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COGNITIVE FLEXIBILITY: USING MENTAL SIMULATION TO IMPROVE
SCRIPT ADAPTATION

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in Modeling and Simulation
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ABSTRACT

Human behavior and decision-making depend largely on past experiences that generate specific action patterns (i.e., scripts, Gioia & Manz, 1985) for specific situations. In an ideal world, in which changes in the environment do not conflict with these action patterns, humans would be able to operate consistently, efficiently, and automatically. However, real-world environments are dynamic and fluid, thus altering behavior and forcing changes in scripts. Research suggests that to implement alternate solutions to changing situations, humans select from a “library” of learned scripts. Since humans tend to implement scripts to the degree that these are successful over a period of time, implementing alternate scripts can be difficult. That is, unless one has the *cognitive flexibility* to adapt scripts, implementing a new solution to a problem can be difficult and/or unsuccessful. Cognitive flexibility allows one to restructure knowledge to form an adaptive response to changes set forth by the environment.

At issue is the difference between possessing a repertoire of scripts that can be selected and implemented to solve a problem, and having the cognitive flexibility to effectively *switch* between scripts when a change in context occurs. The purpose of this dissertation is to: (a) evaluate the effectiveness of *possessing alternate scripts* to respond to situations, and (b) assess the effectiveness of cognitive flexibility training on the *ability to switch between scripts*. The ultimate goal is to improve mental flexibility in situations where a specific approach should be revised and adjusted to conform to changes in context. A total of 48 participants were randomly assigned to one of four conditions in a 2 (number of scripts) x 2 (training present or absent) design: (a) single script, (b) single script and cognitive flexibility training, (c) two scripts, and (d) two scripts and cognitive flexibility training. Participants either learned one script or two scripts

on how to respond to a car engine overheat. In addition, depending on the study condition, participants completed a cognitive flexibility training that used a mental simulation approach. The cognitive flexibility training was intended to allow participants to imagine a number of different scenarios that may impact that task, evaluate assumptions, check assumptions against the situation, imagine a response to such scenarios, and review the effectiveness of the developed solutions. The results of this research suggested that for situations requiring a change or an adaptation to an alternate script, possessing two scripts facilitated correct decision-making, whereas cognitive flexibility training may have hindered decision-making. In addition, for situations requiring a standard script, possessing two scripts was detrimental to decision-making performance, regardless of cognitive flexibility training. Theoretical implications in terms of script-processing and cognitive flexibility, as well as practical implications for training design are provided.

To my parents, who encouraged me to strive for excellence.

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CHAPTER ONE: INTRODUCTION

Statement of the Problem

Human behavior and decision-making depend largely on past experiences that generate specific action patterns (i.e., scripts, Gioia & Manz, 1985) for specific situations. In an ideal world, in which changes in the environment do not conflict with these action patterns, humans would be able to operate consistently, efficiently, and automatically. However, real-world environments are dynamic and fluid, thus requiring the alteration of behavior and forcing changes in action patterns. For instance, a driver can identify the easiest and most efficient path to get to and from work. This path may be used continuously over time, until a change in the environment (e.g., roadblock, road closure, or construction) forces the driver to change the typical action pattern or script. That is, the change in the environment should prompt the individual to recognize that a change has occurred, and an alternative solution should be implemented.

Research suggests that to implement alternate solutions, experts select from a pre-set “library” of learned experiences that can be matched to a current situation (Klein, 1998). As a result, this repertoire of mental representations (i.e., scripts) facilitates adaptation to changes set by the environment. That is, the more scripts one has, the more options are available for responses and decision-making (Kochan, 2005). Others, however, have argued that the complex nature of dynamic environments can make the implementation of “precompiled” scripts inappropriate (Spiro, Feltovich, Jacobson, & Coulson, 1991). In addition, studies have found that experts have more difficulty in adapting to changes in comparison to novices due to an increase in the “strength” of their actual scripts (Kochan, 2005). In fact, studies by Meyer, Reizenstein,

and Schützwohl (1997) and Schützwohl (1998) found that the more successful a solution is in a given environment, the more difficult it becomes to revise it when a change in the environment occurs; especially if the change is task-relevant. For instance, the action script for uphill parking (on the right of the street) requires one to turn the front wheels away from the curb (i.e., turn the steering wheel to the left) so that the rear part of the tires can rest against the curb, using it as a block to prevent the car from rolling into traffic. If the action script in this example is performed successfully over a period of time, the script for uphill parking becomes stronger (i.e., every time uphill parking is required, the same script will be implemented). However, if the same situation occurs without a curb in place, the action of turning the wheels away from the curb ceases to work. If this script is implemented in this alternate scenario, the car is likely to roll into traffic because the tires are not resting against a block. Instead, the correct action in this situation is to turn the front wheels towards the right so that if the car were to roll back, it would roll away from traffic. The continual use of the same script when a change in context has occurred is related to *maladaptive routines* (Bröder & Schiffer, 2006), which are behavior sequences that were at one point in time efficient solutions to a problem but became inefficient when the problem was presented in a different context.

As shown above, in daily life situations, humans are likely to implement solutions to the degree to which these solutions have been successful over time. As such, when changes in context occur, it becomes more difficult to switch to alternate solutions because an overreliance towards a standard solution has been developed. One key component of optimal decision-making is the ability to recognize a change, and having the *cognitive flexibility* to adapt scripts in order to implement a new solution to a problem. Cognitive flexibility has been defined as the ability to

“restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands” (Spiro & Jehng, 1990, p. 165). Put more simply, cognitive flexibility is “the human ability to adapt cognitive processing strategies to new and unexpected conditions in the environment” (Cañas, Antolí, Fajardo, & Salmerón, 2005, p. 95). At issue is the difference between possessing a repertoire of scripts from which to select one and implement it to solve a problem, and the ability to effectively *switch* between scripts when a change in context occurs. That is, how useful is it to possess a repertoire of scripts if the flexibility to switch from one to another does not exist? In addition, if a repertoire of scripts does not exist, can cognitive flexibility training facilitate the restructuring of a current script as a solution to match the changing demands of the environment? Reder and Schunn (1999) have found that better performance in dynamic environments is achieved by having the flexibility to adapt strategies to changes in the environment, and not by possessing a repertoire of strategies. Only a limited amount of research has attempted to understand this issue, and research has yet to investigate the relationship between scripts and cognitive flexibility. As such, the following research questions are put forth:

(RQ1) Does possessing a repertoire of scripts facilitate adaptation to changes in the environment if cognitive flexibility training is provided (i.e., if the ability to switch between these scripts is learned)?

(RQ2) Is simply owning one script and having an understanding that the script may fail, or may need to be revised in a different context (through cognitive flexibility training), enough to avoid overreliance to one standard solution?

(RQ3) What is the cost of cognitive flexibility? Could switching ability negatively affect decision-making when a standard script is required (no switch needed)?

Purpose of this Study

To address the aforementioned research questions, this study investigated the relationship between the theories of script-processing and cognitive flexibility. To this end, I chose script-processing theory since it involves mental knowledge structures that play a large role in activating specific behaviors that are then applied to certain situations (Abelson, 1981). When scripts for certain types of situations are not available, adequate response behaviors may not be elicited. If, however, alternate scripts are stored in memory, an individual may be able to select an appropriate response. As such, it is expected that learning additional alternate scripts can influence adaptation to changes in the environment. In addition, it is expected that cognitive flexibility training will facilitate the ability to effectively switch between scripts and, as a result, avoid intransigence towards alternate, more appropriate solutions.

The idea behind cognitive flexibility is that “revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition” (Spiro, Feltovich, Jacobson, & Coulson, 1992, p. 65). One cost-effective method to achieve cognitive flexibility is to train using mental simulation. Mental simulation refers to the mental act of simulating events, either in the past or in the future, for planning or problem solving purposes (Taylor & Schneider, 1989). Not to be confused with mental practice which focuses on the rehearsal of a response action without the use of body movements (Richardson, 1969), mental simulation allows for “the construction of hypothetical scenarios and the reconstruction of real ones” (Taylor & Pham,

1994, p. 219). That is, mental simulation allows an individual to anticipate the future (i.e., imagine what and how something will happen in the future), such as anticipating sports matches or business meetings (Sanna, 2000). Mental simulation has shown benefits in areas such as education (Pham & Taylor, 1997), motor behavior (Decety & Ingvar, 1990; Decety, Jeannerod, Durozard, & Baverel, 1993), and naturalistic decision-making (Klein, 1998). To train for cognitive flexibility, this study used a type of mental simulation that asked participants to imagine that a specific script has failed (i.e., *premortem method*, Klein, 2007), and thus force them to generate plausible reasons for why the script failed. As a result, cognitive flexibility training should allow participants to mentally visualize a script from different perspectives and contexts, and improve their ability to recognize the need to switch to an alternative script when changes in the environment prompt a change in behavior.

In summary, the purpose of this dissertation was to: (a) evaluate the effectiveness of *possessing alternate scripts* to respond to situations, and (b) assess the effectiveness of cognitive flexibility training on the *ability to switch between scripts*. The ultimate goal was to improve mental flexibility in situations where a specific approach should be revised and adjusted to conform to changes in context.

CHAPTER TWO: LITERATURE REVIEW

To provide further clarity on the theoretical foundation of this dissertation, I next discuss the constructs of scripts, cognitive flexibility, and mental simulation in more detail. In the literature, these constructs may possess multiple connotations. Therefore, the definitions and information provided in the following paragraphs are intended to represent the context and scope of this dissertation. First, I discuss the theory of script-processing and its implications on response behaviors. Second, I discuss the theory of cognitive flexibility and how it can be implemented as a means of training in the form of mental simulation to facilitate script switching when changes in context occur.

Script-Processing Theory

In the literature, the terms schemas, mental models, and scripts are used to describe mental knowledge structures that are used to organize and interpret information received from the environment. However, a closer look into these concepts reveals that although related, there are some fine distinctions between them. A schema is an individual's knowledge structure which is activated by a stimulus and *helps comprehend* current situations/events (Meyer et al., 1991; Rumelhart, 1984). Mental models involve conceptual representations that support knowledge about how a system or situation works (Sein & Bostrom, 1989). This understanding *allows humans to make predictions about the future states* of the system or situation (Gentner, 2002; Rouse, Cannon-Bowers, & Salas, 1992). In contrast to schemas and mental models, *scripts* are defined as conceptual representations of *event sequences held in memory* that are *activated for specific behaviors* that are appropriate for specific situations (Abelson, 1981; Gioia & Poole, 1984). Gioia and Poole argued that, in contrast to schemas (which interpret information, actions,

and expectations), scripts allow individuals to understand situations and provide a guide on how to *behave* appropriately in a situation. For example, during takeoff, pilots invoke a “climb to an initial altitude” schema. This event has not yet occurred, but it is expected to happen at some point during takeoff. Thus, the action of setting an altitude becomes a script that is activated once the aircraft is ascending. Given that the purpose of this dissertation is to understand how humans behave when environmental changes occur, scripts were chosen as the construct of study.

As mentioned before, *scripts* are conceptual representations that are activated to guide behavior in specific situations (Gioia & Poole, 1984; Gioia & Manz, 1985). As such, script-processing theory has been used in cognitive psychology to explain how behavior is guided based on a certain stimulus (Anderson, 1983; Gioia & Poole, 1984). Abelson (1981) argued that scripted behavior occurs when: (a) an individual has a stable cognitive representation of a particular script (based on previous experiences), (b) an evoking context for the script exists (i.e., a stimulus), and (c) the individual “enters” the script (i.e., decides to use the script). For instance, a morning drive to work may invoke a variety of scripts, depending upon how early/late one is for work. Based on previous experiences the individual has a stable cognitive representation on which streets, lanes, or back roads are the most efficient to ensure on-time arrival to work. In this example, on-time arrival to work is the evoking context that activates the script for the most efficient path to work. The individual then decides on which script to use by selecting the appropriate script for the situation, and consequently behaves in a manner that conforms to the appropriate action. If the traffic route in this script unexpectedly deviates from that cognitive representation (e.g., roadblocks, traffic accidents, weather conditions), the script may need to be revised.

Scripts and the RPD Model

The Recognition-Primed Decision (RPD) model of decision-making (Klein, 1989, 1998; Klein, Calderwood, & Clinton-Cirocco, 1986; Klein & Crandall, 1995) is a descriptive model that explains how experts are able to make decisions without comparing different options. According to the model, decisions are based on recognition by merging the processes of situational assessment and mental simulation (see Figure 1). That is, experts are able to assess a situation by generating a most feasible action sequence based on experience (i.e., scripts held in memory).

According to Klein and colleagues, the RPD model consists of three variations of decision-making. Variation 1 involves a simple case in which an event is recognized and a response is rapidly implemented (i.e., recognition match). Specifically, Variation 1 illustrates an instance in which a skilled decision-maker recognizes a situation to be one that was experienced in the past (i.e., scripts already stored in long-term memory). Thus, in this case, if an event is judged to be familiar or routine, the decision is quick and automatic (Phillips, Klein, & Sieck, 2004). However, not all events are familiar, as the environment can be presented in a different, unfamiliar context. This is the case in Variation 2, in which the decision maker needs additional information to understand the current situation because the situation may have not matched a typical situation already stored in memory (i.e., script not available). In these situations, humans tend to interrupt their responses to think about the situation, and generate a solution to the new problem. When a solution cannot be formulated and a script cannot be retrieved, humans may experience states of confusion or “cognitive freeze.” I describe the phenomenon of “cognitive freeze” and its relationship to scripts in the next section.

