie in a Learjet in-flight simulator (Figure 8). They flew the airplane from the right seat (Figure 9), with a test-pilot instructor administering the experimental scenario from the left seat. Objective, subjective, and qualitative data from the participants and the instructor pilots, collected during and after the flight, were used as performance indicators of each step in the process of surprise. A description of the study protocol is provided in Appendix A.

Figure 8. In-flight simulator Learjet.

Figure 9. In-flight simulator Learjet cockpit.

Experimental Stimuli

The experimental flight scenario was designed to allow for the introduction of unexpected events which have been demonstrated to elicit surprise. Pilots are surprised by these selected events, regardless of their experience level or prior training (Kochan & Priest, 2005). Furthermore, even though the pilots were well aware of the nature of the flight (they were participating in an upset recovery training program and this was the pre-test flight), the events were still (quite) novel enough to create surprise. The in-flight simulation technology, employed in this study, allowed for the initiation of the events via an onboard computer, so as to realistically replicate an unexpected event. The experimental flight and stimuli were constructed to allow data collection and foster measurements at each of the four stages in the process model of surprise (assessment of the situation, schema discrepancy check, discrepancy verification, and script switching process). The stimuli in this experiment were three aerodynamic events (pitch, roll, and yaw) representative of airplane upset situations which have led to loss-of-control accidents (Kochan, Priest, & Moskal, 2005). The experimental flight incorporated the following unexpected events.

Pitch Aerodynamic Event

The first event was a simulated runaway stabilizer trim that required the use of full forward elevator control and considerable bank to stop the pitch up. The optimum recovery would have included full use of pitch control, ask for assistance on the controls, call for approriate checklist, and use enough bank angle to control the pitch attitude.

Roll Aerodynamic Event

A roll event that required large aileron inputs to recover, which airline pilots are not used to doing, was presented next. Some rudder input may also be required for the optimum recovery.

In this case it was better to increase the load-factor on the airplane (pull-back) and slow down. If proficient in recovering from this event, a participant could verify that loading is preferable to unloading, and whether rudder or asymmetric thrust would be required to control the uncommanded roll.

Yaw Aerodynamic Event

The third event was a yaw anomoly which should have elicited a rudder input from the participant. The failure was such that the rudder input had no effect, so the yaw rapidly caused a roll rate due to dihedral effect. The roll had to be countered with aileron and unloading assisted in controlling the roll until airspeed was increased or asymmetric thrust was applied. At higher levels of proficiency, the participants could demonstrate techniques to control the instantaneous crossover speed.

Experimental Design

This study was a quasi-experimental methodology involving the study of operational pilots in a simulated, in-flight, operational environment. The research plan called for a 2 (low expertise vs. high expertise) x 2 (low judgment vs. high judgment) between participants design as shown in Table 2.

Table 2

Experimental Design

Expertise Type and Level	Low Judgment (LJ)	High Judgment (HJ)
Low Domain (LD)	LD-LJ	LD-HJ
High Domain (HD)	HD-LJ	HD-HJ

Participants

Participants were volunteers recruited from the larger study participant pool and held at least an FAA Commercial Pilot Certificate with an Instrument Rating. All pilots were current for flying instruments and held an FAA Medical Certificate.

Power analysis suggested that using a minimum of 28 participants (alpha = .05, beta = .95) for an effect size (d) of 1.25 at the power of .80 would have required very robust differences between the study groups. The percent variance in scores accounted for by differences in expertise levels would have to be approximately 28% for main effects; and 33% for any interaction effect. Calculations followed guidance from Murphy and Myors (2004) which showed the sample size would need to be increased to at least 125 in order to detect smaller effect sizes (approximately .10) at power of .80. Therefore, given the high cost per participant ($10,000), initial analyses were conducted with data sets from 46 participants, randomly selected from the 209 available. Final analyses used the available complete data sets from 33 participants.

Materials and Procedures

Copies of the experimental materials and instructions for their use are in Appendix B. Participants were onsite at a designated training facility to participate in the study. After greeting the participants, they were asked to fill out the informed consent and demographic forms. A brief explanation of the protocol was given. They then completed the metacognitive self-efficacy questionnaire and a knowledge quiz on upset recovery causes and procedures. A Learjet preflight safety briefing was given and the experimental flight administered. Instructor pilots completed forms which provided performance and additional input to the experimental measures. Detailed protocols and scenario scripts are displayed in Appendix C.

Informed Consent

This proposed research was conducted under the Code of Federal Regulations, Title 45, "Public Welfare – Department of Health and Human Services", Part 46 "Protection of Human Subjects" (45 CFR 46) as revised 13 November 2001. The research proposal was submitted to the University of Central Florida's Institutional Review Board for approval (see Appendix B). Each participant in the study was presented with an informed consent document to read and sign. Participation in the study was voluntary and the experimental activities did not interfere nor impact ongoing pilot training. Participants were free to decline or discontinue participation at any time without any negative consequences. There were no undue risks associated with participation. A thorough debriefing was offered at the conclusion of the experiment.

Measures

Independent Variables

The independent measures in this study were *domain* expertise and *judgment* skills. Table 3 outlines the operationalization of these constructs. The details of the indicator variables used in the study are presented below.

Operationalizing the Domain "Expert Pilot"

One dilemma facing this study was how to define and operationalize the "expert pilot." Although the qualities of an expert pilot can be listed (Kochan, Jensen, Chubb, & Hunter, 1997), it was necessary to delineate the pilots with higher levels of domain expertise from those with lower levels of domain expertise to facilitate hypothesis testing. General pilot expertise level was determined by a mathematical formula developed pursuant to a factor analytic study by Doane, Sohn, and Jodlowski (2004). A general pilot expertise (experience level) score was calculated as an average of the *z*-scores for flight hours; years flying experience; number of types of aircraft flown; and flight instructor activity. The score was calculated using information reported on the Demographics Form. Specific domain knowledge (upset recoveries) was captured by a paper and pencil knowledge test and instructor evaluations (see Appendix B). These scores were converted to *z*-scores and averaged to be used in the data analysis. The general domain scores were calculated with consideration to be used as a covariate.

Table 3

Descriptions of Independent Variables

Independent Variable	Level (Designation)	Example Description
Domain Expertise	Low (LD)	Low demonstrated level of declarative, procedural, and structural knowledge on written test; low instructor ratings
	High (HD)	Higher demonstrated level of declarative, procedural, and structural knowledge
Judgment	Low (LJ)	Indicated by cognitive rigidity; lack of adaptive expertise skills, does not employ alternate strategies, weak in strategic knowledge
	High (HJ)	Indicated by high level of cognitive flexibility; ability to employ alternate strategies; strong in strategic knowledge

Operationalization of “Judgment”

The construct of judgment was operationalized by measures of metacognition using paper and pencil instruments (Wells & Cartwright-Hatton, 2004; Pintrich, Smith, Garcia, & McKeachie, 1993), adaptive expertise through pretest and post-test self-efficacy (Schmidt & Ford, 2001), and cognitive flexibility (mindfulness) (Klein, 2003). The instruments and scoring procedure used are exhibited in Appendix B. Scores from the individual measures were standardized (*z*-scores) and summed for a total judgment score. High vs. low judgment, as described in Table 3, was determined by median split of the judgment factors composite scores.

Dependent Variables

The experimental plan called for multiple data collection techniques to be used for each of the dependent measures in the study. To best address the proposed hypotheses and minimize threats to scientific validity, a mixture of objective, subjective, and self-report measures were used.

Assessment of Situation

Assessment of situation (Part A) was determined by measures of the participant's ability to recognize the event. The measures used for the variable were a combined score of 0-1 for "event recognition" for each of the three events and an overall instructor rating (Poor = 1 to Excellent = 5) of the participants' monitoring of the environment for changes, trends, and abnormal conditions. These measures were selected to provide multiple sources of information regarding the participant's situation monitoring, from a very specific event perspective and a more general view (overall monitoring). Cronbach's alpha for these four measures was .59. An average *z*-score was calculated from the mean of the event *z*-score and the instructor rating *z*-score.

Schema Discrepancy Check

The dependent variable score for Schema Discrepancy Check (Part B) was composed of the average of the time to recognize the three events as scored by Immediate = 3, Delayed = 2, and Excessive = 1. The scale was designed after observing approximately 100 similar event recoveries from prior studies. From these observations it was clear that the pilot (a) immediately recognized the event and responded (between .5 – 1 seconds); (b) initially hesitated, but was still able to react (approximately 2-5 seconds); or (c) was quite delayed in determining the discrepancy (over 6 seconds). Cronbach's Alpha was .89 for these three items. The average score was converted to a *z*-score value.

Discrepancy Verification

There were seven measures used for the score of the variable Discrepancy Verification (Part C). The verbalization of each event was scored as yes (1) or no (0) based on whether the participant announced the event. In addition, a score of initial recovery input correctness for each of the three events was given with Yes = 2, Somewhat Correct = 1, and Incorrect or No Input = 0. A *z*-score average of the verbalization, plus a *z*-score average of the initial recovery input was added to a *z*-score of the overall instructor evaluation of the participant's verbally communicating the correct nature of the event (Strongly Disagree = 1 to Strongly Agree = 5) for the total score. I chose these measures in order to include multiple facets of the pilot's discrepancy verification indications; verbalization and demonstration. These items (measures) showed a Cronbach's Alpha of .80. The variable score was an average *z*-score of the mean initial recovery input *z*-score, the mean announcement of the event *z*-score, and the instructor's evaluation *z*-score.

Script Switching Process

Participants' scores on Script Switching (Part D) was calculated by averaging their ability to recover, based on the instructors scores which ranged from Recovered = 2, Recovered with Difficulty = 1, and No Recovery = 0 and the instructor's rating of the participant's overall performance on the tasks (Poor = 1 to Excellent = 5). Once again, these measures were chosen based on previous observations of recoveries (approximately 100) and to provide more than one source of data in determining the value for the script switching variable. These items had a

Cronbach's Alpha of .78. These scores were converted to *z*-scores and an average of these *z*-scores was used in the analyses.

A summary of the description of the operationalization of the dependent variable constructs and measurement techniques employed to test the hypotheses are listed in Table 4.

Table 4

Operationalization of Constructs of Interest and Measure of Dependent Variables

Dependent Variable	Construct of Interest	Measure
Assessment of Situation	Cue Recognition (Time)	Cue recognition
Assessment of Situation	Cues Observed	Instructor rating of participant's assessment of situation
Schema Discrepancy Check	Schema Strength	Past history of similar events; prior upset recovery training; time in type (large, transport aircraft)
Schema Discrepancy Check	Action Delay	Time from perceiving event to action
Discrepancy Verification	Confirms Event	Verbalization of event and instructor rating of communication of events
Discrepancy Verification	Confirms Event	Initial response input
Script Switching Process	Change of Plan	Adequacy of recovery
Script Switching Process	Change Level	Ability to carry-out counterintuitive procedures (e.g., push forward on yoke to unstall airplane when pointed straight down

Data Collection

The data collection instruments used in this study are outlined in Table 5. The explicit purpose of each data collection form was de-identified after pre-testing with forms which had the “actual” name of the instrument displayed. Comments from the instructor pilots and participants pre-testing the forms had indicated the form names were distracting. I was also asked many questions regarding the forms’ use and purpose when the descriptive names were displayed. Therefore, the form name as administered to the participants was not indicative of the constructs being measured. De-identified videos from each experimental flight were also reviewed and objectively evaluated for consistency by this author, also a qualified upset recovery instructor. A “Lear Instructor Card #1” and “Lear Instructor Survey #1” were completed while observing the videos and compared to the real-time scores assigned by the instructor pilots. No inconsistencies were found. Inter-rater reliability (Pearson *r*) was greater than .96.

Table 5

Description of Data Collection Forms, Measures, and Administration

Form Name	Description and Purpose	When to Administer and to Whom	How to Administer and Explain
Participant Experience and Flight Time	-“Participant Experience and Flight Time” -To gather demographic and flight experience information from the participants	-Participant completes prior to start of Training	-Send prior to training or have participant complete upon arrival -Instructions on form
Participant Survey #1	-“Self-Efficacy and Metacognitive Score #1” -Used to ascertain how well participants think they will perform and what they think	-Participant completes just prior to Lear Pretest flight	-Hand form to participant after filling out informed consent
Participant Survey #2	-“Self-Efficacy and Metacognitive Score #2” -Used to ascertain how well participants think they performed and how they thought about the task	-Participant completes just after Lear Pretest flight	-Hand form to participant at the end of Pretest Lear flight

Form Name	Description and Purpose	When to Administer and to Whom	How to Administer and Explain
Participant Procedures Survey	-“Participant Knowledge Quiz” - Used to assess declarative and procedural knowledge regarding upset recoveries	-Participant completes after all academics	-Hand form to participant at the end of academics at -Explain per “notes” on slide
Lear Instructor Card #1	-“Lear Instructor Card Pretest” -Used to gather information on anxiety level and pilot performance on pretest upset maneuvers during Lear flight	-Instructor completes after Lear Pretest flight (immediately after Lear flight)	
Upset Recovery Quality Rating Scale	-“Beginning Upset Recovery Quality Rating Scale” -Used to evaluate quality of upset recoveries	-Participant completes (with assistance) before Lear Pretest flight	-Per instructions attached to forms
Upset Recovery Quality Rating Scale	-“Ending Upset Recovery Quality Rating Scale” -Used to evaluate quality of upset recoveries	-Participant completes (with Instructor assistance) after each Lear flight	-Per instructions attached to forms
Lear Instructor Survey	-Lear “Situational Awareness Linked Instances Adapted to Novel Tasks” (SALIANT), mindfulness measure -Used to gather information on the pilot’s situation awareness during the flight	-Instructor completes just after each Lear flight	-Per instructions attached to forms
Debriefing Survey	-“Experimenter Debriefing Survey” -Used to gather additional information regarding retention of training and views on loss of control	-Experimenter verbally administers to participant after all training activities are complete or via telephone	
DVD	-Audio and video recording of the computer generated instrument display in Learjet -Used for data extraction after flight	-Archive with data	
CD-ROM	-Flight history - Records parameters such as attitude, airspeed, altitude, control surfaces, pilot control inputs, and control law values at 100 frames per second.	-Archive with data	

CHAPTER FIVE: RESULTS

Initial Data Screening

Data analyses for this study were performed using SPSS v11.5 with alpha level of .05, unless otherwise stated. Simple effects were calculated using the “Simple.exe” program. The data were first reviewed for accuracy of input by checking for out-of-range values, plausible means and standard deviations, univariate outliers, and missing data. Initial data screening for normality, outliers, linearity, homogeneity of regression, multicollinearity and singularity, and homogeneity of variance-covariance matrices was performed. All measurement scales were checked for reliability.

The variables were also tested for skewness and kurtosis. There were two minimal violations of the assumption of linearity (Part A and Part B), homogeneity of variance (Part A), and slightly unequal cell sizes in the data which could not be resolved. I decided to still use all of the available participants’ data, while checking for anomalies due to the small differences in cell sizes. This provided for an increase in cell sizes, and total sample size, contributing to reduced heterogeneity and increased statistical power (Yang & Sackett, 1996).

I conducted 2 (domain expertise) x 2 (judgment) ANOVAs to determine the effects of domain expertise, judgment skills, and their interaction on the main dependent variables from the four parts of the process model of surprise. Post-hoc analyses of simple effects for interactions found to be significant were also performed. Table 6 displays a summary of the results from the four ANOVAs which will be discussed next in detail. The means, standard deviations, reliabilities, and intercorrelations of the measures and variables used in analyses are displayed in Table 7.

Table 6

Summary of ANOVAS for Domain Expertise and Judgment

Variable	*df*	*F*	Partial η^2	*p*
Part A – Assessment of Situation				
Domain Expertise	1	1.95	.07	.17
Judgment	1	5.03	.17	.03*
Domain x Judgment	1	6.34	.20	.02*
Part B – Schema Discrepancy Check				
Domain Expertise	1	1.34	.05	.26
Judgment	1	1.45	.05	.24
Domain x Judgment	1	7.47	.23	.01*
Part C – Discrepancy Verification				
Domain Expertise	1	0.52	.02	.48
Judgment	1	10.22	.29	< .01*
Domain x Judgment	1	6.42	.20	.02*
Part D – Script Switching Process				
Domain Expertise	1	0.09	.00	.77
Judgment	1	5.83	.19	.02*
Domain x Judgment	1	1.83	.07	.18

Note. *Denotes Significant Effect

Table 7

Means, Standard Deviations, Reliabilities, and Inter-correlations of Study Variables

Variable (# of Items)	N	Mean	S. D.	1	1a	1b	2	2a	2b	2c	2d	3a	3b	3c	3d
1. Domain Expertise (2)	40			1.00	.87**	.06	.25	-.11	.05	.39*	.36*	.30	.07	.22	.06
1a. Domain Expertise Score (5)	22	41.53	7.9		.87[1]	-.03	.10	.02	.02	.22	.16	.25	-.21	.08	-.03
1b. Demonstrated Knowledge (1)	32	3.53	1.13			1.00	.09	.01	-.09	.57**	.62**	.59**	.58**	.75**	.96**
2. Judgment (4)							.77**[2]	.62**	.06	.44*	.30	.47**	.21	.57**	.48**
2a. Adaptive Expertise (6)	23	22.43	4.25					.94[1]	.03	-.20	-.10	.15	-.10	-.09	.01
2b. Metacognition Scale (4)	23	15.83	4.30						.47[1]	-.19	-.26	.27	-.17	-.07	-.09
2c. Cognitive Flexibility Scale (3)	31	12.64	2.88							.94[1]	.80**	.79**	.56**	.70**	.57**
2d. Decision Making (1)	31	4.10	1.19								n/a	-.56**	.62**	.74**	.62**
3. Process Model															
3a. Part A – Situation Assessment (4)	31				.							.59[1]	.58**	.71**	.59**
3b. Part B – Schema Check (3)	31												.89[1]	.77**	.59**
3c. Part C – Discrepancy Verify (7)	30													.80[1]	.75**
3d. Part D – Script Switching (4)	32														.78[1]

Notes. ** = $p < .01$, * = $p < .05$

[1] = Internal Consistencies, [2] = R

Part A – Assessment of Situation

The results for the ANOVA on the measure for Part A – Assessment of Situation indicated a main effect of judgment, $F(1,25) = 5.03$, $p = .03$, partial $\eta^2 = .17$. Those classified as having low judgment ($M = -0.44$, $SD = 1.03$) scored significantly lower on the task than the high judgment group ($M = 0.31$, $SD = 0.47$). A significant interaction between domain expertise and judgment was also found $F(1,25) = 6.34$, $p = .02$, partial $\eta^2 = .20$. The effect of domain expertise was not significant, $F(1,25) = 1.95$, $p = .17$, partial $\eta^2 = .07$.

Simple effects of the influence of judgment were explored, and significant differences were found for judgment at low levels of domain expertise, $F(1,25) = 11.33$, $p < .001$, partial $\eta^2 = .31$. The low judgment group ($M = -0.82$, $SD = 1.04$) scored significantly lower on the measure than did the high judgment group ($M = 0.48$, $SD = 0.31$). The effect of level of domain (low vs. high) at low judgment was also significant, $F(1,25) = 7.66$, $p = .01$, partial $\eta^2 = .23$ with the low domain expertise group ($M = -0.82$, $SD = 1.04$) scoring lower than the high domain expertise group ($M = 0.25$, $SD = 0.58$). These results are displayed in Figure 11.

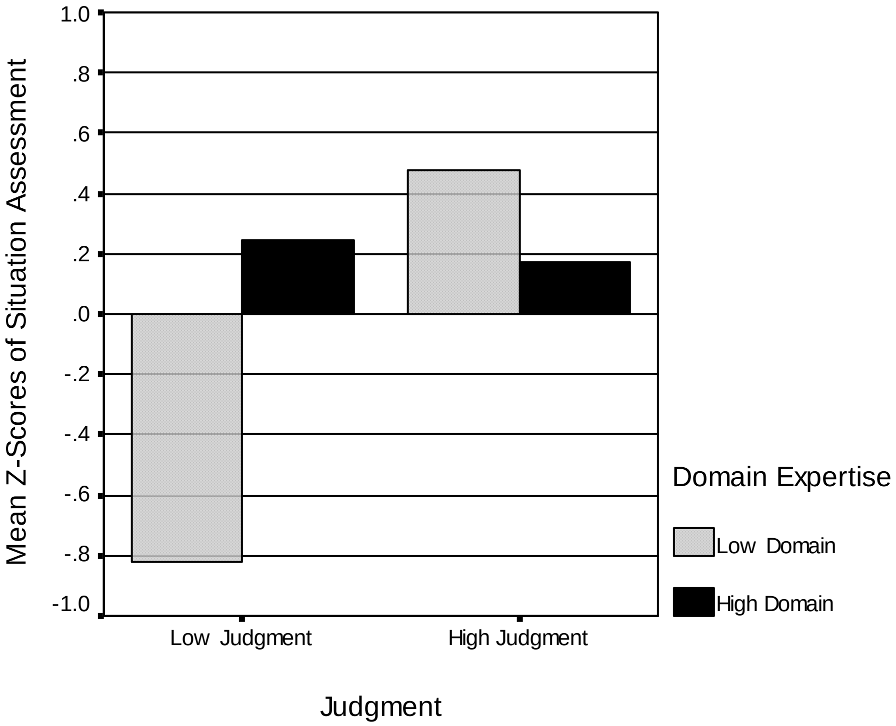


Figure 11. Mean *z* -scores on Part A for domain expertise and judgment.

Part B – Schema Discrepancy Check

The main effects of domain expertise and judgment on the measure of Schema Discrepancy Check were not significant, $F(1,25) = 1.34$, $p = .26$, partial $\eta^2 = .05$ and $F(1,25) = 1.45$, $p = .24$, partial $\eta^2 = .05$, respectively. A significant effect was, however, found for the interaction of domain expertise and judgment, $F(1,25) = 7.47$, $p = .01$, partial $\eta^2 = .23$ as shown in Figure 12. Investigation of the simple effects of the interaction revealed a significant effect of judgment (low vs. high) for the low domain expertise, $F(1,25) = 7.75$, $p = .01$, partial $\eta^2 = .24$ where the mean scores of the low judgment group ($M = -0.65$, $SD = 0.92$) were lower than the mean scores of the high judgment group ($M = 0.56$, $SD = 0.51$). Differences in Part B scores were also significant as a function of domain expertise, at low judgment levels, $F(1,25) = 7.57$, $p = .01$, partial $\eta^2 = .23$ with low domain expertise group scores ($M = -0.65$, $SD = 0.92$) being lower than high domain expertise group scores (*M* = 0.55, *SD* = 0.70) for participants with low judgment.