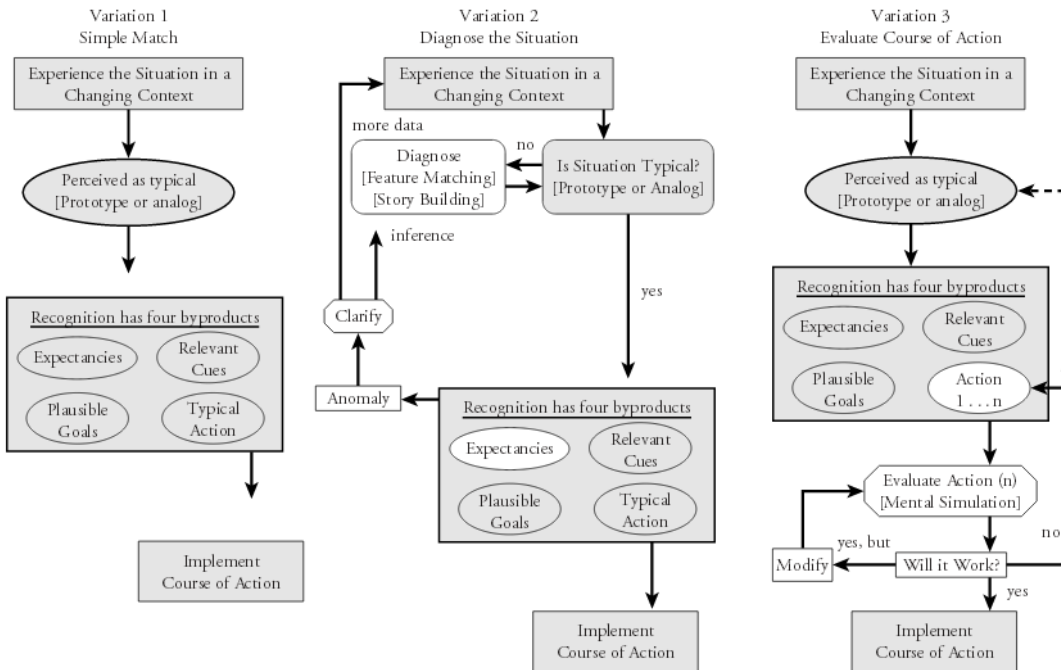


Figure 1. The RPD Model (adapted from Phillips et al., 2004).

Scripts and Cognitive Freeze

Changes in the environment can also block the ability to think and therefore respond effectively. In these cases, humans may experience “cognitive freeze,” which refers to an individual’s inability to retrieve an appropriate script that provides a solution to an unexpected and/or an emergency situation (Delahaij, Gaillard, & Soeters, 2006). In response to emergency situations, for instance, the human tendency to “cognitively freeze” involves a neuro-cognitive function, as well as a time required to process the steps between perception of the event and correct selection of response (Leach, 2004). Leach stated that the more complex a cognitive task is, the more neural support is needed, and hence, the longer will be the cognitive processing time.

To decrease cognitive processing time, individuals should have prepared responses that are based on what they have learned through training or past experiences. In turn, these

experiences can lead to faster selection of scripts and/or response sets. Conversely, individuals who do not have pre-set responses will need to create new scripts while simultaneously facing an emergency situation, and thus this prolongs effective responses necessary for survival (Leach, 2004). Leach proposed that during unexpected situations, response outcomes vary according to these three conditions: (a) if an appropriate response/script has already been created, previously prepared, and/or trained, responses can be delivered quickly (100 ms), (b) if various responses/scripts are available, selecting the correct behavior can take up to 1-2 s, and (c) if no responses/scripts exist in one's cognitive database, then a new script must be created, which can take up to 8 s to 10 s under "optimal circumstances," or longer, during more severe conditions. When scripts are not available, the human physiological response can therefore result in the state of being stunned, shocked, freeze, or cognitively paralyzed.

Scripts stored in a mental database need, therefore, to match the required behavior based on a specific situation. Typically, the environment requires a standard script, which is defined as the consistent script normally implemented in a given situation. However, decisions can be altered given the situational requirements set by the environment. That is, although a standard script is typically the one required, changes in the environment may prompt the implementation of an alternate script (i.e., a switch to an alternate script). Possessing both a standard script and an alternate script can aid decision-making when a change in script is required. Nevertheless, possessing both types of scripts can interfere in situations where just the standard script is required since the incorrect script may be selected. Based on this logic, the following hypothesis is put forth:

Hypothesis 1. There will be an interaction between script quantity and situational requirement (standard script vs. alternate script). Specifically, participants who learn two scripts

(standard and alternate) will perform better on test items that require a switch to an alternate script than participants who learn a single script. In contrast, participants who learn a single script will perform better on test items that require maintaining a standard script.

In summary, scripts are conceptual representations of action sequences that are activated based on a stimulus, and therefore help us guide behavior. The larger the script database, the more automatically a situation is judged as familiar. When a script is not available, the individual must then revise the current script or create a new script which could prolong responses execution. As such, possessing a database of scripts gives one the ability to quickly match a script to a situation.

Cognitive Flexibility

As noted in the previous section, individuals possess scripts that guide actions in a given context. Having many scripts stored in one's memory database can be beneficial in situations where a relevant change in context has occurred and an appropriate alternate script is available to be selected from the mental database. However, having a large database of scripts is only helpful if one has the ability to effectively switch to a correct alternate script, as switching to an incorrect script could yield an unwanted outcome. Therefore, individuals who have the ability to correctly switch to an alternate script or adapt one script to form a new solution are more "cognitive flexible" when it comes to responding to situations that change in context.

Cognitive flexibility is defined as having the mental capacity to rapidly revise a response in order to adapt to unforeseen situations (Spiro, Coulson, Feltovich, & Anderson, 1988). That is, humans who are cognitively flexible can "restructure ... [their] knowledge, in many ways, in adaptive response to radically changing situational demands" (Spiro & Jehng, 1990, p. 165).

Before discussing cognitive flexibility in more detail, it is necessary to briefly mention that the concept is related to adaptive flexibility (Duchesne, 1997), adaptive expertise (Hatano & Inagaki, 1981), and the theory of cognitive transformation (Klein & Baxter, 2006).

Adaptive flexibility is the ability to respond flexibly to change (Kolb, 1984). Individuals who are high in adaptive flexibility are labeled as “adaptive experts.” Adaptive experts are readily able to adapt to changing environmental demands (Duchesne, 1997). That is, they have the ability to easily solve previously encountered problems and generate solutions to new problems (Hatano & Inagaki, 1986). This is different from *routine expertise*, which is the ability to automatically execute standard procedures in a given task. For example, Hatano and Inagaki (1986) discussed how, in home cooking, an individual can become a routine expert by using the same standard materials described in a recipe to make a dinner. However, when these materials are not available, a routine expert may not know how to adapt the routine based on the materials that are available at that given time. As such, according to Hatano and Inagaki, when a skill is developed through the repetitive application of a standard procedure, adaptive expertise is not achieved. In contrast, if the skill is repeatedly applied with variations (i.e., situational randomness), it is more likely to lead to adaptive expertise. Based on these definitions, adaptive flexibility and adaptive expertise are essentially the same as cognitive flexibility, except that adaptive expertise is more focused on how experts adapt to changes.

Cognitive transformation theory centers on shedding mental models and adopting new ones, instead of adding more knowledge to an individual’s cognitive database (Klein & Baxter, 2006). Klein and Baxter suggested that mental models get “harder” to disconfirm as one develops more expertise. When anomalies occur, individuals need to shed these “hard” mental models and transform them with new ones. As such, previous mental models can act as barriers

to understanding changes in situations, resulting in mental inflexibility. Instead of scripts, cognitive transformation theory is more focused on mental models and, therefore, I chose not to utilize the theory for this study.

Cognitive Flexibility: Background

Research on cognitive flexibility dates back to the 1940s, and focused initially on one's inability to modify thought processes even when more adequate solutions were available (also called the Einstellung-effects). The Einstellung-effects were investigated by Luchins (1942) and Luchins and Luchins (1959), by having individuals solve water jug problems. The studies showed that after experiencing a successful solution to a series of problems, individuals continued to use the same solution even when simpler solutions were available to new problems. Individuals who show an ability to revise their solutions are identified as cognitively flexible, and they typically use inductive reasoning, think "outside-the-box," and tend to be more creative in generating solutions (De Dreu, Nijstad, & Baas, 2011; Guilford, 1959).

Cognitive flexibility has been studied extensively in child development, in order to explore differences in cognitive development and to understand at what age children become more mentally flexible (Chevalier & Blaye, 2008; Deak, 2003). For instance, the Dimensional Change Card Sorting Task (DCCS) is designed for children, and its purpose is to have children sort cards based on different dimensions. First, children are asked to sort the cards based on a single dimension (e.g., color). Sequentially, the children are asked to sort the cards based on another dimension such as shape (Müller, Steven Dick, Gela, Overton, & Zelazo, 2006). When it comes to sorting the cards based on the new dimension (shape), three-year-old children are

unable to make the switch, while five-year-olds are able to switch to the new dimension (Kirkham, Cruess, & Diamond, 2003).

In addition to child development, cognitive flexibility has also been explored in clinical psychology as being a factor in mental health issues such as autism (Van Eylen et al., 2011), eating disorders (Tchanturia et al., 2012), schizophrenia (Delahunty, Morice, & Frost, 1993), and obsessive-compulsive disorder (Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006). Individuals with these mental health issues have been found to not have the flexibility to switch based on changing task demands. That is, these individuals tend to remain stuck in one task, and cannot allocate attention to changes in that task. Typically, card sorting tasks are used to assess the relationship between cognitive flexibility and these mental health issues. For instance, the Wisconsin Card Sorting Test (WCST) developed by Berg (1948) assesses someone's ability to adjust to altered rules by sorting cards according to dimensions. As described by Anderson, Damasio, Jones, and Tranel (1991), participants have to adapt their responses to the unexpected change in principle. Typically, individuals who struggle to adapt to the changes in principle are less cognitively flexible than the ones who can quickly adapt, change the strategy, and correctly sort the cards based on the new principle (even when the old strategy was successful over time). Therefore, this type of test can be used as a tool to measure if someone has the ability to adapt to changing situations in comparison to others.

Cognitive Flexibility and Script Strength

As alluded to before, humans typically rely on past successful experiences to guide action, and, therefore, they may exhibit a tendency to implement a solution even when that solution ceases to be correct (i.e., overreliance towards a standard solution). As a result, due to

the past success of a solution, the script becomes stronger, making it more difficult to revise when a change in the environment occurs. The phenomenon of script strength has been studied as a function of schemata, but the task discussed in these studies prompted participants to elicit a specific action based on a shown stimulus, and thus has also implications for scripts.

A script's strength tends to increase to the degree to which it has been implemented successfully in the past. Research on this concept has been conducted based on building a specific schema over a number of trials. Although the following studies evaluated response times based on schemata, the results have implications for script-processing. In their laboratory-based study, Meyer, Niepel, Rudolph, and Schützwohl (1991) asked participants to determine the position of a dot (relevant stimulus), which would appear either above or below two words (distractors). These words appeared simultaneously, one above the other, with the dot appearing at different intervals. If the dot appeared above the upper word, participants were instructed to click the left key on the keyboard. If the dot appeared below the word, participants were instructed to click the right key on the keyboard (action script). During the first 29 trials, the words appeared on a white background with black color font, which was to create a consistent schema of how words and dots would appear. Then, to produce a schema-discrepant event, the next trial (i.e., trial 30) presented one of the words in a photo-negative presentation, that is in white color font on a black background. Results indicated that the change in context (i.e., in this case, the white word on a black background) led to delays in reaction time (even when the change was task-irrelevant, i.e., the change occurred to the distractor items). Meyer et al. suggested that response time delays were due to participants analyzing the situation to decide if the change in context influenced their schema.

In a follow-up study, Meyer et al. (1997) used the same method as that described above (Meyer et al., 1991), except that the relevant stimulus (i.e., the dot) was manipulated to present a change in context (i.e., change was task-relevant). After 31 trials of participants responding to a black dot on a white background, participants were presented with a white dot on a black background. Results indicated that participants had a more pronounced response time delay in the trial in which the relevant stimuli was manipulated, as compared to an equivalent change in a distractor stimulus. These two studies show that after building and successfully implementing a specific schema over time, the strength of that schema increases. In turn, the strength of the schema delays responses to the changes, especially if the changes are task-relevant. Schützwohl (1998) corroborated these results, as he also found that participants who possessed strong schemata took longer to respond to an ongoing activity when an unexpected event occurred. As such, Schützwohl argued that the ability to rapidly switch schemata is contingent on the strength of the activated schema.

The aforementioned studies investigated response times based on schemata, but the results have implications for script-processing. It can be argued that a script was formed once the participants learned they needed to press a key every time a stimulus was presented. In turn, a script was created that triggered the action of pressing a key each time the stimulus was present. In all, if the participants had the flexibility to switch scripts and adapt to the unfamiliar situation, interruption delays would be less likely to occur. The ability to continually evaluate an event and revise action scripts is necessary towards successful adaptation to changes in the environment (Kochan, 2005).

In a similar context, studies have found that the strength of a set routine also influences flexibility and adaptation. Betsch, Haberstroh, Glöckner, Haar, and Fiedler (2001) manipulated decision routines in a micro-world simulation in which participants learned to develop a weak or strong routine. During learning, strong routines were developed after implementing a specific routine for 30 times, and weak routines were developed after implementing a specific routine for 15 times. The results showed that during testing, participants who developed a strong routine were less likely to adapt to changes in the environment that demanded a deviation from the current routine. In contrast, participants in the weak routine were less likely to maintain the learned routine, and were able to switch to a different routine based on the environmental changes.

Besides routines, researchers have explored the difficulty of adapting *strategies* to changes in situations. For instance, Bröder and Schiffer (2006) utilized a hypothetical stock market game, in which participants developed decision strategies. A change in payoff structure occurred after 80 decision trials, which should have prompted participants to switch their strategy and adapt to a more optimal strategy. The results indicated that when the change in payoff structure occurred, participants continued to rely on the success of the strategy used at the beginning of the task, even when the strategy ceased to be optimal. In related research, Cañas, Quesada, Antolí, and Fajardo (2003) investigated cognitive flexibility when developing a successful strategy in a complex problem-solving task. The results showed that after developing a successful strategy in consecutive trials, performance decreased when a change in the environment demanded an adjustment to the strategy. Furthermore, they found that performance decreased when the changes in the environment were relevant to the problem-solving strategy

developed. As such, it is likely that if participants were high in cognitive flexibility, they would be able to switch strategies based on environmental demands.