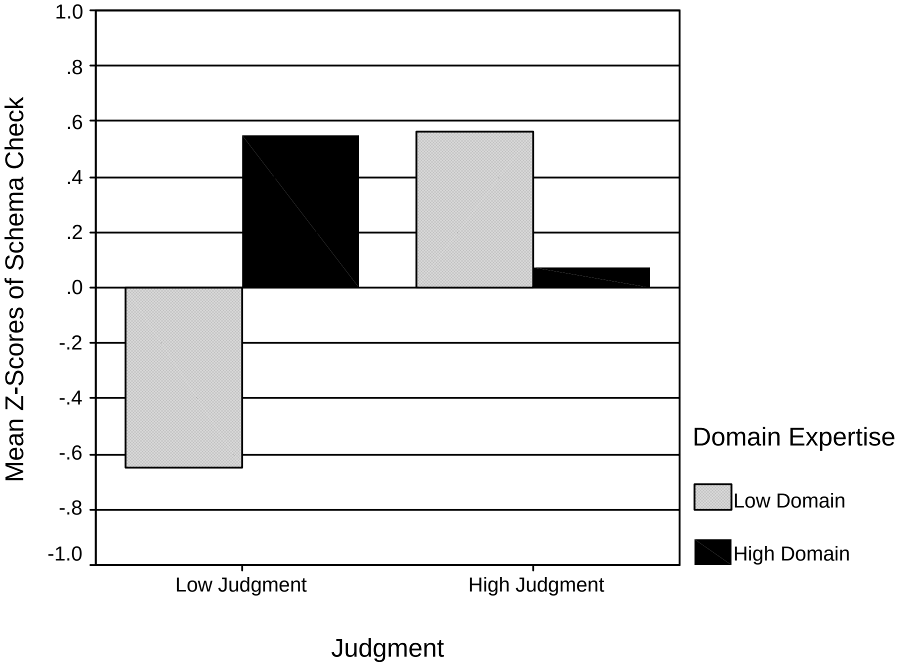


Figure 12. Mean *z* -scores on Part B for domain expertise and judgment.

Part C – Discrepancy Verification

Analysis of the effects of domain expertise and judgment on the measure of Discrepancy Verification showed a significant main effect for judgment *F*(1,25) = 10.22, *p* <.01, partial η^2 = .29. Participants with low judgment had significantly lower scores (*M* = -0.50, *SD* = 0.68) than those with high judgment (*M* = 0.33, *SD* = 0.64). The interaction of domain expertise and judgment, *F*(1,25) = 6.42, *p* = .02, partial η^2 = .20 was also significant. The main effect of domain expertise was again, non-significant, *F*(1,25) = 0.51, *p* = .48, partial η^2 = .02. These results are shown in Figure 13.

Investigation of the simple effects of the significant interaction again found significance for the effect of judgment at low levels of domain expertise, *F*(1,25) = 16.42, *p* < .001, partial η^2

= .40. The scores of those with low judgment (*M* = -0.77, *SD* = 0.59) were significantly lower than those with high judgment (*M* = 0.56, *SD* = 0.48). In addition, there were significant differences of domain expertise (low vs. high) at low judgment, *F*(1,25) = 5.28, *p* = .03, partial η^2 = .17, where participants with low domain expertise had scores significantly lower (*M* = -0.77, *SD* = 0.59) than those high in domain expertise (*M* = -0.01, *SD* = 0.59).

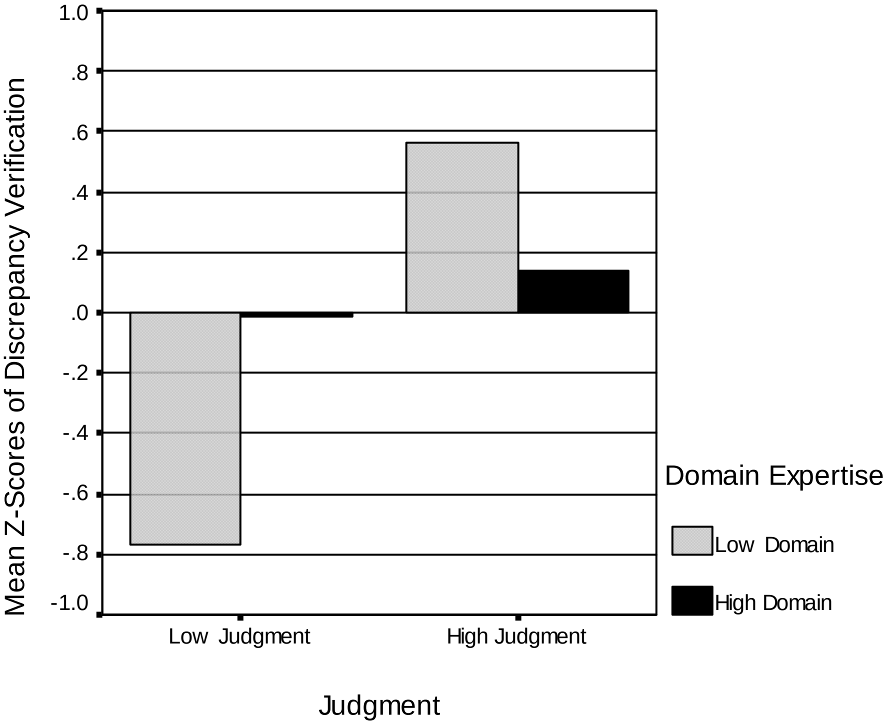


Figure 13. Mean *z* -scores on Part C for domain expertise and judgment.

Part D – Script Switching Process

The results for the ANOVA investigating the effects of domain expertise and judgment on the measure for the final part of the model, the Script Switching Process, only showed significance for the main effect of judgment *F*(1,25) = 5.83, *p* = .02, partial η^2 = .19. Participants with low judgment had significantly lower scores (*M* = -0.53, *SD* = 0.94) than those with high judgment (*M* = 0.35, *SD* = 0.91). The main effects of domain expertise and the interaction were not significant, $F(1,25) = 0.09$, $p = .77$, partial $\eta^2 < .01$and $F(1,25) = 1.83$, $p = .19$, partial $\eta^2 = .07$, respectively. Figure 14 displays the means of the *z* -scores for this part.

Simple effects tests revealed a significant influence of judgment at low levels of domain expertise, $F(1,25) = 7.10$, $p = .01$, partial $\eta^2 = .22$ where the scores of those with low judgment ($M = -0.66$, $SD = 0.85$) were significantly lower than those with high judgment ($M = 0.66$, $SD = 0.66$). Significance for the effect of domain expertise (low vs. high) at low judgment was not found in this case, $F(1,25) = 0.48$, $p = .46$, partial $\eta^2 = .02$.

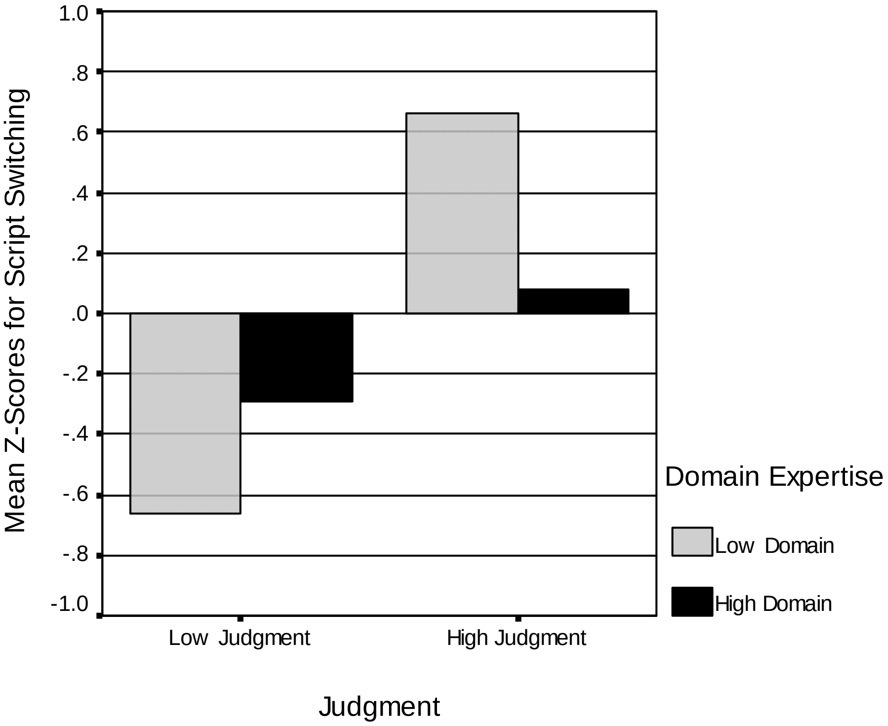


Figure 14. Mean *z*-scores for Part D for domain expertise and judgment.

CHAPTER SIX: DISCUSSION AND CONCLUSION

Discussion

The general hypothesis for this study was that judgment would influence reactions and responses to unexpected events as viewed through a process model, at different stages and in different ways than would domain expertise. The results from this study overwhelmingly support this hypothesis and offer insight into how pilots with different levels of judgment skills handle unexpected events. Overall, general judgment skills showed differential influence in performance measures at every juncture in the model used as the framework for the study. Conversely, there were no significant effects of a pilot's level of domain expertise on reactions to unexpected events. Most interesting, were the significant interactions between domain expertise and judgment skills which were found at every stage where measures were taken in the model.

Effects of Domain Expertise and Judgment on Assessment of the Situation (Part A)

This task required the participants detect and perceive the salient cues associated with the aerodynamic upsets presented as experimental events. The cues included visual cues (displayed on the flight instruments and out-the-window), tactile cues (yoke or rudder pedal movement), and proprioceptive cues from movement of the airplane in pitch, yaw, and/or roll. This cue processing was likely influenced by perceptual and covert biases as put forth by Damasio (1999) and Kagan (2002). The measure of the task was whether the cues were detected and interpreted appropriately.

The hypotheses regarding pilots' ability to detect and use the appropriate information when dealing with an unexpected event were partially supported. I had predicted in Hypothesis 1a, that the assessment of the situation would covary with domain expertise. This was not supported with a main effect. However, investigation of the significant interaction between domain expertise and judgment revealed a significant difference in scores based on judgment level for low domain expertise group participants. The simple effect of this interaction was very large (partial $\eta^2 = .31$) and showed that there was better assessment of the situation for pilots with higher domain expertise than those with lower domain expertise at *low levels* of judgment. This suggests that domain expertise contributes to the ability to acquire cues at lower levels of judgment skills. This is congruent with the notion that those more expert in a domain possess a wider selection of patterns suitable to an appropriate action script (Schützwohl, 1998).

However, Hypothesis 1b stated that high judgment may have a detrimental effect (lower scores) on one's assessment of a situation. This was also demonstrated and the size of this effect was large (partial $\eta^2 = .23$). Participants in the high judgment group had lower scores on assessment of the situation across levels of domain expertise (low vs. high). High judgment skills may negatively influence the high domain expertise participants' ability to perceive and utilize the appropriate cues present in the unexpected event as compared to those with low domain expertise. This could be due to the stronger schemas experts are believed to hold, (Schützwohl, 1998) and their possible disregard of cues which do not fit with "known" patterns (Klein, 2003). An alternative explanation may be due to the likely use of more intuitive decision making styles, where these unexpected, and often ill-defined events, require more analysis and evaluation (Kahneman, 2003).

These results indicate (a) at least a certain requisite amount of domain knowledge is necessary to acquire and use the information (cues) available from the environment, and (b) well-practiced and often-used schemas and action scripts or the overuse of intuitive processing may lead pilots to miss or misinterpret salient cues (Hammond, 2000). The results suggest that high levels of judgment may interfere with "intuitive" processing at higher levels of domain expertise while enhancing cue processing for those lower in domain expertise. Even though these events were highly time sensitive (decisions and actions needed to be completed within an average of 20 seconds, lest the airplane crashed), it appears there was still time for analytical reasoning regarding the cues presented as evidenced by the superior performance by those in the low domain expertise group with high levels of judgment. A summary of possible mechanisms and explanations which are congruent with these results, at this beginning stage of the process of responding to unexpected events, are presented in Table 8.

Table 8

Possible Explanations for the Effects of Domain and Judgment on Assessment of the Situation

	Judgment Level	
Expertise Level	*Low Judgment*	*High Judgment*
Low Domain	More effort needed to look for cues Poor assessment of cues (not familiar) Covert biases producing high anxiety	Cognitively flexible Employs more than one decision strategy Abililty to perceive and process “novel” cues Less influence of perceptual biases
High Domain	Disregards relevant cues Cognitively inflexible to “novel” cues	Over-studies irrelevant cues Too cognitively flexible (never satisfices)

Effects of Domain and Judgment on Schema Discrepancy Check (Part B)

Part B of the process model addressed the pilots’ identification of the event as something more discrepant than their personal threshold. This threshold determination included the strength of their activated schemata, the context of the event, and the perceived probability that this event could happen, especially to them. Even though the participants were expecting aerodynamic events to occur during the course of the flight (context), there was still the unexpectedness of the type and size of the event they would encounter. Once the event had been recognized, the pilots had to determine what “it” was and if “it” was significantly contrary to cues consistent with their ongoing action script and activated schemata. Table 9 shows a sample of possible cognitive mechanisms occurring at this stage of the process.

Hypothesis 2a had predicted that the stronger schemas and erroneous probability estimates of pilots with high domain expertise may interfere with the correct identification of an event discrepant with the ongoing action script. Although not significant, high levels of judgment appeared to negatively influence the identification of an event as discrepant, only for those with *high* domain expertise. This could be an indication that high levels of judgment mediate the initial appraisal of an event because even though the event was *expected*, the features of the cues (e.g., rapidity of presentation, magnitude of movement) may not have been expected (Handy, Green, Klein, & Mangun, 2001).

Hypothesis 2b stated there would be no significant main effect of judgment on the determination of the unexpectedness of an event. This was supported by the data. The time it took to initially recognize the event and determine how discrepant it was from their personal, ongoing script, may have been attributable to the interaction between domain expertise and judgment. Although this interaction had not been predicted, it showed a moderately large effect (partial η^2 = .23). Further analysis showed there was, again, a significant influence of judgment at low domain expertise. Better (higher) judgment aided those with low domain expertise more so than those with low judgment to quickly identify whether the event was indeed discrepant. The effect size was large, partial η^2 = .22. This enhanced ability to determine the event was discrepant is in line with the Meyer et al. (1997) studies on surprise and unexpectedness which demonstrated those with a weaker schema for the task, were faster to identify a target as "different". On the other hand, it was difficult for those low in domain expertise and low in judgment to even determine just what was happening.

Table 9

Possible Explanations for Effects of Domain and Judgment on Schema Discrepancy Check

	Judgment Level	
Expertise Level	*Low Judgment*	*High Judgment*
Low Domain	Probability estimate errors Less experience with aerodynamic events Weak schema/low threshold Unable to discriminate novel events	Probability estimate errors (lack of knowledge) Ability to use adaptive expertise for what is known Able to better monitor level of understanding of event
High Domain	Probability estimate errors Schema may be too strong Not flexible enough to modify threshold Unfamiliar context	Probability estimate errors (won’t happen to me) Schema may be too strong Threshold set too high Misapplication of adaptive expertise to cues

Effects of Domain Expertise and Judgment on Discrepancy Verification (Part C)

Part C of the process showed significant effects of judgment and the interaction of domain expertise and judgment as hypothesized (Hypotheses 3a, 3b, and 3c). This stage of the process resulted in a measure of the interruption to ongoing cognitive processing and behavioral activities. The verification of exactly what the event was, and what the appropriate initial inputs for response to the situation would be, required a mix of intuitive and analytical decision making. Unfortunately, there was very little time available to analyze and evaluate the unexpected event before *something* had to be done. It was quite clear (partial $\eta^2 = .29$) that judgment enhanced pilots’ ability to verify the situation and begin a recovery effort. Possible explanations for this effect are offered in Table 10. These results support research by Mauro, Barshi, Pederson, and Bruininks (2001) which addressed differences in reactions based on the degree of unexpectedness of an event. Highly discrepant events were found to elicit negative affective and cognitive reactions, which could not be countered with an increase in domain knowledge alone.

It is reasonable to predict that good cognitive flexibility, adaptive expertise, and the ability to shift decision making strategies aided those higher in judgment skills with analyzing and verifying the aerodynamic events presented in this study. All of the experimental events, studied here, were highly discrepant from normal flight regimes, providing the worst-case scenario for potential interruption of ongoing activities. Therefore, the pilot had to quickly analyze and evaluate the situation and then reallocate his attention back to the task at hand (flying the airplane) after verifying the event as discrepant (Wickens, 2003). It was predicted at this stage, that high levels of judgment would assist those with low levels of domain expertise more than those with high levels of domain expertise (Hypothesis 3c). This was supported with a large effect size, partial η^2 = .17. The ability of pilots to verify the discrepancy, determine possible explanations of the event, weigh the associated risks of actions, and employ alternative decision strategies was integral to their ability to choose the appropriate course of action.

Simple effects also showed that judgment skills made more of a contribution to the analysis and evaluation for pilots in the low domain expertise group than for those with high domain expertise. This was a very large effect with partial η^2 = .40. This is the stage in the model where the influence of judgment for those lower in domain expertise becomes increasingly more helpful. Generally, the action delay created by focusing on the unexpected event could be devastating if a pilot fixated on only one aspect of the event. Being able to continue processing and using information from multiple sources (e.g., physical movement of the airplane, visual cues on the cockpit display, physiological disturbances, etc.) during this analysis and evaluation phase was critical for recovery from the event to be initiated.

Table 10

Possible Explanations for the Effects of Domain and Judgment on Discrepancy Verification

Expertise Level	**Judgment Level** *Low Judgment*	*High Judgment*
Low Domain	Too many alternatives considered Long action delay Fixation possible	Shorter action delay; gets to work on problem Applies novel solutions to problem Fixation countered with overt searching for cues
High Domain	May only use intuitive-based decisions Pattern matching may be flawed Tendency to not *verify* discrepancy	Adaptive expertise allows use of known patterns Cognitively flexible to consider alternatives Chance of *not* verifying discrepancy

Effects of Domain Expertise and Judgment on Script Switching Process (Part D)

The hypotheses for the final part in the process model stressed the advantages of judgment in changing one's course of action or applying counter-intuitive solutions to dealing with unexpected events. The results definitely support the notion that judgment skills assist one's cognitive and behavioral responses to an unexpected event. The prediction that high levels of judgment would mitigate potential negative effects of high domain expertise (e.g., cognitive rigidity) was supported by observing the mean scores; however, the results did not produce a statistically significant result. Pilots high in domain expertise, with low levels of judgment (*M* = -0.29, *SD* = 1.15) appeared to not script shift as well as those with high domain expertise and high levels of judgment (*M* = 0.08, *SD* = 1.05). Hammond (2000) suggested intuitive decision making would have been useful in dealing with these unexpected aerodynamic events needing immediate response. It appears in this situation, however, that the use of good judgment skills (including analytical decision making strategies) contributed to being able to take the correct necessary actions which, in these experimental events, were actually counter-intuitive. Therefore, the more expert pilots had to forego their instinctive or intuitive reactions in favor of a response which was far from their habit patterns to achieve a successful outcome (Weick & Sutcliffe, 2001).

Results demonstrated significantly that good judgment skills may have also enhanced pilots' abilities to script shift as evidenced by the implementation of the correct action selection and execution in response to the event for those with low levels of domain expertise. This suggested the utility of judgment skills when faced with an unexpected event, in particular, for those low in domain expertise, supporting Hypothesis 4c. One plausible explanation for this is the enhancement judgment skills bring to the task of analytical decision making. Regardless of one's level of domain expertise, more analytical-based (vs. intuitive) decision making becomes necessary when dealing with novel or ill-defined events (Kahneman, 2003). People lower in domain expertise typically use analytical styles of decision making more often and in more situations than do those with more expertise in a field (Klein, 1997, 2003). The advantage seen here may be in the practice of using good judgment skills in concert with practiced analytical decision making. This is evidenced by low domain expertise/high judgment groups' ability to script shift, even more readily than do those in the high domain expertise/high judgment group. A summary of possible explanations for these observations are presented in Table 11.

Table 11

Possible Explanations for the Effects of Domain and Judgment on Script Switching Process

	Judgment Level	
Expertise Level	*Low Judgment*	*High Judgment*
Low Domain	May freeze May not know an alternative Correct action, incorrect execution	Will change plans (script shift) Will attempt *something* Correct action, incorrect execution
High Domain	May show confirmation bias Applies incorrect response	Will change plans (script shift) Ability to counter intuitiveness

DISCUSSION AND CONCLUSIONS

Discussion

It is now obvious that pilots need to better understand that modern aviation requires more than knowledge of the principles of flight. The challenge now is to focus on possible remedies which will ensure the acquisition of good judgment skills in concert with advancing domain expertise. One logical place to start is with the regulators, who mandate the requirements for the trainers, who train the trainers, who train the pilots. Judgment skills are integral to the skills required in this type of domain and cannot be relegated to the preface of a training manual or one chapter in a book on flying. Research studies, and more realistically training time and dollars, suggest we will never be able to train for every potential unexpected event. Therefore, as the results of this study show, the focus of training needs to *include* teaching judgment skills along with technical skills.

The long-held belief that judgment skills develop "naturally" with an increase in domain expertise does not appear to be supported in research, or more importantly, in accident and incident data. While there is believed to be a moderate correlation of domain expertise and judgment with time, the data from this study suggest that this does not occur automatically for all people. Therefore, we need to teach judgment skills early (student pilot), and reinforce often (every training and evaluation session for the duration). This would be a monumental change for our aviation system, although we have seen glimpses of hope, such as the theory behind the Advanced Qualification Program.