Cognitive Flexibility Training

The idea behind training is to learn new skills with the intent to apply them to specific contexts. Training is said to transfer when the learned skills and knowledge are maintained and generalized over a period of time (Salas & Cannon-Bowers, 2001). Furthermore, the trained skills and knowledge form scripts about how to respond to different situations. Realistically, the environment in which these scripts are applied can be unpredictable, and if the learned scripts are not adapted within that environment, performance can suffer. For instance, Cañas, Antolí, Fajardo, and Salmerón (2005) explored the effects of training on cognitive flexibility. In their study, participants were assigned to one of two training conditions: (a) constant training conditions (training in situations where no environmental changes occur), and (b) variable training condition (training in which exposure the parameters of the task constantly changed). It was expected that the participants in the constant training condition would have difficulty adapting to environmental changes presented in later trials, and show a tendency to continue to use the same strategy developed in earlier trials. Since participants in the variable condition were trained in variable environmental conditions, they were expected to have difficulties in developing a specific strategy. As a result, this lead to easier adaptation to new environmental conditions presented during later trials. The results showed that when training under constant conditions, participants were inflexible towards adapting their strategies (maintained their original developed strategy), while training under variable conditions facilitated the switch from one strategy to another. This finding is congruent to arguments by Hatano and Inagaki (1986)

and Spiro et al. (1992), who stated that if a skill is repeatedly applied with variations (i.e., at different times, in rearranged contexts, and from different perspectives), it is more likely to lead to adaptive abilities.

Premortem Mental Simulation as a Tool for Cognitive Flexibility Training

Mental simulation is an approach in which the pre-enactment of events takes place in the mind. That is, mental simulation calls upon the use of one's *imagination* to represent a past or future event unfolding over time. The term imagination refers to the capability of an individual to engage in mental activities that are necessary in order to visualize actions over a time continuum (Taylor, Pham, Rivkin, & Armor, 1998). For example, an athlete can use imagination to mentally visualize scoring a game-winning goal; a writer can imagine finishing a most anticipated manuscript; whereas a pilot can imagine the next procedural steps during aircraft descent. In fact, people tend to rehearse future events while engaged in routine activities such as showering, driving, or eating (Taylor & Schneider, 1989). Kahneman and Tversky (1982) explained that mental simulation gives one the ability to "mutate" or substitute an outcome with a hypothetical alternative outcome. This ability serves to modify the outcomes of past events into other differing outcomes (Wells & Gavanski, 1989). Likewise, this ability can be used to modify events that have yet to occur by providing a desirable outcome, or enabling a set of possibilities about the outcomes in a distant future (Taylor et al., 1998).

A *pre-mortem* mental simulation is an exercise technique in which mental simulation is used to improve decision-making, by imagining that a certain plan has failed (Klein, 2007). The idea focuses on generating plausible reasons for why a plan failed, instead of coming up with reasons why a plan might fail. According to Klein, a typical pre-mortem session begins after a

certain plan is developed. Then, a leader informs the team in charge of developing the plan that the plan has failed. As a result, the team has to identify reasons as to why the plan failed by imagining plausible problems with the developed plan. The purpose of this exercise is two-fold: First, the exercise allows individuals to understand that no matter how great a plan may be, it could still potentially fail. As a result, the exercise forces individuals to revise the plan by identifying areas that were initially weak and find new solutions to strengthen the overall plan. At the same time, the exercise keeps individuals from anchoring to one plan, which would make it difficult to see past future potential problems. Second, by imagining different plausible failure scenarios, the individual begins to build alternative solutions towards future problems. As such, the individuals can prepare to act effectively if such problems become real since they have already a stored representation of such an instance in memory.

Although one can learn the action sequence to develop a specific script, this sequence may be affected by the changing dynamics and varying complexities of unexpected situations in the environment. Given the impact that changes in standard contexts have on cognition performance (e.g., judgment, decision-making, and action-plan development), practicing pre-mortem exercises could foster preparedness. In turn, performance would improve as the individual would have the ability to select an appropriate response by efficiently switching between scripts. In comparison to merely knowing one or two scripts about a specific situation, cognitive flexibility training allows one to imagine a number of different scenarios that may impact that task, evaluate assumptions, check assumptions against the situation, imagine a response to such scenarios, and review the effectiveness of the developed solutions. In turn, this rehearsal should facilitate script flexibility and improve decision-making.

Two factors are reasoned to be instrumental when understanding the relationship between cognitive flexibility and performance. First, individual differences in cognitive flexibility can influence who could be more flexible in switching between scripts in dynamic situations. Individuals high in cognitive flexibility as evaluated by the Wisconsin Card Sorting Test, for example, can be predicted to perform better than individuals who are low in cognitive flexibility. Second, training can also impact cognitive flexibility and performance. Individuals who are trained to be more cognitively flexible are more likely to perform better at switching between scripts when a change in the environment occurs. What is not clear is if training can further improve performance for someone with cognitive flexibility. Alternatively, could training negatively affect performance? As such, the following hypotheses are put forth:

Hypothesis 2. There will be a significant positive relationship between cognitive flexibility and performance. Specifically, cognitive flexibility will help participants correctly switch between scripts based on changes in the environment.

Hypothesis 3. Individuals high in cognitive flexibility, as measured by the WCST, will obtain better performance outcomes than individuals low in cognitive flexibility.

Hypothesis 4. Flexibility training will improve cognitive flexibility and yield better performance outcomes.

Hypothesis 5. Flexibility training will moderate the relationship between pre-measured cognitive flexibility and cognitive flexibility. Specifically, flexibility training will not negatively affect the performance of individuals who have high cognitive flexibility (as pre-measured by the WCST).

Although cognitive flexibility can be beneficial in helping switch between scripts in situations that require an alternate script, it could be detrimental when a switch is not required. That is, when environmental changes are irrelevant, maintaining a standard script (instead of switching to an alternate) is the best solution (Sternberg & Powell, 1983). As such, in situations where a standard script is required, having cognitive flexibility could interfere with decision-making. As such, the following hypothesis is set forth:

Hypothesis 6. There will be an interaction between cognitive flexibility and the situational requirement (standard script vs. alternate script). Specifically, cognitive flexibility will facilitate performance on test items that require a switch to an alternate script than test items that require a standard script (no script switch required).

The quantity of learned scripts can also influence how cognitive flexibility facilitates performance. In situations where two scripts are learned (i.e., a standard and an alternate), and the situation calls for a switch to an alternate script, cognitive flexibility is most likely to facilitate performance. However, if a situation demands the use of a standard script, and two scripts are mentally available, then cognitive flexibility may interfere with decision-making. Therefore, having knowledge of a single script with low cognitive flexibility may be best when the situation requires a standard script. Based on this logic the following hypothesis is put forth:

Hypothesis 7. Depending on the quantity of scripts learned, having cognitive flexibility will result in better performance outcomes based on situational requirement (standard script required vs. alternate script required). That is, participants who learn a single script and are low in cognitive flexibility will perform better on test items that require a standard script in comparison to participants who learn two scripts and are either high or low in cognitive

flexibility. Participants who learn two scripts and are high in cognitive flexibility will perform better on test items that require a switch to an alternate script in comparison to participants who learn one script and are either high or low in cognitive flexibility.

Chapter Summary

Cognitive flexibility refers to an individual's ability to revise their way of thinking in order to adapt to changes in the environment. Typically, if a script has been successful over time, individuals may have difficulty revising or switching between to another script when a change occurs. As such, providing cognitive flexibility training that focuses on mentally simulating a script failing, while also imagining appropriate alternative solutions will facilitate script adaptation and improve cognitive readiness when a change in context occurs. Figures 2 captures the relationship between the study's constructs and the proposed hypotheses, with the intent to visualize their linkage.

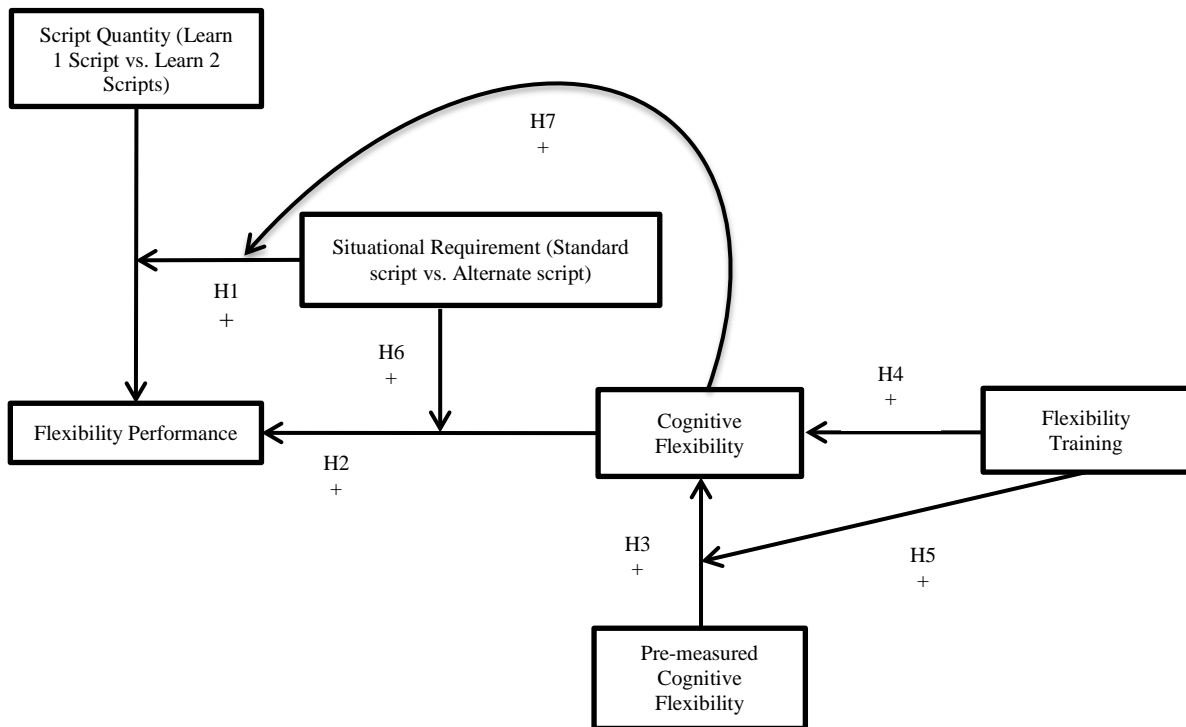


Figure 2. Relationship between constructs based on the proposed hypotheses.

CHAPTER THREE: METHODOLOGY

Participants

The participants for this study were 53 students recruited from the participant pool provided by the University of Central Florida's SONA Systems website. The SONA Systems website uses a pre-screening measure that students have to complete before participating in any study. For this study, students were screened for age and color deficiency in order that only participants who were 18 and older and not color deficient (self-reported) would be able to participate in this study. The students received course credit for their participation.

Of the 53 participants, three were excluded from the analysis because they exhibited symptoms of simulator sickness (e.g., nausea, dizziness, vertigo). Also, one participant was excluded because they continued to and began working on another section of the study without my approval, and another participant was excluded because she did not follow the safety instructions while driving (sped through the stops signs and red lights).

A power analysis was conducted to determine an adequate sample size based on a medium effect size (.25) at an alpha level of .05 with a power level of .8 (Faul, Erdfelder, Buchner, & Lang, 2009). The estimated sample size was 48 participants, 12 in each study condition (four total study conditions). The suggested sample size provided by the power analysis indicated that the final sample size of 48 participants was adequate to reach sufficient power. Of the 48 participants, 25 were male and 23 were female, with ages ranging from 18 to 32 years-old ($M_{age} = 19.52$). All of the participants had driven a car before, and all except one

participants had a valid driver’s license or permit. This participant claimed given that due to moving complications, he was in the process of obtaining his license.

Design

In order to test the effectiveness of cognitive flexibility training on decision-making, this study used a 2 Script Quantity Training (single script vs. two scripts) x 2 Flexibility Training (absent vs. present) x 2 Situational Requirement (standard script required vs. alternate script required) mixed-model factorial design. Flexibility training and script quantity training were the between-subjects independent variables (see Table 1). Situational requirement was the only within-subjects variable. The dependent variable was accuracy of selected script.

Table 1

Between-subjects independent variables

Script Quantity	Cognitive Flexibility Training	
	Absent	Present
Single Script	Single Script, Training Absent	Single Script, Training Present
Two Scripts	Two Scripts, Training Absent	Two Scripts, Training Present

Apparatus

The study was administered on a L3 Communications driving simulator for the testing portion of the experiment (Figure 3 and Figure 4).



Figure 3. L3 Communications driving simulator.



Figure 4. L3 Communications driving simulator.

Experimental Task

The task of driving is a fluid and dynamic process. As one accumulates driving experience, action scripts are formed, facilitating behavior and decision-making. Given that the environment plays a large role when executing driving decisions, one must be able to adapt to its changes. As such, the scripts developed while driving need to be adapted to the changes triggered by the dynamic driving process. For example, the standard script to fix an overheating car usually requires one to turn off the car and check the coolant. This script, however, is dependent on the type of coolant problem (overheating due to loss of coolant vs. overheating due to high load) and on outside temperature. For example, during high temperatures, the implementation of the standard script is not the most effective, as simply pulling to the side of the road while leaving the engine running is the most effective solution. Having a large database of alternative scripts can help in this type of decision-making, but having the flexibility to adapt to situations that deviate from a standard solution could improve decision-making.