The overall results of this study point to the fact that pilots low in domain expertise, but high in judgment skills, were actually best able to adapt to the unusual circumstances surrounding the unexpected aerodynamic events. At each stage of the process of reacting to the unexpected events, these pilots, low in domain expertise, but high in judgment skills, had the highest mean performance scores of all the groups in the study. This was a particularly surprising outcome, but indeed may be one of the most important findings of this work. If judgment skills are really domain non-specific, then people with good judgment skills, who may not yet be experts in their field, may have distinct advantages when dealing with uncertain, ill-defined, and unexpected situations. Furthermore, those who are already domain experts can benefit from enhanced judgment skills in unexpected situations by thwarting cognitive rigidity and the overuse of intuitive decision strategies.

Finally, attempting to resolve unwanted outcomes precipitated by an unexpected situation with more technology and automated devices (e.g., warning systems, alerts, and flight envelope protection) is not the solution. There will still (and always) be unexpected events which may become even more difficult to respond to as there would now be another interaction with the automated function(s). Ultimately, we need to help the human better deal with the unexpected in a generic sense, because “it” is lurking around every corner.

Limitations of the Study

The most salient limitation of this study was the small sample size in a complex, quasi-experimental design. However, the significant results and moderate to large effect sizes indicated that additional participants may not have added to the ultimate conclusions of this experiment. There existed the possibility of mono-method bias in the individual scales used to calculate the overall judgment score, although, three of the scales had been previously validated and internal consistencies were high. Also, it must be noted that the data used for assigning pilots to the high vs. low judgment groups came from different sources (self-report) than those used as dependent measures in Parts A to D (instructor ratings and post-hoc assessments from the video tapes).

Consequently, it is likely that pilots in the low judgment group showed poorer judgment on the flight events not as an artifact of the study, but instead, as a result of their poorer judgment.

Implications for Training

So, what should be trained and how could "it" be implemented into existing training programs? First, judgment skills, although put forth to be domain non-specific, are not necessarily domain independent. As the results of this study demonstrated, there is a significant interaction between domain expertise and the judgment skills. Therefore, attempts to train judgment skills might best be situated in the context of the specific domain. Briefly, topics and methods demonstrated to be successful in improving judgment skills are:

- Define, explain, measure, and discuss the concepts of metacognition, adaptive expertise, cognitive flexibility, and decision making strategies
- Train through helping to build and enhance mental models of equipment, environments, teams, and situations
- Specifically present conceptual models of situations and tie declarative, procedural, and strategic knowledge together using judgment skills
- Integrate the above concepts into scenarios used for teaching at every opportunity
- Obtain, distribute, and reinforce examples of the use of good judgment skills in domain specific situations
- Train and evaluate using scenario-based examples and focus on the adequacy of the interaction of domain specific skills and judgment skills

Summary and Outlook

The introduction to this study explored the influence of unexpected events on cognitive and behavioral processes. It also addressed the possibility that there are two separate skill sets, domain expertise and judgment, that come into play when dealing with the unexpected. My investigation revolved around determining to what extent these two skill sets were involved in pilots' reactions to aerodynamic events. Using a model which outlined the cognitive processes elicited by the unexpected, I captured performance measures at each of four representative stages of activities. The study was conducted with real airline pilots, in a real airplane (In-Flight Simulator Learjet configured as a typical Transport Category airplane), using real, live, inflight aerodynamic upsets.

The results of this investigation have shown that pilots with higher levels of judgment skills (based on measures of adaptive expertise, cognitive flexibility, metacognition, and decision making strategies) appear to be significantly better at responding and reacting to a selection (pitch, yaw, and roll) of unexpected aerodynamic events. Aviation experience (years flying, total flight time, number of different aircraft flown, etc.) made no difference in if, or how well, a pilot recovered from the upsets. One's level of specific upset recovery *knowledge* (based on written tests and instructor evaluations), taken alone, had no influence on the pilot's performance. However, there were significant interaction effects between upset recovery knowledge and the level of judgment skills (low or high). In other words, possessing and/or being trained in specific judgment skills (which are, essentially domain nonspecific) have the potential to enhance pilot performance; especially when faced with novel, ill-defined, or even everyday unexpected events.

The focus of this body of research was specific to reactions and results of unexpected events in aviation. Previous studies and investigations (Kochan, Breiter, & Jentsch, 2004) have indicated that it is, more often than not, an unexpected event which triggers a process which results in an unwanted outcome for the "highly experienced" or "expert" aviator. Therefore, there is reason to believe that these same results would be found in other highly dynamic, complex domains where there are numerous opportunities to deal with unexpected events. These areas may include military operations, nuclear power plants, oilrigs, medical operating rooms, law enforcement, fire fighting, weather forecasting, and national security. Any domain where dealing with the unexpected may be part and parcel to successful operations may find this study relevant.

Future Research

It should be clear by now that the conclusion from this study is that unexpected events can be handled better by pilots with better judgment skills, particularly in cases where there is low domain expertise. The challenge now is to determine how best to utilize this knowledge and structure programs which will best prepare everyone for dealing with the unexpected and the potentially deadly results. Specifically, we need to find the optimum curriculum and training tools needed to teach the diverse skill sets of adaptive expertise, cognitive flexibility, metacognition, and decision making strategies as the main contributors to good judgment.

Studies are needed to answer the following: Can judgment skills be taught generically and then applied to specific domains? If not, should “judgment training” be conducted in the context of the domain at the beginning of training, at the end, for the duration, or not at all? Should “judgment training” even be a “separate” subject or is it a training philosophy and methodology? Why do experts at the same level of domain expertise, exhibit different levels of judgment skills? Were they taught judgment skills, specifically, or was it the nature of their domain task?

The project on which this study was based will be continued. I look forward to the opportunity to increase the sample and cell sizes and minimize threats to validity. Enhanced measures, such as a “Need for Cognition” scale will be included in the research protocol and data analysis will continue. In addition, the “judgment training” component (the overall training philosophy, in this case) of the program will be formalized and enhanced. Testing to see if the composite skill set of judgment already under investigation can be further enhanced in a short-term training venue will also be initiated. This will provide an opportunity to define a judgment training protocol and evaluate known and new judgment training strategies, at least in one small niche, of one small domain, where the unexpected are plentiful.

APPENDIX A: FAA UPSET RECOVERY TRAINING AND RESEARCH PROGRAM

FAA Funded FRTC Training and Research Program

This three-day training course is offered to study participants on the Eastern New Mexico University – Roswell (ENMU-R) campus located on the site of the Roswell Industrial Air Center (KROW) airport. It consists of classroom instruction and flights in an aerobatic Beech Bonanza and an In-Flight Simulator (IFS) Learjet, configured as a generic swept-wing twin-engine jet transport.

What sets this program apart is that the training is offered in an IFS aircraft. This aircraft has a fly-by-wire flight control system that is programmed to represent the characteristics and feel of a much larger transport aircraft. Furthermore, upset events are programmed into the system so that the trainee can experience Loss-of-Control (LOC) in the controlled environment of a simulation albeit as real-world as you would want. This is our focus because one common thread in nearly all of the upset-induced accidents we've studied is the crew being faced with an abnormal or unknown aircraft behavior. Clearly, a comprehensive URT program must include not only training in extreme-attitude-flight but also in analyzing and correcting such an occurrence.

The FRTC training (ground and flight) is tailored to meet individual trainee's needs. The emphasis placed on each specific step depends largely on the trainee's background and recent experience. However, the core of the flight training is the IFS experience. Current syllabus was developed with an experienced aviator in mind. We targeted a mid-career captain with high-performance jet time. That said, we do not assume the trainee has any significant aerobatic experience. The Bonanza flight is intended to get all trainees up-on-the-step so as to have ample knowledge and proficiency to handle the Lear flight. However, if the trainee has military fighter experience, the Bonanza flight could be considered optional. On the other hand, if the trainee has never been upside-down, additional Bonanza flights might be warranted. In the Lear flight, the trainee must have sufficient situational awareness to be able to recognize the unusual attitude and sufficient knowledge to know what to do about it. However, data from the over 200 pilots studied, indicates that this situational awareness is necessary but not sufficient when it comes to recovering from the challenging jet upsets pre-programmed into the IFS system. It turns out that the critical skill set required for a successful recovery is a well-practiced alternate control strategy focused on the precipitating upset event itself.

Classroom Instruction

The classroom instruction is broken down into two parts. After receiving part one, the trainee is prepared to fly the Aerobatic Bonanza. Likewise, part two is focused on preparing the trainee for the IFS Learjet flight. With in that context, in each briefing, the trainees learn the causes of upsets, the underlying aerodynamic concepts that govern upset recovery, and various recovery techniques. In discussing upset causal factors, we study previous LoC accidents using National Transportation Safety Board (NTSB) developed animations in an effort to teach-by-examples as much as possible. We find the time spent discussing previous upset events very productive as doing so clearly illustrates just how difficult recovery can be when faced with real-world constraints such as time-pressure, inadequate or unknown information, and stress. The perspective of the Aerodynamics discussion is the pilot's view from the flight deck. While the discussion is thorough, it is limited to what information the pilot can readily extract from normal cockpit displays and on-board systems. We intentionally deemphasize more complex issues that would not directly contribute to the pilot's ability to recover from an upset event. When discussing recovery techniques, the concept of flight path and how it is controlled is introduced. The discussion covers recovery from all possible aircraft attitudes. General categories of upset events are introduced and the requisite recovery strategies are detailed. In addition to the classroom instruction, trainees are also given instruction in a companion ground-based trainer.

Companion Ground Trainer

This ground training system is a cab with flight displays and controls that make it sufficiently representative of the IFS aircraft to serve as a familiarization and flight rehearsal tool. After completing this portion of the training, the trainee will be familiar with how the IFS aircraft simulation system operates, the look and feel of the displays, and will have seen a broad selection of representative upset events. The goal is for the trainee to gain first-hand experience with the scenarios and recovery techniques to ensure the underlying principals are understood before the flight training begins.

Companion Ground Trainer Used to Prepare Trainee for In-Flight Simulator Training

Flight Training

The two aircraft are used in the training: an aerobatic Beech Bonanza and a Learjet IFS. The aerobatic Bonanza is used to teach unusual attitude recoveries and accelerated flight. Here, the purpose is to increase the trainee’s ability to recognize and recover from extreme attitudes in an expeditious manner and, ultimately, to increase the trainee’s situational awareness. The Learjet IFS aircraft, pre-programmed with upset events, is used to teach actual upset recoveries. The events programmed into the simulation system range from atmospheric effects and a wake turbulence encounter to extreme control failures and control surface hard-overs.

Learjet In-Flight Simulator Teaches Trainees to Recover from Real-World Upset Events

Aerobatic Bonanza Introduces Trainees to Extreme Attitudes and Accelerated Flight

APPENDIX B: STUDY FORMS

IRB Submission Form

1. **Title of Project: Expertise and Unexpected Events**

2. **Principle Investigator(s)**

Name: Ms. Janeen Adrion Kochan
Degree: M.S. in Human Factors
Title: Ph.D. Candidate
Department: Psychology
College: Arts & Sciences
Telephone: 863-297-8080
Facsimile: 863-293-1718
Email: jdkochan@aol.com

Signature:____________________________
Janeen Adrion Kochan, M.S. Date

3. **Supervisor (if PI is a student):**

Name: Dr. Florian Jentsch
Degree: Ph.D. in Psychology
Title: Associate Scientist/Scholar
Department: Psychology
College: Arts & Sciences
Telephone: 407-882-0304
Facsimile: 407-882-0306
Email: fjentsch@pegasus.cc.ucf.edu

Signature:____________________________
Florian Jentsch, Ph.D. Date

4. **Date of Proposed Project**: From: May 18, 2005 To: July 31, 2005

5. **Source of Funding (as indicated to the Office of Research)**:

   Federal Aviation Administration Grant 99-G-047
   (Extension of grant through December 31, 2005 pending.)