Materials and Measures

Informed Consent

Participants were greeted at the experiment facility and then given an informed consent form. This form explained to the participant the purpose of the study, as well as any risks associated with participating in the study. Participants were told that their participation in the study was strictly voluntary and that they could decline or withdraw from participation at any point of the study.

Pre-Training Measures

Before engaging in their assigned study condition, participants completed several individual difference measures. The first measure was the demographics data form, which included questions regarding age, gender, driving experience, and gaming/simulation experience. Then, participants completed the WCST (Berg, 1948), which assesses an individual's ability to adjust to altered rules by sorting cards according to dimensions (see Appendix E). In addition, before training, the Mental Imagery Questionnaire was administered to assess the participants' imagery ability (cf. Jentsch, 1997). Given that spatial ability has been found to be highly correlated with the ability to perform mental simulations to solve problems (Hegarty & Sims, 1994), the Guilford & Zimmerman Spatial Visualization Test (Guilford & Zimmerman, 1948) was also administered.

Performance Measure (Driving Scenarios)

The performance measure was composed of a set of 13 driving scenarios involving an overheating car. These scenarios varied in situational requirement (the requirement of a standard script or an alternate script). The situational requirement in each scenario prompted participants to select the correct script based on the visually perceived environmental conditions. Before these 13 scenarios, participants completed two practice sessions in order to help them become more familiar with the car simulator (e.g., steering wheel, brakes, speed, etc.). After the completion of these practice sessions, participants were presented with eight trials of car overheating scenarios that required a standard script with the intent to build a consistent, strong, and successful script. The next scenarios involved overheating scenarios that required a standard script and an alternate script (change in environment that requires an alternate set of actions).

Specifically, Scenarios 9 and 11 required the implementation of the alternate script, while Scenarios 10 and 12 required the implementation of a standard script. A last scenario was presented which involved a unique situation that required a different type of script not learned in the script tutorials (i.e., neither the standard nor the alternate script). After Scenarios 6 and 13, participants completed the Simulator Sickness Questionnaire (Kennedy, Lane, Berbaum, & Lilienthal, 1993, see Appendix L) in order to assess if participants had symptoms of simulator sickness (e.g., nausea, vertigo, dizziness, etc.).

Participants were videotaped to record their actions during the simulation (e.g., turning off A/C, moving to the side of the road, parking, and turning off the engine, etc.). For each scenario, the engine overheat was triggered at different locations to avoid expectancy and the ability to predict at which point the engine overheat would occur (see Appendix K). However, every participant completed the same scenarios, in the same order. In addition, if the participant did not realize that the engine had overheated (based on the engine temperature increase), an auditory alert would be triggered. If this alert was ignored, the engine would consequently fail, and the scenario would come to an end. Pre-established auditory directions guided participants as they drove around in the simulation. Next, the overheating car scenario is discussed in more detail.

Responding to an Overheating Car

The script to effectively respond to an overheating car is first determined by the type of coolant problem (overheating due to loss of coolant vs. overheating due to high load) and by ambient temperature. When a car is overheating, the temperature gauge will increase towards the “hot area,” and steam may be seen emerging from the hood (see Figure 5). In instances in which

the car is traveling with low load during low ambient temperature conditions, the failure is likely a loss of coolant, a blockage of the coolant lines, or a failure of the coolant pump. Since most people travel with low load during normal ambient temperature conditions, these instances are the most typical to occur. As such, these instances require the standard script which involves the following action steps: (a) turning off the A/C, (b) pulling over to the side of the road and parking, and (c) turning off the engine. In instances in which the car is traveling in high ambient temperature conditions, while also exerting more energy due to high load, but not involving any of the failures above, the alternative script is required. Since these instances do not occur often, these instances therefore require an alternate script. The alternate script involves the following: (a) turning off the A/C, (b) pulling over to the side of the road and parking, and (c) keep the engine running (to circulate coolant through the system as one waits for the car to cool down).

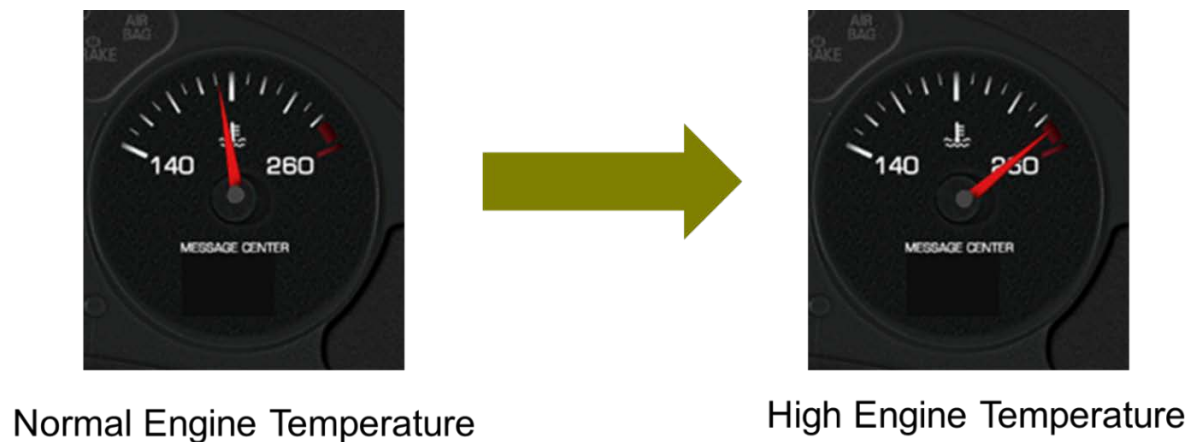


Figure 5. Example of normal vs. high engine temperature.

Post-Testing Measures

After completion of the performance measure, a training reactions questionnaire was administered (adapted from Jentsch, 1997). Specifically, the training reactions questionnaire was composed of 10 items to which participants indicated their level of agreement on a 6-point Likert

scale (1 = strongly disagree, 6 = strongly agree) about the efficacy of the completed mental simulation training (see Appendix D). In addition, participants completed a self-efficacy questionnaire adapted from Kochan (2005). Specifically, this self-efficacy questionnaire was composed of 10 items to which the participants indicated their level of agreement on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree) about how well they perceived they performed on the performance task (see Appendix M).

Study Conditions

Participants were randomly assigned to one of four study conditions, in a 2 (number of scripts) x 2 (training present or absent) design: (a) single script, (b) single script and cognitive flexibility training, (c) two scripts, and (d) two scripts and cognitive flexibility training.

Single Script

Participants assigned to the “single script” condition were trained on only the standard script on how to respond to an overheating car (see Appendix F). Specifically, participants completed a self-paced tutorial presentation in which they learned the following standard script: (a) turning off the A/C, (b) pulling over to the side of the road, and (c) turning off the engine.

Single Script and Cognitive Flexibility

Participants assigned to the “single script and cognitive flexibility training” condition were exposed to learning the standard script. As such, participants completed a self-paced tutorial presentation in which they learned the following standard script: (a) turning off the A/C, (b) pulling over to the side of the road, and (c) turning off the engine. In addition, participants engaged in a mental simulation technique which required them to imagine a situation in which they enter different types of restaurants (see Appendix H). A restaurant setting was chosen due

the relative ease with which participants would be able to remember the action steps to make effective decisions, and also because it was unrelated to driving.

For the cognitive flexibility training, participants were asked to imagine how they would respond if they entered what appeared from the outside architecture to be a high-end, “5-star” restaurant, but inside, this restaurant appeared to have mixed characteristics of both a high-end and a fast food restaurant. In this case, implementing the “5-star” restaurant script is ineffective, and, therefore, participants should adapt to the new environment by evaluating their assumptions and checking those assumptions against the current environment. Participants were briefed about the availability and description of certain items (e.g., menus, sit-down tables, cash registers, waiting area, etc.) and people (e.g., host, server, cooks, etc.). With this information, participants were given five minutes to determine a course of action. After the five minutes, participants were asked about their assumptions and decisions in the task with the following questions:

- Why did you respond in that way?
- What were your assumptions about the situation?
- What is your biggest concern about your plan of action?
- What items from the briefing were important to you and why?
- What would you have done differently if other stimuli was present or not present?

Two Scripts

Participants assigned to the “two scripts” condition received instruction on both the standard script (as described in the single script condition) and an alternate script (i.e., how to respond to an overheat occurring because of high load) - see Appendix G. Specifically,

participants learned the following alternate script: (a) turning off the A/C, (b) pulling over to the side of the road, (c) keep the engine running (as one waits while the car cools down).

Two Scripts and Cognitive Flexibility

Participants assigned to the “two scripts and cognitive flexibility training” condition received instruction on both the standard script and alternate script on how to respond to an overheating car, as detailed in the other conditions. After learning the scripts, participants engaged in the same mental simulation scenario as participants in the “single script and cognitive flexibility” condition.

Declarative Knowledge Test

After completing their assigned conditions, participants completed a declarative knowledge test with the intent to measure if the participants acquired the information presented during the script tutorial sessions (see Appendix I and J).

Procedure

After arrival, participants were randomly assigned to one of four conditions: (a) single script, (b) single script and cognitive flexibility training, (c) two scripts, and (d) two scripts and cognitive flexibility training. Participants then read the informed consent and completed the demographics questionnaire and pre-training measure tests of cognitive flexibility, spatial ability, and mental imagery. Then, participants completed their assigned training conditions. After training, participants completed the declarative knowledge test, and began the performance measure (driving scenario). The performance measure consisted of a set of 13 driving scenarios (eight standard script scenarios, and four scenarios consisting of standard and alternate script scenarios). A last trial was presented which involved a unique scenario that required a different

type of script (neither the standard nor the alternate script). Last, participants completed the post-testing measures, before being debriefed and dismissed. Figure 6 summarizes the study's progress and procedure.

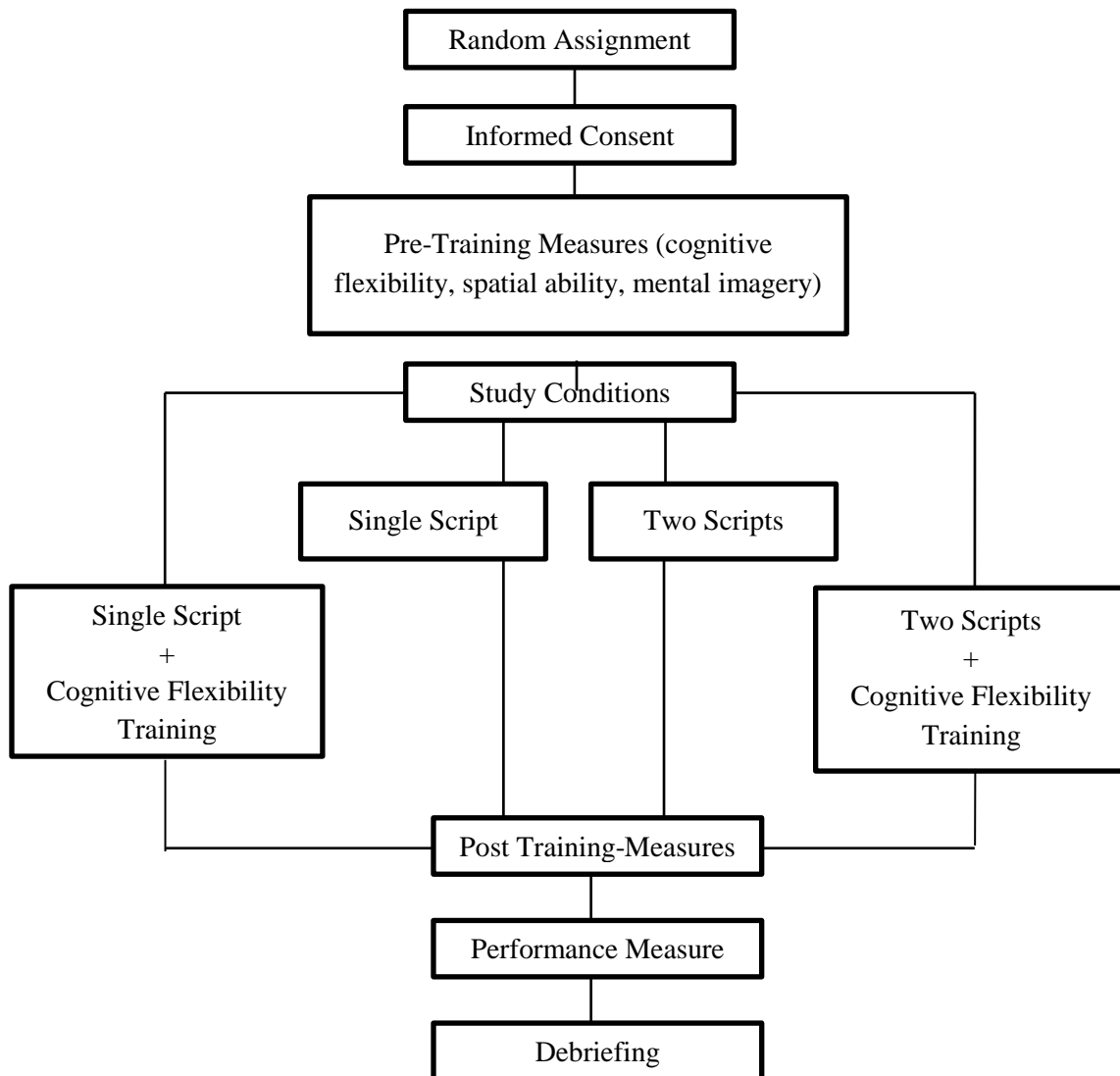


Figure 6. Study progress and procedure.

CHAPTER FOUR: RESULTS

Statistical analyses were performed using SPSS version 23 with an alpha level of .05 unless otherwise noted.

Demographic Variables

Table 2 provides means, standard deviations, and inter-correlations for the demographic variables in this study. The significant correlations indicated that the males in the study were older, had higher spatial ability, had more auto knowledge (average of knowledge of car parts inside the hood, knowledge about the coolant system, and knowledge of auto body parts), and enjoyed performing car maintenance (average of enjoying performing car maintenance, enjoying performing repairs, and enjoying outfitting cars) more than females. In addition, older participants had more driving experience, specifically in urban and rural terrains.

Table 2

Descriptive statistics and inter-correlations among study variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	19.52	2.63	–											
2. Gender	.52	.50	-.34*	–										
3. GPA	3.05	1.26	.17	.17	–									
4. Spatial visualization	13.68	8.88	.28	-.48**	.04	–								
5. Driving experience	2.74	.79	.67**	-.12	.09	.24	–							
6. Experience urban terrain	6.12	1.16	.38**	-.18	.08	.03	.55**	–						
7. Experience rural terrain	5.54	1.24	.37**	-.25	-.00	.27	.43**	.16	–					
8. Experience on hills	3.58	1.93	.20	-.12	-.11	.23	.23	-.19	.44**	–				
9. Auto knowledge	3.59	1.65	.15	-.44**	-.09	.28	.12	.04	.32*	.20	–			
10. Familiarity with car simulators	3.93	1.89	.20	-.28	-.28	.09	.16	.17	.26	.24	.44**	–		
11. Enjoy car maintenance	2.60	1.70	.22	-.46**	.04	.40*	.15	-.06	.30*	.25	.69**	.46**	–	
12. WCST	3.67	1.14	-.02	-.01	.18	-.07	-.22	.03	-.05	-.13	-.15	-.12	-.19	–

Note. Gender was coded as 0 = male, and 1 = female. Driving experience was coded as 1 = 0-6 months, 2 = 1-2 years, 3 = 3-4 years, and 4 = 5+ years. Terrain experience, knowledge of auto parts, familiarity with car simulators, and car maintenance enjoyment were Likert-scales in which, 1= not familiar, 7= very familiar. * $p < .05$ ** $p < .01$

Check of Random Assignment

To verify that the sample was randomly assigned among the study conditions (i.e., single script, two scripts, single script and cognitive flexibility training, two scripts and cognitive flexibility training) based on demographic differences, a series of one-way analyses of variance (ANOVAs) were conducted. Table 3 lists the mean results for these analyses which did not reach

statistical significance. To assess if there was an association between gender and the study conditions, and gender and cognitive flexibility (low vs. high pre-task measure), two Chi-Square (χ^2) tests were conducted. Both tests were not significant, $p > .05$ (see Table 4 for distribution of gender within the study conditions and high vs. low cognitive flexibility). In addition, a Chi-Square (χ^2) test was conducted to assess if there was an association between the study conditions and cognitive flexibility (low vs. high pre-task measure). This test was not significant, $p > .05$ (see Table 5 for distribution of pre-task measure of cognitive flexibility within the study conditions).

Table 3

Group means and standard deviations for the demographics variables based on study conditions

Variable	Overall <i>M (SD)</i>	Single Script <i>M (SD)</i>	Two Scripts <i>M (SD)</i>	Single Script and Cog Flex Training <i>M (SD)</i>	Two Scripts and Cog Flex Training <i>M (SD)</i>	<i>df</i>	<i>F</i>	<i>p</i>
Age	19.52 (2.63)	20.25 (4.25)	19.58 (2.15)	19.25 (1.71)	19.0 (1.71)	3,47	.49	.69
Gender	1.48 (.50)	1.67 (.49)	1.42 (.51)	1.42 (.51)	1.42 (.51)	3,47	.72	.54
GPA	3.0 (1.26)	3.2 (1.11)	3.1 (1.08)	3.1 (1.57)	2.8 (1.37)	3,44	.25	.86
Spatial Visualization	13.68 (8.88)	8.29 (8.24)	17.13 (7.31)	15.67 (8.61)	13.63 (9.61)	3,47	2.49	.07
Driving Experience	2.74 (.79)	2.75 (.87)	2.72 (.79)	2.75 (.87)	2.75 (.75)	3,46	.002	≈1.0
Experience urban terrain	6.13 (1.16)	6.0 (1.28)	6.41 (.79)	6.0 (1.35)	6.08 (1.24)	3,47	.34	.80
Experience rural terrain	5.54 (1.24)	5.08 (1.24)	5.42 (1.38)	5.67 (1.23)	6.0 (1.04)	3,47	1.20	.32
Experience on hills	3.58 (1.93)	3.33 (1.97)	3.83 (2.08)	3.83 (2.04)	3.33 (1.83)	3,47	.26	.86
Auto Knowledge	3.59 (1.65)	3.00 (1.38)	4.06 (1.48)	3.75 (1.63)	3.56 (2.07)	3,47	.86	.47
Familiarity with car simulators	3.94 (1.90)	3.5 (2.06)	4.0 (1.76)	4.08 (1.98)	4.17 (1.95)	3,47	.29	.84
Enjoy car maintenance	2.58 (1.70)	2.00 (1.15)	2.89 (1.99)	2.75 (1.86)	2.69 (1.75)	3,47	.64	.59
WCST	3.67 (1.14)	3.33 (1.37)	2.92 (1.35)	2.50 (.97)	3.0 (.79)	3,47	.72	.55

Table 4

Sample size by gender, condition, and pre-task measure of cognitive flexibility

Gender	Overall	Single Script	Two Scripts	Single Script and Cognitive Flexibility Training	Two Scripts and Cognitive Flexibility Training	Low Cognitive Flexibility	High Cognitive Flexibility
Male	25	4	7	7	7	9	16
Female	23	8	5	5	5	10	13
Total	48	12	12	12	12	19	29

Table 5

Sample size by condition and pre-task measure of cognitive flexibility

Pre-task measure of Cognitive Flexibility	Overall	Single Script	Two Scripts	Single Script and Cognitive Flexibility Training	Two Scripts and Cognitive Flexibility Training
Low	19	6	3	5	5
High	29	6	9	7	7
Total	48	12	12	12	12

Manipulation Check

This study included one manipulation check to ensure that participants understood the instructions in the scripts tutorial. For the script tutorial, it was important that participants learned the required action steps necessary to respond to an overheating engine, depending on the quantity of scripts learned. To determine if participants learned how to respond to an overheating engine, they completed a declarative knowledge test that was specific to the quantity of scripts learned (i.e., either one script or two scripts, see Appendix I and J). The acceptable overall score criteria was set at 60% (i.e., 3 out of 5 items correctly) for the single script group, while for the two scripts group the acceptable overall score criteria was set at 71% (i.e., 5 out of 7 items

correctly). In addition, if participants incorrectly answered the question regarding the correct action step that should be implemented when an engine overheats occurs; they were to be excluded from further analysis. The descriptive statistics indicated that all of the participants scored higher than the minimum set criteria for overall scores in the declarative knowledge test. Also, given their assigned group, all the participants correctly answered the test item regarding the action script that should be implemented when an engine overheats occurs. The results of this manipulation check indicated that participants understood and learned the information presented in their assigned script tutorial session.

Accuracy of Selected Script Coding

Before analysis, the engine overheat scenarios were coded in order to determine how well participants responded to the overheat scenarios. Given that the main difference between the two learned types of scripts was the last action step (i.e., turning off the engine or leaving the engine running), the scenarios were coded using a binary approach (1 = correct script selected or 0 = incorrect script selected). That is, if the scenario required for the engine to be turned off and the participant turned off the engine, then the response was coded as a 1. Similarly, if the scenario required for the engine to be left running and the participant left the engine running, then the response was coded as a 1.

Interrater Reliability

Accuracy in the performance measure was examined by two raters based on the binary coding. To determine consistency between raters, an interrater reliability analysis was conducted using Cohen's kappa. The kappa coefficient achieved a value of 1.0, indicating perfect agreement between the two raters.

Descriptive Statistics on Overall Accuracy Performance

Before exploring if the study's hypotheses were supported, I decided to assess overall accuracy performance on each test scenario in an attempt to find trends and have a better conceptual understanding of what the test scenario data depicted. Figures 7-10 shows the descriptive statistics for accuracy on each scenario based on grouping by script quantity, grouping by cognitive flexibility training, and grouping by study condition. From a high level approach, the figures below illustrate that Scenario 2, Scenario 7, Scenario 9, and Scenario 11 seemed to be influencing the participants' decision-making. Specifically, Figure 8 shows that for Scenario 2 and Scenario 7, possessing two scripts might have been inducing incorrect responses, whereas Scenario 9 and Scenario 11 show that only possessing one script might be influencing incorrect responses. Similarly, Figure 10 shows the same trends on Scenario 2, 7, 9, and 11, between the study conditions. Furthermore, Figure 10 shows that cognitive flexibility training may have interfered with decision-making, and influenced incorrect responses when possessing two scripts.

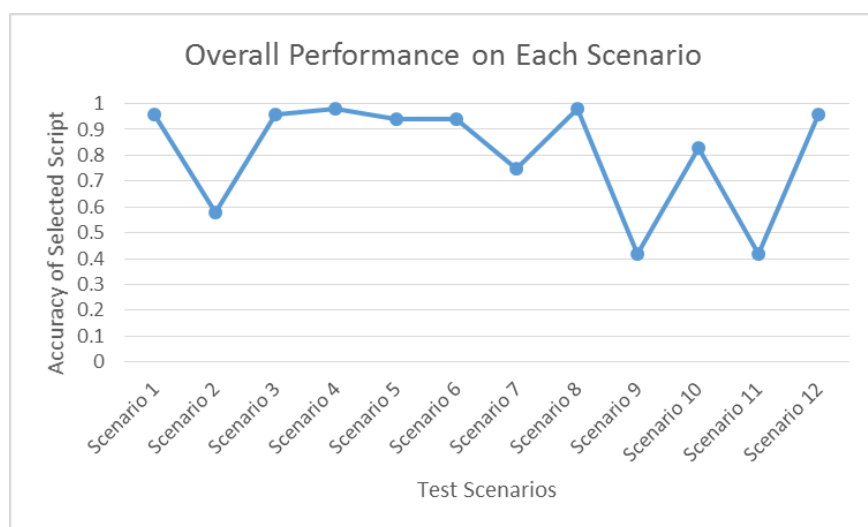


Figure 7. Overall performance on each scenario.

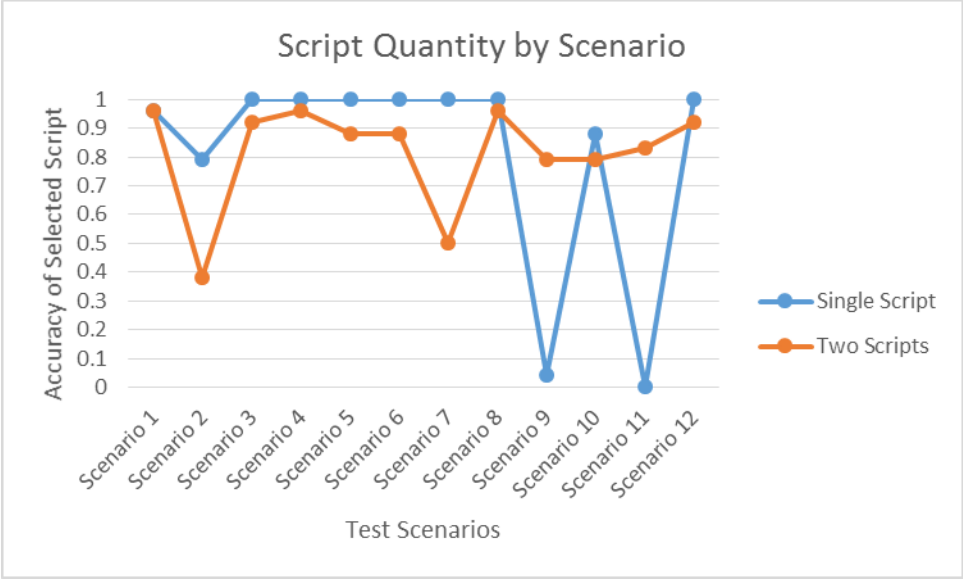


Figure 8. Performance grouped by script quantity on each scenario.

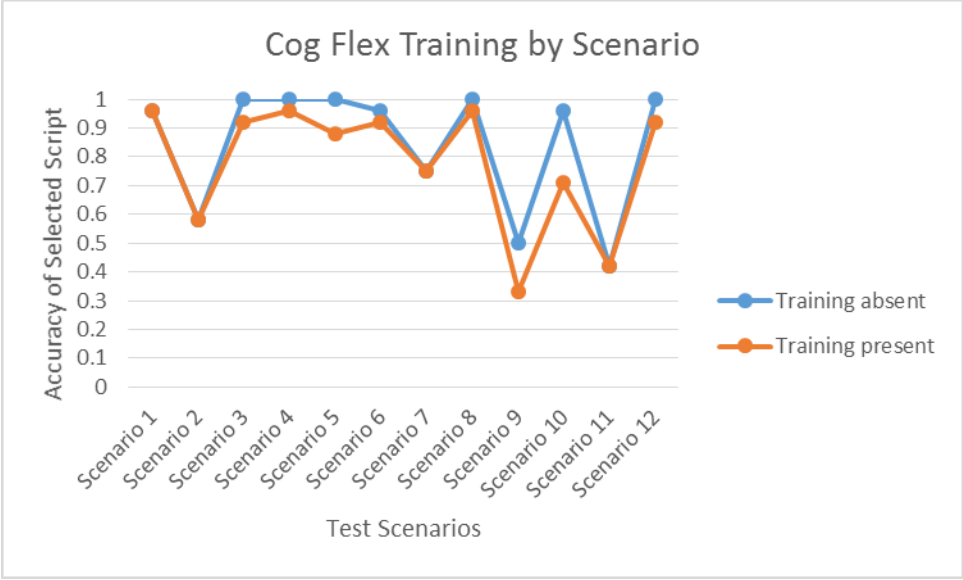


Figure 9. Performance grouped by cognitive flexibility training on each scenario.