6. **Scientific Purpose of the Investigation**:

   Loss of control in flight was the largest category of fatal accidents reported in commercial flight operations (Boeing Commercial Airplanes Group, 2003) and the second largest category of accidents in general aviation (Federal Aviation Administration, 2003). Research suggests one underlying facet of unwanted outcomes in aviation is the occurrence of a surprising or unexpected event.

The purpose of this study will be to investigate how different aspects of expertise affect one's ability to detect and react to an unexpected event.

7. **Describe the Research Methodology in Non-Technical Language**:

The informed consent and surveys will be administered by experimenters to pilots (See Appendix A). The surveys include subjective rating questions, fill-in questions, and background/demographics questions. The surveys will be strictly anonymous, and no questions are asked which could potentially identify any participant.

8. **Potential Benefits and Anticipated Risks**:

Potential benefits of this study include gaining an understanding of what types of events pilots perceive as surprising and how unexpected events influence the outcome of a flight. Only minimal risks associated with filling out the surveys are anticipated for this investigation.

9. **Describe how participant (s) will be recruited, the number and age of participants, and proposed compensation (if any):**

Participants are pilots from regional, commuter, and major airlines who have previously agreed to participate in an FAA sponsored Upset Recovery Training Program Research Project. These participates have already given informed consent for a larger study of which this investigation is a small portion. Please see Appendix B, Approved Informed Consent and Institutional Review Board Approval Forms from full study.

10. **Describe the informed consent process:**

All informed consent information will be presented and signed before any surveys are administered to the participant by the researcher.

I approve this protocol for submission to the UCFIRB. ______________/____
Department Chair/Director Date

University of Central Florida

Informed Consent

Name: ____

Please read this consent document carefully before you decide to participate in this study.

Project Title: Expertise and Unexpected Events
Sponsor: Federal Aviation Administration

A. Purpose

The goal of this study will be to investigate how different aspects of pilot expertise affect one's ability to detect and react to an unexpected event.

B. Nature of Test and Experiment

In this research, you will participate in a study investigating the differences in pilot expertise in responding to unexpected events. This part of the study will consist of three parts. The first part will focus on obtaining some background information. Next, you will complete a number of questionnaires that are commonly used in studies on expertise. Your answers on these surveys will remain completely confidential (see below). Finally, evaluations on your reactions to unexpected events will be compared with your answers on the questionnaires

C. Risks and Benefits

Participation in the current study does not involve any risks other than those commonly associated with filling out personal data questionnaires, which is minimal. All performance and personal data will be kept confidential. Potential benefits of this study include gaining an understanding of what types of events pilots perceive as surprising and how unexpected events influence the outcome of a flight.

D. Confidentiality of Personal Data and Records

All data in this study will be held in strict confidentiality by the researchers to the extent provided by law. Individual data will not be revealed to anyone other than the researchers and their immediate assistants. In particular, individual data, answers to the surveys, and performance measures will not be revealed to the Federal Aviation Administration, the National Transportation Safety Board, or to any other airline, flight school, or air carrier. Instead, only group mean scores and standard deviations will be published in a final report. Individual information will be assigned a code number. The list connecting my name to this number will be kept confidential and in a secure place. When the study is completed and the data have been analyzed, the list will be destroyed.

E. Compensation

No compensation will be provided to the participants.

F. Right to withdraw from the study

Participation in this research is completely voluntary. You can withdraw my participation at any time without penalty or perjury - this includes removal/deletion of any data that may have already been collected. Should you decide not to complete the mission; no penalty of any kind will be incurred.

G. Answers to Questions

This research is conducted by principal investigator Florian Jentsch, Ph.D., and graduate research assistant Janeen Kochan. Feel free to ask the research assistant any questions you may have. For any other questions regarding this research, contact Dr. Florian Jentsch:

Dr. Florian Jentsch
Team Performance Lab
University of Central Florida
Orlando, FL 32816-1390
Phone: 407-882-0304

H. Whom to Contact Regarding Your Rights

Information regarding your rights as a research volunteer may be obtained from:

Barbara Ward, CIM
IRB Coordinator
Office of Research, 12443 Research Parkway, Suite 302, Orlando, FL 32826-0150
Email: IRB@mail.ucf.edu or bkward@mail.ucf.edu
Phone: 407-823-2901
Fax: 407-823-3299

If you believe you have been injured during participation in this research project, you may file a claim against the State of Florida by filing a claim with the University of Central Florida's Insurance Coordinator, Purchasing Department, 4000 Central Florida Boulevard, Suite 360, Orlando, FL 32816, (407) 823-2661. University of Central Florida is an agency of the State of Florida and that the university's and the state's liability for personal injury or property damage is extremely limited under Florida law. Accordingly, property damage suffered during this research project is very limited.

Please acknowledge that you are at lease 18 years of age and that the purposes of the procedures used in this project have been explained to your satisfaction. You understand that participation in this study is voluntary and that you am free to withdraw at any time with no penalty. With these acknowledgements, please consent to your participation by signing below. Thank you.

Signature: ______________________________

Date: ______________________________

PARTICIPANT EXPERIENCE AND FLIGHT TIME

Participant ID #________

Please fill out this form as completely as possible. Let us know if you have any questions.

BLOCK 1: BACKGROUND INFORMATION

Please answer as appropriate:

Total Years Flying: ____________

Are you instrument current? Yes____No____

If no, how long since instrument currency? ________

Date of last flight? ____________

Did you attend military flight training?____________

Total Number of Military Aircraft Flown____________

List Military Aircraft Flown in Excess of 25 Hours:

Fighter: ______________________________

Transport: ______________________________

Rotorcraft: ______________________________

Do you have military flight test experience? (Circle)

Yes No

Total Number of Civilian Aircraft Flown____________

List Civilian Aircraft Flown in Excess of 25 Hours:

Transport: ______________________________

Non-Transport: ______________________________

Rotorcraft: ______________________________

Do you have civilian flight test experience? (Circle)

Yes No

List Different Aerobatic Aircraft Flown Conducting Aerobatics (Military and Civilian) ________________

Please Circle:

Are you currently flight instructing? Yes No

Are you a check airman? Yes No

BLOCK 2: FLIGHT TIMES

Total Flight Hours ______Hours in Last Year__________

PIC Hours_________PIC in Last Year____________

SIC Hours_________SIC in Last Year____________

Total Hours Military Transport ___________________

Total Hours Civilian Transport_____________

Total Instrument Time (Actual)_________________

Total Night Time_____________________________

Total Hours of Aerobatic Flight__________________

Hours of Aerobatic Flight in Last Year___________

Total Rotorcraft Hours (Military and Civilian)_______

Total Glider Hours__________LTA Hours__________

Dual Instruction Given (Military and Civilian)_______

Dual Instruction Given in Last Year_____________

BLOCK 3: SIMULATOR EXPERIENCE

How comfortable do you feel using a computer?

Not At All Comfortable_____Fairly Uncomfortable____

Fairly Comfortable________Very Comfortable_______

How many simulators have you flown (list) ?_____________

BLOCK 4: EDUCATION AND EXPERIENCE

Aerobatic Experience: (Please check one)

None __________
Some __________
Extensive __________

Extent of Aerodynamic Education: (Please check one)

None __________
Some __________
Extensive __________

Source of Aerodynamic Education: (Please check all that apply)

Pilot Training __________
Undergraduate __________
Graduate __________

Extent of Control Theory Education: (Please check one)

None	__________
Some	__________
Extensive	__________

Source of Control Theory Education: (Please check all that apply)

Pilot Training	__________
Undergraduate	__________
Graduate	__________

BLOCK 5: UPSET RECOVERY EXPERIENCE

How comfortable are you in the practice of recovering from unusual attitudes in an aircraft?

Not At All Comfortable_____
Fairly Uncomfortable______
Fairly Comfortable________
Very Comfortable_________

Have you experienced an inflight upset?
Yes ___No____

If yes, most recent date____________

How many times?__________

Please describe the most recent event____________
____
____
____
____
____
______
____

BLOCK 6: PREVIOUS UPSET RECOVERY TRAINING

Have you had previous upset recovery training?
Yes ___No____

If yes, most recent date____________

How many times?________________

Place of upset recovery training:
Airline___________________________
Flight School_____________________________
Other (please list)____________________

If you have had airline upset recovery training:

Was there a formal upset recovery training academic program? Yes ___No____
If yes, how many hours?_______

Did the airline include upset training in transition training?
Yes ___________No____Do Not Know__

Was the training repeated during each recurrent cycle?
Yes ______No____Do Not Know__

Were simulators used for the airplane-upset training?
Yes ___________No____Do Not Know__

Did the airline's instructors receive specific training for airplane upsets?
Yes ___________No____Do Not Know__

PARTICIPANT SURVEY #1

Participant ID #________

DIRECTIONS: Please answer the following questions by circling the appropriate rating.

1. I believe I will receive excellent ratings for my performance on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

2. I'm certain I can handle the most difficult situations presented in this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

3. I memorize key words to remind me of the important concepts when studying.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

4. I practice material mentally while “chair flying.”

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

5. Considering the difficulty of this task and my skills, I think I will do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

6. I believe that I will perform within the top 10 % of all participants on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

7. I read over my notes and the course materials often when I am in training.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

8. I expect to do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

9. I am confident I can do an excellent job on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

10. I make lists of important terms and memorize the lists.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

PARTICIPANT SURVEY #2

Participant ID #________

DIRECTIONS: Please answer the following questions by circling the appropriate rating.

1. I believe I received excellent ratings for my performance on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

2. I am certain I handled the most difficult situations presented in this task well.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

3. I memorized key words to remind me of the important concepts in upset recovery when studying.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

4. I practiced the upset recovery material mentally while “chair flying.”

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

5. Considering the difficulty of this task and my skills, I think I did well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

6. I believe that I performed within the top 10 % of all participants on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

7. I read over my notes and the upset recovery course materials often.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

8. I expected to do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

9. I was confident I could do an excellent job on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

10. I made lists of the important terms for upset recovery and memorized the lists.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

PARTICIPANT PROCEDURES SURVEY

Participant ID #________

1. How can an aircraft's pitch be controlled?

2. What is the procedure for recovering from an aileron failure (hardover)?

3. How can Dutch roll be dampened in a transport category aircraft?

4. What can happen when flying with a CG too far aft?

5. How do you recover from a nose down trim failure?

PARTICIPANT SURVEY #3

Participant ID #________

DIRECTIONS: Please answer the following questions by circling the appropriate rating.