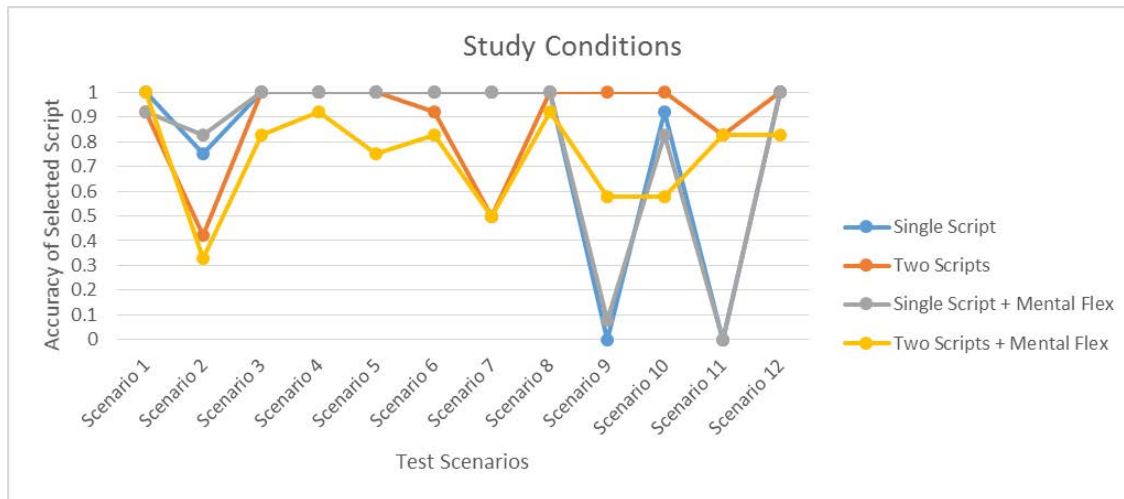


Figure 10. Performance grouped by study condition on each scenario.

The fact that participants with two scripts seemed to have poor performance on Scenarios 2 and 7 (scenarios that require a standard script) may be due to the fact that, in these scenarios, the engine failure occurred after travelling uphill. These two specific scenarios had participants travel uphill to avoid that Scenario 9 (alternate script required) would be the first time that participants encountered rural/hill terrain. The presences of the hill may have created ambiguity and negatively influence decision-making. Based on the results of this descriptive analyses, I chose to further explore performance differences between the ambiguous scenarios (Scenario 2 and Scenario 7), the “switch to alternate” scenarios (Scenarios 8 to 9, Scenarios 10 to 11), and “switch back” scenarios (Scenarios 9 to 10, and Scenarios 11 to 12).

Ambiguous Standard Scenarios

Two of the standard scenarios (Scenarios 2 and 7) required participants to travel uphill, although the engine overheat did not happen while on the hill or in high temperature. Given that these two scenarios were ambiguous, they might have interfered with the decision-making of the participants with two scripts. As a result, I decided to conduct a series of one-way ANOVAs to

explore performance differences between the study conditions on Scenarios 1, 2, 6, 7. Results of the series of one-way ANOVAs indicated that there were significant differences between the study conditions on performance for Scenario 2, $F(3, 47) = 3.35, p = .03$, and for Scenario 7, $F(3, 47) = 7.33, p < .001$ (see Table 6). There were no significant differences found between the study conditions on performance for Scenarios 1 and 6, $p > .05$.

Table 6

One-way ANOVAs for study conditions and accuracy performance on Scenarios 1, 2, 6, and 7

Scenario Type	Condition	Mean (SD)	F	Sig. (P-value)	Pairwise comparisons (LSD)
Scenario 1 (Standard Script)	Single Script	1.00 (.00)	.67	.58	n.s.
	Two Scripts	.92 (.29)			
	Single Script and Cog Flex Training	.92 (.29)			
	Two Scripts and Cog Flex Training	1.00 (.00)			
Scenario 2 (Standard Script-ambiguous)	Single Script	.75 (.45)	3.35	.03	(a) Single Script vs. Two Scripts and Cog Flex Training* (b) Single Script and Cog Flex Training vs. Two scripts* (c) Single Script and Cog Flex Training vs. Two scripts and Cog Flex Training*
	Two Scripts	.42 (.51)			
	Single Script and Cog Flex Training	.83 (.39)			
	Two Scripts and Cog Flex Training	.33 (.49)			
Scenario 6 (Standard Script)	Single Script	1.00 (.00)	1.30	.29	n.s.
	Two Scripts	.92 (.29)			
	Single Script and Cog Flex Training	1.00 (.00)			
	Two Scripts and Cog Flex Training	.83 (.39)			
Scenario 7 (Standard Script-ambiguous)	Single Script	1.00 (.00)	7.33	<.001	(a) Single Script vs. Two Scripts* (b) Single Script vs. Two Scripts and Cog Flex Training* (c) Single Script and Cog Flex Training vs. Two Scripts* (d) Single Script and Cog Flex Training vs. Two Scripts and Cog Flex Training*
	Two Scripts	.52 (.15)			
	Single Script and Cog Flex Training	1.00 (.00)			
	Two Scripts and Cog Flex Training	.50 (.52)			

Note. Pairwise comparisons $p < .05$*

To better understand if there were significant differences between the study conditions, the standard scenarios, and the ambiguous standard scenarios, I conducted a series of mixed model ANOVAs for the following scenario pairs: (a) Scenario 1 (standard script required) vs.

Scenario 2 (standard script required- ambiguous scenario), and (b) Scenario 6 (standard script required) vs. Scenario 7 (standard script required- ambiguous scenario).

Scenario 1 vs. Scenario 2

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 standard scenarios (Scenario 1 vs. Scenario 2) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and the first two standard scenarios. A significant interaction was found between condition and scenario type, $F(3, 44) = 3.27, p = .03, \eta^2 = .18$ (see Figure 11). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). Follow-up tests indicated that for Scenario 2 (ambiguous standard script scenario), participants in the single-script condition ($M = .75, SD = .45$) performed better than participants in the two scripts and cognitive flexibility training condition ($M = .33, SD = .49$). Also for Scenario 2, participants in the single script and cognitive flexibility training condition ($M = .83, SD = .39$) performed better than participants in the two scripts condition ($M = .42, SD = .51$) and the two scripts and cognitive flexibility condition ($M = .33, SD = .49$). Participants in the two scripts condition performed better on Scenario 1 ($M = .92, SD = .29$) than on Scenario 2 ($M = .42, SD = .51$). Likewise, participants in the two scripts and cognitive flexibility training condition performed better on Scenario 1 ($M = 1.00, SD = .00$), than on Scenario 2 ($M = .33, SD = .49$).

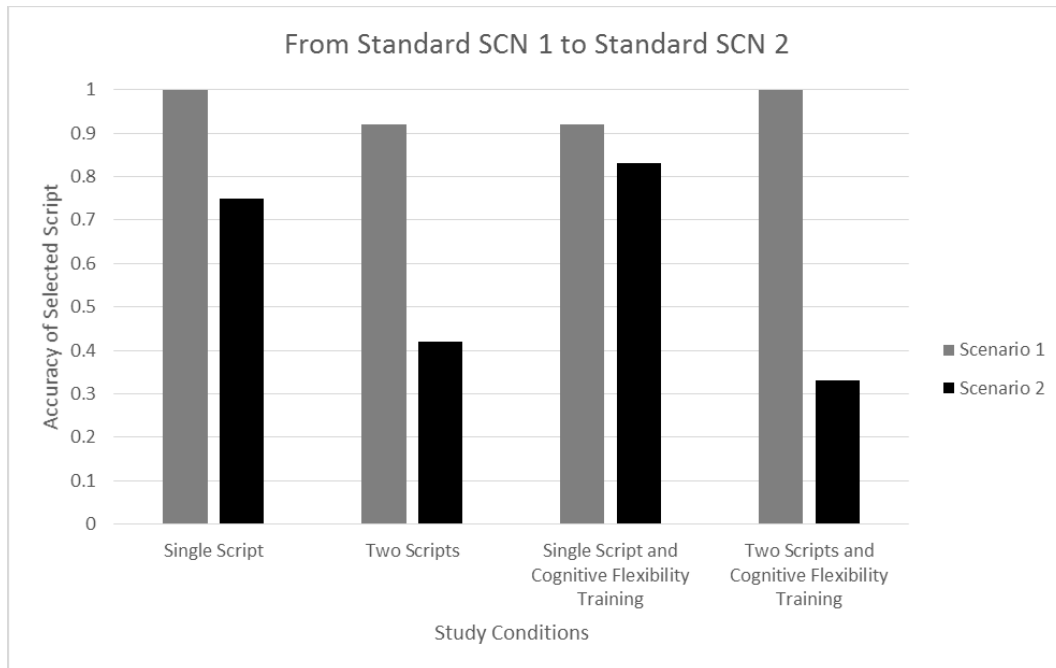


Figure 11. Accuracy from Standard SCN 1 to Standard SCN 2 (ambiguous).

Scenario 6 vs. Scenario 7

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 standard scenarios (Scenario 6 vs. Scenario 7) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and Scenario 6 and Scenario 7. A significant interaction was found between the condition and scenario type, $F(3, 44) = 4.54, p = .01, \eta^2 = .24$ (see Figure 12). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparisons). Follow-up tests indicated that for Scenario 7 (ambiguous standard script scenario), participants in the single script condition ($M = 1.00, SD = .00$) performed better than participants in the two scripts condition ($M = .50, SD = .52$) and two scripts and cognitive flexibility training condition ($M = .50, SD = .52$). Also for Scenario 7, participants in the single script and cognitive flexibility training condition ($M = 1.00, SD = .00$) performed better than participants in the two scripts condition ($M = .50, SD = .52$), and the two scripts and cognitive

flexibility condition ($M = .50, SD = .52$). Participants in the two scripts condition performed better on Scenario 6 ($M = .92, SD = .29$) than on Scenario 7 ($M = .50, SD = .52$). Likewise, participants in the two scripts and cognitive flexibility training condition performed better on Scenario 6 ($M = .83, SD = .39$) than on Scenario 7 ($M = .50, SD = .52$).

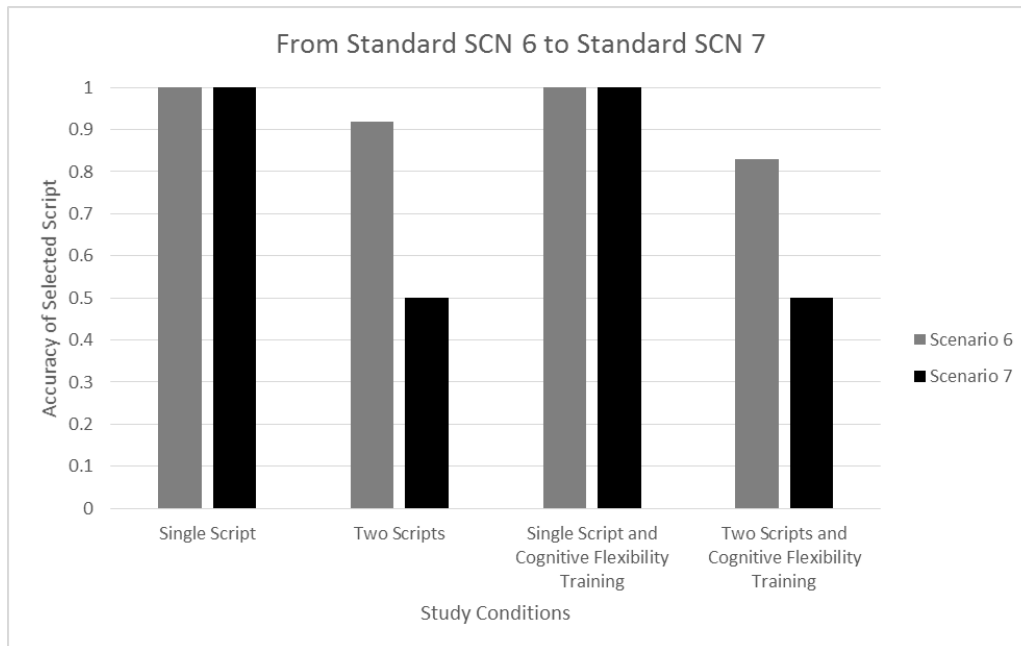


Figure 12. Accuracy from Standard SCN 6 to Standard SCN 7 (ambiguous).

Switch to Alternate and Switch Back Scenarios

“Switch to alternate” scenarios included those scenarios in which a switch from a standard script to an alternate script was needed, while “switch back” scenarios included those scenarios in which a switch from the alternate script to the standard script was needed. “Switch to alternate” included Scenario 8 to Scenario 9, and Scenario 10 to Scenario 11. “Switch back scenarios” included Scenario 9 to Scenario 10, and Scenario 11 to Scenario 12. First, I conducted a series of one-way ANOVAs that explore performance differences between the study conditions on Scenarios 8, 9, 10, 11, and 12. Results of the series of one-way ANOVAs indicated that there

were significant differences between the study conditions on performance for Scenario 9, $F(3, 47) = 29.97, p < .001$, for Scenario 10, $F(3, 47) = 3.11, p = .04$, and for Scenario 11, $F(3, 47) = 36.67, p < .001$ (see Table 7). There were no significant differences between the study conditions on performance for Scenarios 8 and 12, $p > .05$.