1. I believe I will receive excellent ratings for my performance on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

2. I'm certain I can handle the most difficult situations presented in this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

3. I memorize key words to remind me of the important concepts when studying.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

4. I practice material mentally while “chair flying.”

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

5. Considering the difficulty of this task and my skills, I think I will do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

6. I believe that I will perform within the top 10 % of all participants on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

7. I read over my notes and the course materials often when I am in training.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

8. I expect to do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

9. I am confident I can do an excellent job on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

10. I make lists of important terms and memorize the lists.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

PARTICIPANT SURVEY #4

Participant ID #________

DIRECTIONS: Please answer the following questions by circling the appropriate rating.

1. I believe I received excellent ratings for my performance on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

2. I am certain I handled the most difficult situations presented in this task well.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

3. I memorized key words to remind me of the important concepts in upset recovery when studying.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

4. I practiced the upset recovery material mentally while “chair flying.”

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

5. Considering the difficulty of this task and my skills, I think I did well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

6. I believe that I performed within the top 10 % of all participants on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

7. I read over my notes and the upset recovery course materials often.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

8. I expected to do well on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

9. I was confident I could do an excellent job on this task.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

10. I made lists of the important terms for upset recovery and memorized the lists.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

UPSET RECOVERY QUALITY RATING SCALE

To optimize the in-flight simulation based upset recovery training, we need to be able to measure how much the participant's ability to recover, from a variety of upsets, improved during the training. Then we need to assess the value of the various events to the participant. In other words: How much did you learn?; and: How valuable is what you learned to you?

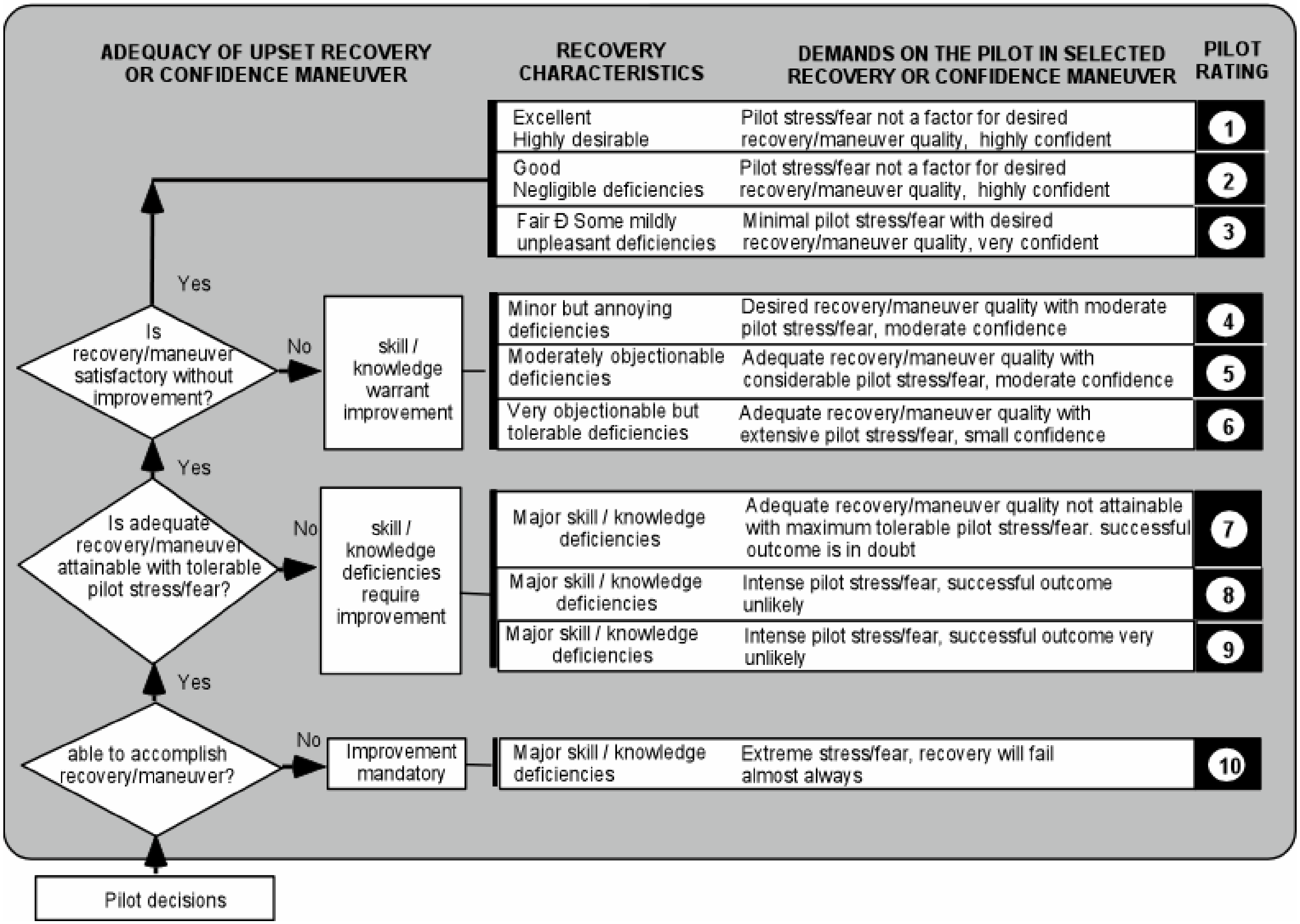
Measuring a pilot's ability to recover is a difficult task. Unfortunately, the seemingly straightforward concept of measuring performance parameters such as reaction times, maximum bank or pitch angles, etc. may be inadequate in similar circumstances. The reasons for this are manifold and would require a separate document to discuss. Perhaps a simple thought experiment from everyday experiences may best illustrate the difficulty of measuring how readily a task is accomplished by measuring the performance.

Consider that a single driver has two cars; car "A" steers poorly, car "B" steers like a dream. If you follow each of these cars for 10 miles, with the same driver, you may not be able to tell which car drives the best. When he drives car "A", he pays strict attention to the task and rarely stays from the center of the lane. When he drives car "B", his attention may wander to other things resulting in his straying further from the center of the lane than that with car "A". To the outside observer, using quantitative measures, it might appear the car "A" drives better. The most expeditious way of finding out which car drove the best is to ask the driver. He will be able to tell you unequivocally about his mental and physical workload, his level of apprehension and or stress, and his confidence in doing the job, none of which can accurately be determined from the performance. Driver opinion would then say car "B" was the better. Thus, in the long run, it may be much more cost effective and accurate to ask the driver (or the pilot) to provide the evaluation.

The flight test organizations around the world have adopted the Cooper-Harper rating scale to facilitate quantifying aircraft handling qualities. The Cooper-Harper scale considers performance and workload to assist the pilot at arriving at a single rating accompanied by supporting comments.

Measuring the quality of a pilot's recoveries presents a similar problem. We must consider both the performance, and the mental and physical workload. So we have modified the Cooper-Harper Handling Quality Scale to fit our needs. The resulting Recovery Quality Rating Scale is shown below. Currently it is used near the beginning of the Upset Training portion of the flight to obtain a "beginning" rating and then again after practice near the end of the flight for an "ending" rating. This is aimed at answering the question: How much did the participant learn from the practice? The second question, (How valuable is what was learned to the participant?) is addressed by a post flight evaluation form filled out by the participant at the end of the entire course.

RECOVERY QUALITY RATING SCALE



RECOVERY CHARACTERISTICS	DEMANDS ON THE PILOT IN SELECTED RECOVERY OR CONFIDENCE MANEUVER	PILOT RATING
Excellent Highly desirable	Pilot stress/fear not a factor for desired recovery/maneuver quality, highly confident	1
Good Negligible deficiencies	Pilot stress/fear not a factor for desired recovery/maneuver quality, highly confident	2
Fair Ð Some mildly unpleasant deficiencies	Minimal pilot stress/fear with desired recovery/maneuver quality, very confident	3
Minor but annoying deficiencies	Desired recovery/maneuver quality with moderate pilot stress/fear, moderate confidence	4
Moderately objectionable deficiencies	Adequate recovery/maneuver quality with considerable pilot stress/fear, moderate confidence	5
Very objectionable but tolerable deficiencies	Adequate recovery/maneuver quality with extensive pilot stress/fear, small confidence	6
Major skill / knowledge deficiencies	Adequate recovery/maneuver quality not attainable with maximum tolerable pilot stress/fear. successful outcome is in doubt	7
Major skill / knowledge deficiencies	Intense pilot stress/fear, successful outcome unlikely	8
Major skill / knowledge deficiencies	Intense pilot stress/fear, successful outcome very unlikely	9
Major skill / knowledge deficiencies	Extreme stress/fear, recovery will fail almost always	10

LEAR INSTRUCTOR CARD #1

Participant ID #:______________ **Instructor:_________________**

1. The apparent anxiety level of the participant prior to flight was:

Very Relaxed	Relaxed	Anxious	Very Anxious	Performance Impaired
1	2	3	4	5

Comments:____

2. The participant's overall performance as compared to the average airline pilot was:

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

Comments:____

3. During the flight the participant was:

Very Relaxed	Relaxed	Anxious	Very Anxious	Performance Impaired
1	2	3	4	5

Comments:____

Nose High Trim Runaway (Circle)

Recognized: Yes No
Time to Recognition Was: Immediate Delayed Excessive
Verbalized: Yes No
Initial Recovery Inputs Correct: Yes Somewhat No None
Recovery: Yes Difficulty No None
Time to Recovery: _____Seconds

Aileron Failure - Hardover (Circle)

Recognized: Yes No
Time to Recognition: Immediate Delayed Excessive
Verbalized: Yes No
Initial Recovery Inputs Correct: Yes Somewhat No None
Recovery: Yes Difficulty No None
Time to Recovery: _____Seconds

Rudder Failure - Hardover (Circle)

Recognized: Yes No
Time to Recognition: Immediate Delayed Excessive
Verbalized: Yes No
Initial Recovery Inputs Correct: Yes Somewhat No None
Recovery: Yes Difficulty No None
Time to Recovery: _____Seconds

LEAR INSTRUCTOR SURVEY

Participant ID #: _______ **Instructor:____________**

1. The participant’s overall monitoring of the environment for changes, trends, and abnormal conditions was.

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

2. Overall, the participant recognized the upset events in sufficient time to initiate recovery:

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

3. Overall, the participant verbally communicated the correct nature of the event.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

4. Overall, the participant demonstrated knowledge of the appropriate recovery technique(s) after an average amount of practice (i.e., compared to the average participant).

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

5. The participant exhibited skill in situation awareness.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

6. The participant attempted to obtain additional help or information regarding the situation.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	2	3	4	5

UPSET RECOVERY TRAINING
PROGRAM SURVEY

Thank you for your participation in the URT program. We would like to know how effective the course elements were in improving your airmanship in relation to recovering from future upsets you might encounter. **Participant ID #____________**

DIRECTIONS: Please answer the following questions about the URT program by circling the appropriate rating.