Table 7

One-way ANOVAs for study conditions and accuracy performance on Scenarios 9, 10, 11, and 12

Scenario #	Condition	Mean (SD)	F	Sig. (P-value)	Pairwise Comparisons
Scenario 8 (Standard Script)	Single Script	1.00 (.00)	1.00	.40	n.s.
	Two Scripts	1.00 (.00)			
	Single Script and Cog Flex Training	1.00 (.00)			
	Two Scripts and Cog Flex Training	.92 (.29)			
Scenario 9 (Alternate Script)	Single Script	.00 (.00)	29.97	<.001	(a) Single Script vs. Two Scripts*
	Two Scripts	1.00 (.00)			(b) Single Script vs. Two Scripts and Cog Flex Training*
	Single Script and Cog Flex Training	.08 (.29)			(c) Single Script and Cog Flex Training vs. Two Scripts*
	Two Scripts and Cog Flex Training	.58 (.51)			(d) Two Scripts vs. Two Scripts and Cog Flex Training*
					(e) Single Script and Cog Flex Training vs. Two Scripts and Cog Flex Training*
Scenario 10 (Standard Script)	Single Script	.92 (.29)	3.11	.04	(a) Single Scripts vs. Two Scripts and Cog Flex Training*
	Two Scripts	1.00 (.00)			(b) Two Scripts vs. Two Scripts and Cog Flex Training*
	Single Script and Cog Flex Training	.83 (.39)			
	Two Scripts and Cog Flex Training	.58 (.51)			
Scenario 11 (Alternate Script)	Single Script	.00 (.00)	36.67	<.001	(a) Single Script vs. Two Scripts*
	Two Scripts	.83 (.39)			(b) Single Script vs. Two Scripts and Cog Flex Training*
	Single Script and Cog Flex Training	.00 (.00)			(c) Single Script and Cog Flex Training vs. Two Scripts*
	Two Scripts and Cog Flex Training	.83 (.39)			(d) Single Script and Cog Flex Training vs. Two Scripts and Cog Flex Training*
Scenario 12 (Standard Script)	Single Script	1.00 (.00)	2.20	.10	n.s.
	Two Scripts	1.00 (.00)			
	Single Script and Cog Flex Training	1.00 (.00)			
	Two Scripts and Cog Flex Training	.83 (.39)			

Note. Pairwise comparisons* $p < .05$

To better understand if there were significant differences between the study conditions, the “switch to alternate” scenarios, and the “switch back” scenarios, I conducted a series of mixed model ANOVAs for the following scenario pairs: Scenario 8 (standard script required) vs. Scenario 9 (alternate script required), Scenario 9 (alternate script required) vs. Scenario 10 (standard script required-switch back), Scenario 10 (standard script required) vs. Scenario 11 (alternate script required), and Scenario 11 (alternate script required) vs. Scenario 12 (standard script required-switch back).

Scenario 8 vs. Scenario 9 (Switch to Alternate)

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 standard and alternate scenarios (Scenario 8 vs. Scenario 9) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and Scenarios 8 and 9. A significant interaction was found between condition and scenario type, $F(3, 44) = 33.68, p < .001, \eta^2 = .70$ (see Figure 13). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). Follow-up tests indicated that for Scenario 9 (switch to an alternate script required), participants in the two scripts condition ($M = 1.00, SD = .00$) and two scripts and cognitive flexibility training condition ($M = .58, SD = .51$) performed better than participants in the single script condition ($M = .00, SD = .00$) and single script and cognitive flexibility condition ($M = .08, SD = .29$). Also, for Scenario 9, participants in the two scripts condition ($M = 1.0, SD = .00$) performed better than participants in the two scripts and cognitive flexibility training condition ($M = .58, SD = .51$). In addition, participants in the single script condition performed better on Scenario 8 ($M = 1.00, SD = .00$) than on Scenario 9 ($M = .00, SD = .00$). Participants in the single script and cognitive flexibility training condition performed better on

Scenario 8 ($M = 1.00, SD = .00$) than on Scenario 9 ($M = .083, SD = .29$). Participants in the two scripts and cognitive flexibility training condition performed better on Scenario 8 ($M = .92, SD = .29$) than on Scenario 9 ($M = .58, SD = .51$).

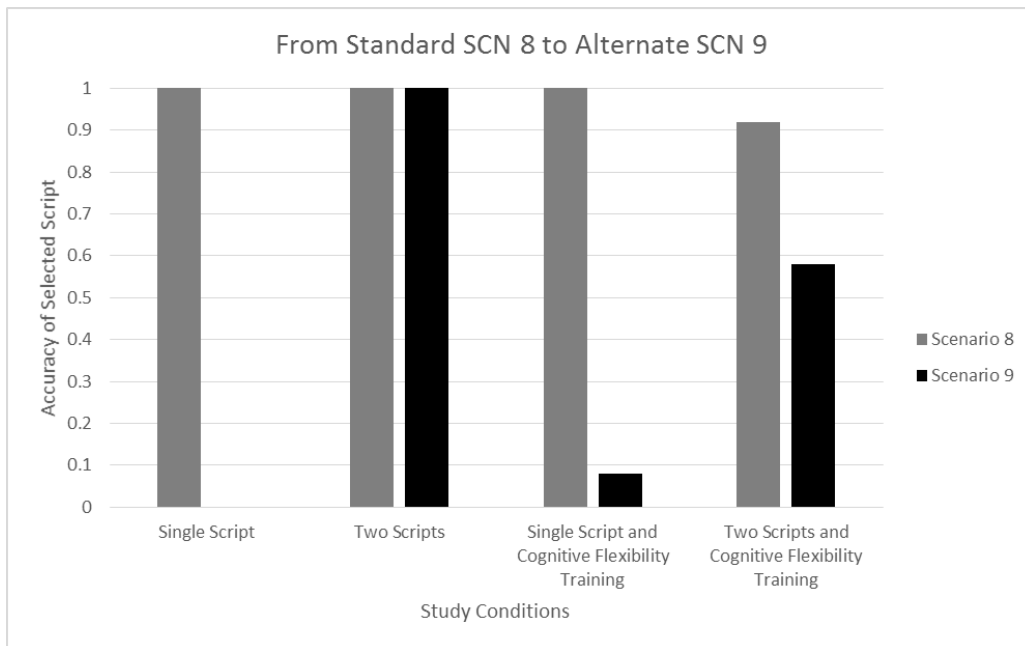


Figure 13. Accuracy on “switch to alternate” scenarios (from standard SCN 8 to alternate SCN 9).

Scenario 9 vs. Scenario 10 (Switch Back)

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 switch back scenarios (Scenario 9 vs. Scenario 10) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and Scenarios 9 and 10. A significant interaction was found between condition and scenario type, $F(3, 44) = 17.40, p < .001, \eta^2 = .54$ (see Figure 14). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). Follow-up tests indicated that for Scenario 9 (alternate script required), participants in the two scripts condition ($M = 1.00, SD = .00$) and two scripts and

cognitive flexibility training condition ($M = .58, SD = .51$) performed better than participants in the single script condition ($M = .00, SD = .00$) and single script and cognitive flexibility condition ($M = .08, SD = .29$). Also, for Scenario 9, participants in the two scripts condition ($M = 1.0, SD = .00$) performed better than participants in the two scripts and cognitive flexibility training condition ($M = .58, SD = .51$). For Scenario 10, participants in the single script condition ($M = .92, SD = .29$), two scripts condition ($M = 1.0, SD = .00$), and single script and cognitive flexibility training condition ($M = .83, SD = .39$) performed better than participants in the two scripts and cognitive flexibility training condition ($M = .58, SD = .51$). Participants in the single script condition performed better on Scenario 10 ($M = .92, SD = .29$) than on Scenario 9 ($M = .00, SD = .00$). Participants in the single script and cognitive flexibility training condition performed better on Scenario 10 ($M = .83, SD = .39$) than on Scenario 9 ($M = .083, SD = .29$).

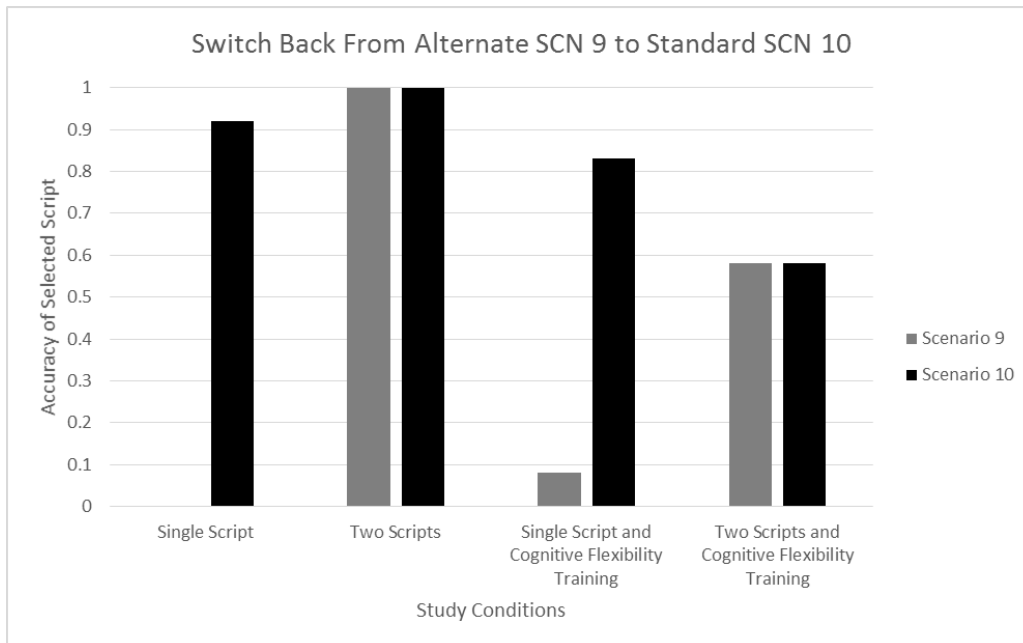


Figure 14. Accuracy on “switch back” scenarios (from alternate SCN 9 to standard SCN 10).

Scenario 10 vs. Scenario 11 (Switch to Alternate)

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 standard and alternate scenarios (Scenario 10 vs. Scenario 11) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and Scenarios 10 and 11. A significant interaction was found between condition and scenario type, $F(3, 44) = 19.27, p < .001, \eta^2 = .57$ (see Figure 15). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). Follow-up tests indicated that for Scenario 10 (standard script required), participants in the single script condition ($M = .92, SD = .29$), two scripts condition ($M = 1.00, SD = .00$), and single script and cognitive flexibility training condition ($M = .83, SD = .39$) performed better than participants in two scripts and cognitive flexibility training condition ($M = .58, SD = .51$). For Scenario 11, participants in the two scripts condition ($M = .83, SD = .39$) and two scripts and cognitive flexibility training condition ($M = .83, SD = .39$) performed better than participants in the single script condition ($M = .00, SD = .00$) and single script and cognitive flexibility training condition ($M = .00, SD = .00$). Participants in the single script condition performed better on Scenario 10 ($M = .92, SD = .29$) than on Scenario 11 ($M = .00, SD = .00$). Participants in the single script and cognitive flexibility training condition performed better on Scenario 10 ($M = .83, SD = .39$) than on Scenario 11 ($M = .00, SD = .00$).

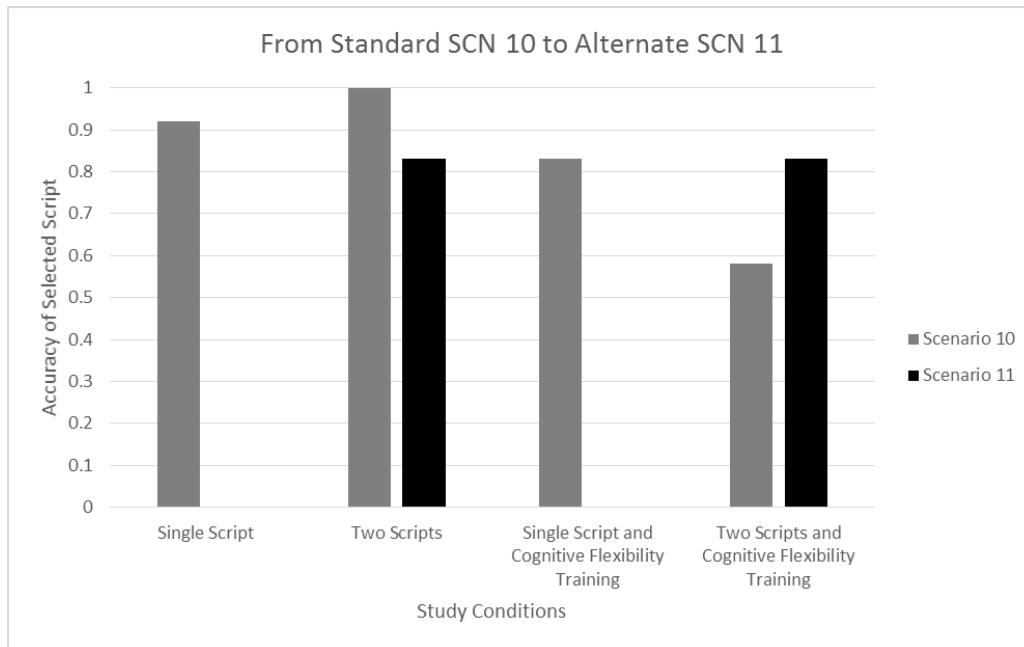


Figure 15. Accuracy on “switch to alternate” scenarios (from standard SCN 10 to alternate SCN 11).

Scenario 11 vs. Scenario 12 (Switch Back)

A 4 Condition (single script vs. two scripts vs. single script and cognitive flexibility training vs. two scripts and cognitive flexibility training) X 2 switch back scenarios (Scenario 11 vs. Scenario 12) repeated measures ANOVA was conducted to determine if there was an interaction between the study conditions and Scenarios 11 and 12. A significant interaction was found between condition and scenario type, $F(3, 44) = 41.00, p < .001, \eta^2 = .74$ (see Figure 16). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). Follow-up tests indicated that for Scenario 11 (switch to an alternate script required), participants in the two scripts condition ($M = .83, SD = .39$) and two scripts and cognitive flexibility training condition ($M = .83, SD = .39$) performed better than participants in the single script condition ($M = .00, SD = .00$) and single script and cognitive flexibility condition ($M = .00, SD = .00$). For Scenario 12 (switch back to the standard script required),

participants in the single script condition ($M = 1.00$, $SD = .00$), two scripts condition ($M = 1.00$, $SD = .00$), and single script and cognitive flexibility training condition ($M = 1.00$, $SD = .00$) performed better than participants in the two scripts and cognitive flexibility training condition ($M = .83$, $SD = .39$). Participants in the single script condition performed better on Scenario 12 ($M = 1.00$, $SD = .00$) than on Scenario 11 ($M = .00$, $SD = .00$). Participants in the single script and cognitive flexibility training condition performed better on Scenario 12 ($M = 1.00$, $SD = .00$) than on Scenario 11 ($M = .00$, $SD = .00$).