Example:

1 2 3 4 5
Poor Fair Good Very Good [✓ Excellent]

BLOCK 1: ACADEMICS (GROUND SCHOOL)

1. **The classroom instruction overall was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

2. **The briefing on aerodynamics and aircraft control (flight path, force, and controls) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

3. **The briefing on unusual attitude recovery (attitude, pitch and bank effect, corner speed) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

4. **The bonanza profile briefing was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

5. **The briefing on aerodynamics and aircraft control (dihedral, crossover, large aircraft differences, etc.) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

6. **The briefing on upset recovery (recovery process, crew coordination, automation, etc.) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

7. **Comments on academics:**

____

BLOCK 2: BONANZA FLIGHT

8. **Overall the Bonanza flight was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

9. **The benefit of the confidence maneuvers (lazy-8, loop, aileron roll, etc) flown in the Bonanza was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

10. **The "g" awareness demo in the Bonanza was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

11. **The nose high unusual attitude recovery (use of g and bank) in the Bonanza was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

12. **The nose low unusual attitude recovery in the Bonanza was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

13. **Comments on Bonanza flight:**

____

BLOCK 3: LEAR FLIGHT

14. **Overall the Lear flight was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

15. **The center of gravity changes demonstration was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

16. **The Dutch roll demonstration and recoveries was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

17. **The nose high unusual attitude recovery (transport category aircraft characteristics, use of g and bank, control strategies, etc.) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

18. **The nose low unusual attitude recovery (transport category aircraft characteristics, use of g and bank, control strategies, etc.) was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

19. **The wake turbulence recoveries were:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

20. **The nose up trim failure recoveries were:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

21. **The aileron failure recoveries were:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

22. **The rudder failure recoveries were:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

23. **The nose down trim failure recoveries:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

24. **The complete hydraulic failure recoveries were:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

25. **Comments on Lear flight:**

<u>BLOCK 4: OVERALL COURSE</u>

26. **Overall the Upset Recovery Training program was:**

1 2 3 4 5
Poor Fair Good Very Good Excellent

27. **What do you think could be done to improve the training? What would you like to see added, expanded upon, or left out?**

28. **Overall comments on the course including what aspects you found most informative and least informativel.**

DEBRIEFING SURVEY

Participant ID #________

11. What was the most important aspect of your upset recovery training?

12. Which recoveries did you find the most difficult?

13. Why?

14. How do you plan on maintaining your proficiency in upset recoveries?

15. What do you consider the most dangerous aspect of loss of control in flight?

DESCRIPTIONS AND INSTRUCTIONS FOR COMPLETEION OF URT FORMS

Form Name	Description and Purpose	When to Administer and to Whom	How to Administer and Explain
Participant Experience and Flight Time	-“Participant Experience and Flight Time” -To gather demographic and flight experience information from the participants to use in data analysis	-Participant completes prior to start of Training	-Send prior to training or have participant complete upon arrival -Instructions on form
Participant Survey #1	-“Self-Efficacy and Metacognitive Score #1” -Used to ascertain how well participants think they will perform and how they think about the task	-Participant completes just prior to Lear Pretest flight	-Hand form to participant after filling out informed consent
Participant Survey #2	-“Self-Efficacy and Metacognitive Score #2” -Used to ascertain how well participants think they performed and how they thought about the task	-Participant completes just after Lear Pretest flight	-Hand form to participant at the end of Pretest Lear flight
Participant Procedures Survey	-“Participant Knowledge Quiz” - Used to assess declarative and procedural knowledge regarding upset recoveries	-Participant completes after all academics	-Hand form to participant at the end of academics at “Research Slide” -Explain per “notes” on slide

Form Name	Description and Purpose	When to Administer and to Whom	How to Administer and Explain
Lear Instructor Card #1	-"Lear Instructor Card Pretest" -Used to gather information on anxiety level and pilot performance on pretest upset maneuvers during Lear flight	-Instructor completes after Lear Pretest flight (immediately after Lear flight)	
Upset Recovery Quality Rating Scale	-"Beginning Upset Recovery Quality Rating Scale" -Used to evaluate quality of upset recoveries	-Participant completes (with Instructor assistance) before Lear Pretest flight	-Per instructions attached to forms
Upset Recovery Quality Rating Scale	-"Ending Upset Recovery Quality Rating Scale" -Used to evaluate quality of upset recoveries	-Participant completes (with Instructor assistance) after each Lear flight	-Per instructions attached to forms
Lear Instructor Survey	-Lear "Situational Awareness Linked Instances Adapted to Novel Tasks" (SALIANT), mindfulness measure -Used to gather information on the pilot's situation awareness during the flight	-Instructor completes just after each Lear flight	-Per instructions attached to forms
Upset Recovery Training Program Survey	-"Upset Recovery Training Program Evaluation Survey" -Used to gather pilot perceptions and opinions on all elements of the URT program	-Participant completes after all training activities are complete or returns via mail	-Hand form to participant and ask to fill out now or return in envelope -Stress the importance of this information to the program
Debriefing Survey	-"Experimenter Debriefing Survey" -Used to gather additional information regarding retention of training and views on loss of control	-Experimenter verbally administers to participant after all training activities are complete or via telephone	
DVD	-Audio and video recording of the computer generated instrument display in Learjet -Used for data extraction after flight	-Archive with data	
CD-ROM	-Flight history - Records parameters such as attitude, airspeed, altitude, control surfaces, pilot control inputs, and control law values at 100 frames per second.	-Archive with data	

APPENDIX C: EXPERIMENTAL PROTOCOL

Expertise and Unexpected Events Research Project

Procedure Overview

The current Upset Recovery Training (URT) program offered by the Flight Research Training Center under contract to the Federal Aviation Administration is continually monitored and revised to maximize training effectiveness. The purpose of this customized protocol is to address the specific training needs of the all-cargo airline and collect the data necessary to refine the course elements for this target pilot population. This protocol incorporates the training and data collection aspects of the current URT protocol under FAA Contract No. 6647-1. The methodology and events selected for this protocol were determined through initial analysis of existing URT study data and the review of loss-of-control accident and incident data.

Training Condition

Table 1 displays the order of training and the evaluation events for this customized protocol. The content, description, and presentation of the training and evaluation events and associated performance measures are presented in detail in Table 2. The majority of the performance measures and data to be collected are as discussed in the original experimental design of the URT program. In addition, repeated measures of self-efficacy and metacognition will be collected (Participant Performance Questionnaire). Instructor real time objective and subjective measures will also be recorded during the evaluation flights. The instruments and forms to be used in this calibration study are displayed in Appendix B.

Table 1

Order of Training and Evaluation Activities by Condition

ORDER OF ACTIVITY / **CONDITION**	**1**	**2**	**3**	**4**	**5**	**6**
All Trainees	Lear Pretest	Academics (Bonanza Briefing) I	Bonanza	Academics (Lear Briefing) II	Ground Simulator	Lear Training/ Lear Posttest I

Table 2

Content of Training and Evaluation Activities with Associated Performance Measures

Activity	**Content**	**Performance Measures**
Lear Pre-Brief	Safety briefing for Lear Pretest	
Lear Pretest	At altitude, participants will experience three upset events; 1) Nose up trim failure 2) Aileron failure (hardover) 3) Rudder failure (hardover)	- Pretest Self-Efficacy and Metacognition Scale - Instructor Performance Rating (Reaction Time, Success in Recovery, Stress Indices) - Situation Awareness Rating - Recovery Quality Rating Scale - Postflight Self-Efficacy and Metacognition Scale - Flight Performance Parameters
Academics I (Bonanza Briefing)	1) Causes of upsets 2) Aerodynamic fundamentals 3) Recovery techniques	
Bonanza Flight	1) Stalls 2) Unusual attitudes 3) Accelerated flight	- Instructor performance rating
Academics II (Lear Briefing)	1) Causes of upsets 2) Aerodynamic fundamentals 3) Recovery techniques	- Declarative Knowledge Quiz on Upset Recoveries
Ground Simulator Training	1) Introduction to upsets 2) Practice in recovery techniques	
Lear Training	1) Real world experience of upsets 2) Practice in recovery from a variety of upsets	
Lear Posttest I	At altitude, participants will experience three upset events;	- Pretest Self-Efficacy and Metacognition Scale

	1) Aileron failure (hardover) 2) Nose up trim failure 3) Rudder failure (hardover)	- Instructor Performance Rating (Reaction Time, Success in Recovery, Stress Indices) - Situation Awareness Rating - Recovery Quality Rating Scale - Postflight Self-Efficacy and Metacognition Scale - Flight Performance Parameters

Flight Profile Standardization

The flight profiles are standardized by utilizing scripted scenarios and calibrated computer generated events in the IFS. The instructor pilot administers the protocol in a uniform manner across participants and IFS events. Any deviations from the scripted protocol will be noted on the Instructor’s Evaluation Card. The study administrator will also monitor the consistency of the training and evaluation events.

NOTE: The order of activities will vary dependant on the participant’s experimental condition.

1) Review participant folder for completeness including:
    a) Informed Consent Form
    b) Pilot Demographic Form
    c) Pilot Flight Time Form
    d) Experimenters’ Checklist
    e) Participant Performance Questionnaire #1
    f) Participant Performance Questionnaire #2
    g) Participant Performance Questionnaire #3
    h) Participant Performance Questionnaire #4
    i) Situation Awareness (SALIANT) Form #1
    j) Situation Awareness (SALIANT) Form #2
    k) Instructor’s Lear Evaluation Card #1
    l) Instructor’s Lear Evaluation Card #2
    m) Instructor’s Bonanza Evaluation Card
    n) Recovery Quality Rating Scale #1
    o) Recovery Quality Rating Scale #2
    p) Flight Releases (1-4)
    q) Program Evaluation Survey
    r) Experimenter’s Debriefing Form

2) Have participant fill out the Informed Consent forms, Pilot Demographic Form, and Pilot Flight Time Form.

3) Make copy of pilot certificates, driver’s license, and medical certificate.

4) Administer Participant Performance Questionnaire #1. While participant completes this, check over demographic and flight time forms for complete information. If information appears to be missing, query participant.

5) Present study introduction from transcript.

Study Introduction Transcript

Thank you for your participation in the URT program. As you know, we are constantly evaluating the components of the training; therefore, your training may occur in a slightly different order than other participants. You will complete all phases of the program and indeed will have the opportunity to fly the Lear more than once. Today, we will take a short flight in the Lear as an introduction to the training program. Once we are at altitude, you will have the opportunity to fly the IFS and experience a few of the upsets.

6) Administer Participant Performance Questionnaire #1 to participant.

7) Learjet Evaluation Briefing (per program).

8) Lear flight - Administer Lear Pretest protocol as printed on Instructor's Lear Evaluation Card #1 and complete Instructor's Lear Evaluation Card #1.

9) Administer Recovery Quality Rating Scale #1 to participant.

10) Administer Participant Performance Questionnaire #2 to participant.

11) Instructor completes Situation Awareness Form #1.

12) Academics I – Bonanza briefing (per program).

13) Bonanza flight (per program); complete Instructor's Bonanza Evaluation Card.

14) Academics II – Lear briefing (per program).

15) Administer knowledge quiz.

16) Ground simulator training (per program).

17) Administer Participant Performance Questionnaire #3 to participant.

18) Lear flight II; Administer Lear training (per program) followed by Lear Posttest I protocol as printed on Instructor's Lear Evaluation Card #2 and complete Instructor's Lear Evaluation Card #2.

19) Administer Recovery Quality Rating Scale #2 to participant.

20) Administer Participant Performance Questionnaire #4 to participant.

21) Instructor completes Situation Awareness Form #2.

22) Administer Program Evaluation Survey; encourage comments.

Experimenter's debriefing form completed.

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