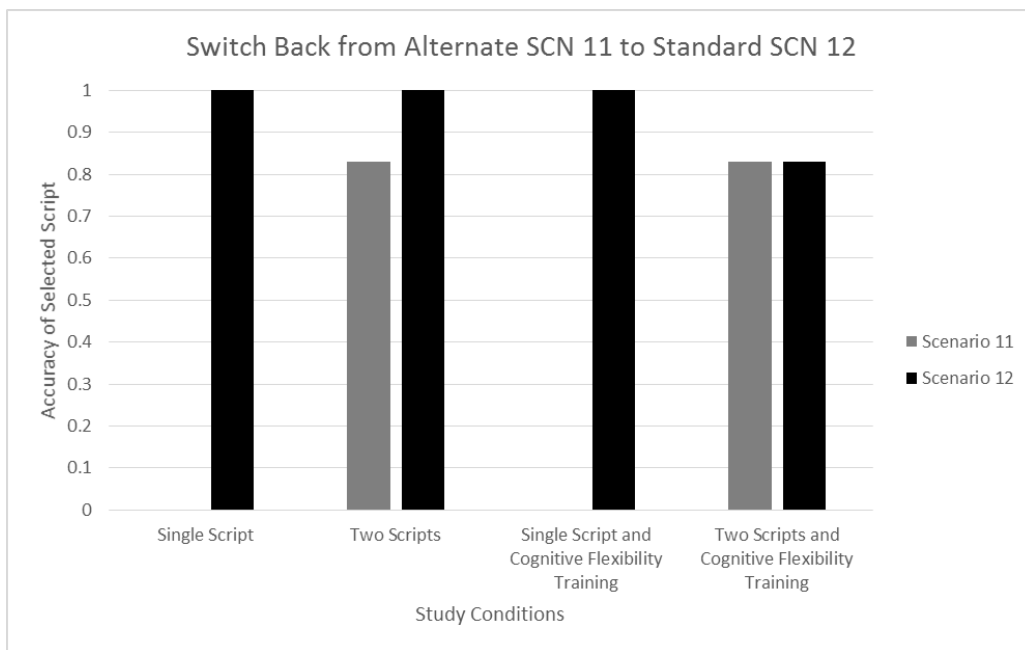


Figure 16. Accuracy on “switch back” scenarios (from alternate SCN 11 to standard SCN 12).

Test of Hypotheses

For these analyses, I focused on analyzing the data by calculating an average performance score for the standard scenarios (Scenarios 1-8, 10, and 12) and all alternate scenarios (Scenarios 9 and 11). Also, the pre-task WCST to measure cognitive flexibility was only administered to collect baseline scores (pre-test), and was not administered as a post-test to

assess if cognitive flexibility training improved or negatively affected WCST performance scores. As a result, Hypotheses 2 to 7 were not analyzed as proposed. Instead, these hypotheses were analyzed using a 2 cognitive flexibility (low vs. high pre-task measure groups) by 2 cognitive flexibility training (absent vs. present) design: (a) low cognitive flexibility, training absent, (b) high cognitive flexibility, training present, (c) low cognitive flexibility, training absent, and (d) high cognitive flexibility, training present. To assess if there was an association between gender and these cognitive flexibility groups, a Chi-Square (χ^2) test was conducted. The test was not significant, $p > .05$ (see Table 8 for distribution of gender within the new cognitive flexibility groups).

Table 8

Sample size by gender and cognitive flexibility

Gender	Overall	Low Flex, Training Absent	High Flex, Training Absent	Low Flex, Training Present	High Flex, Training Present
Male	25	2	9	7	7
Female	23	7	6	3	7
Total	48	9	15	10	14

Hypothesis 1 Analysis

There will be an interaction between script quantity and situational requirement (standard script vs. alternate script). Specifically, participants who learn two scripts (standard and alternate) will perform better on test items that require a switch to an alternate script than participants who learn a single script. In contrast, participants who learn a single script will perform better on test items that require maintaining a standard script.

A 2 (single script vs. two scripts) X 2 (standard script required vs. alternate script required) repeated measures ANOVA was conducted to determine if there was an interaction between script quantity and situational requirement. A significant interaction was found between script quantity and the situational requirement, $F(1, 46) = 173.68, p < .001, \eta^2 = .79$, (see Figure 17). Follow-up tests were conducted to evaluate significant pairwise differences among the means (LSD pairwise comparison). The pairwise comparisons indicated that participants who learned one script ($M = .96, SD = .06$) performed better on scenarios that required a standard script (i.e., turn off the engine), than participants who learned two scripts ($M = .81, SD = .19$). In addition, participants who learned two scripts ($M = .81, SD = .29$) performed better on scenarios that required an alternate script (i.e., leave the engine running), than participants who only learned one script ($M = .02, SD = .10$). Furthermore, participants who only learned one script performed better on scenarios that required the standard script ($M = .96, SD = .06$), than scenarios that required an alternate script ($M = .02, SD = .10$). The results supported Hypothesis 1, given that possessing two scripts was more beneficial when a switch to an alternate script was required, while only possessing one script was more beneficial when the standard script was required.

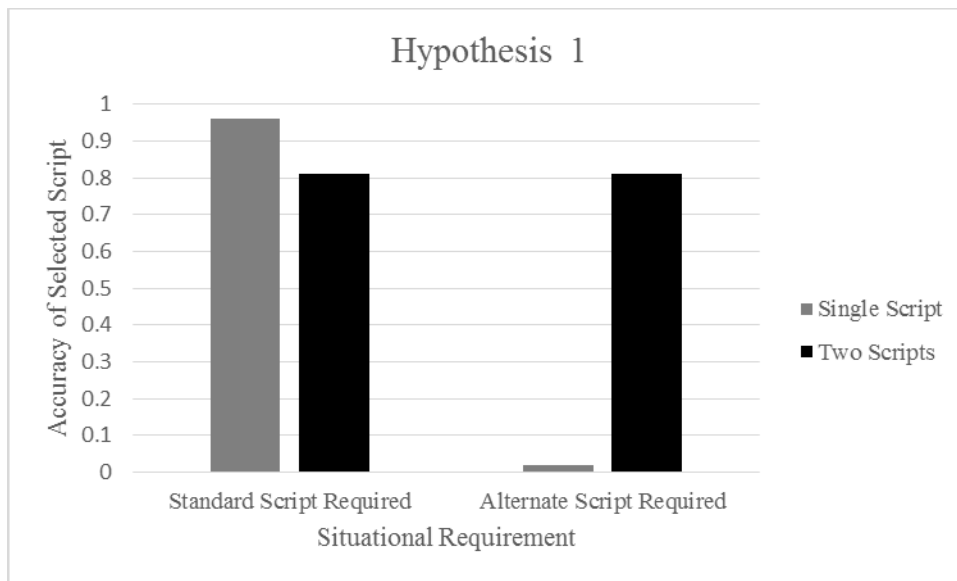


Figure 17. Interaction between script quantity and situational requirement.

Hypotheses 2-6 Analysis

As a whole, Hypotheses 2-6 explored the effects of cognitive flexibility on performance on the test scenarios. Specifically, cognitive flexibility was predicted to facilitate performance on test items that require a switch to an alternate script than test items that require a standard script (no script switch required).

A 4 cognitive flexibility (low cognitive flexibility and training absent, high cognitive flexibility and training absent, low cognitive flexibility and training present, high cognitive flexibility and training present) x 2 situational requirement (standard script required vs. alternate script required) repeated measures ANOVA was conducted to determine if there was an interaction between the pre-task high vs. low cognitive flexibility, cognitive flexibility training, and situational requirement. There was no significant interaction found, $F(3, 44) = .31, p > .05, \eta^2 = .02$ (see Figure 18).

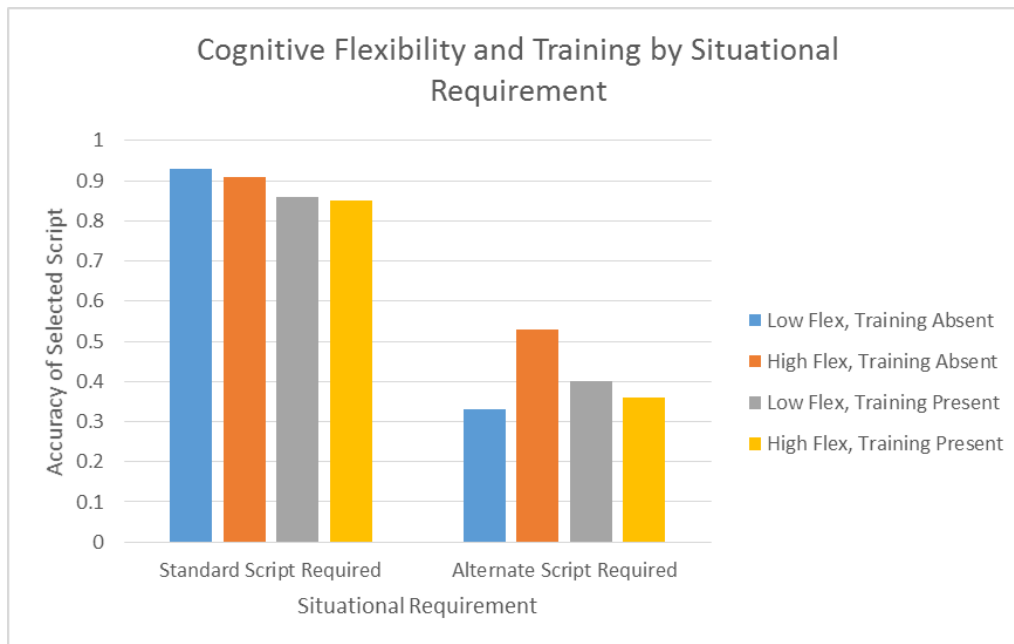


Figure 18. Low vs. high cognitive flexibility and cognitive flexibility training by situational requirement.

The results did not support this hypothesis, as cognitive flexibility did not facilitate performance on the alternate items in comparison to the standard items.

Hypothesis 7 Analysis

Depending on the quantity of scripts learned, having cognitive flexibility will result in better performance outcomes based on situational requirement (standard script required vs. alternate script required). That is, participants who learn a single script and are low in cognitive flexibility will perform better on test items that require a standard script in comparison to participants who learn two scripts and are either high or low in cognitive flexibility. Participants who learn two scripts and are high in cognitive flexibility will perform better on test items that require a switch to an alternate script in comparison to participants who learn one script and are either high or low in cognitive flexibility.

A 2 script quantity (single script vs. two scripts) X 4 cognitive flexibility (low cognitive flexibility and training absent, high cognitive flexibility and training absent, low cognitive flexibility and training present, high cognitive flexibility and training present) X 2 situational requirement (standard script required vs. alternate script required) repeated measures ANOVA was conducted to determine if there was a three-way interaction between script quantity, cognitive flexibility, and situational requirement. A three-way interaction failed to reach significance, $F(3, 40) = .75, p > .05, \eta^2 = .05$ (see Figure 19 and 20).

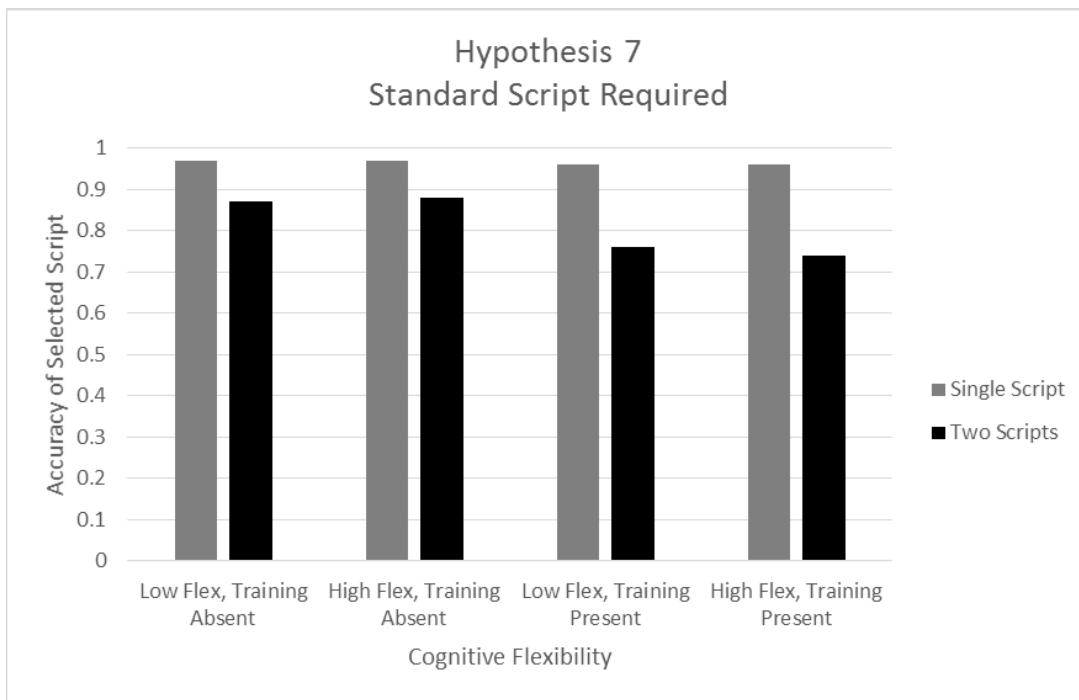


Figure 19. Three-way interaction between cognitive flexibility, script quantity, and standard script required.

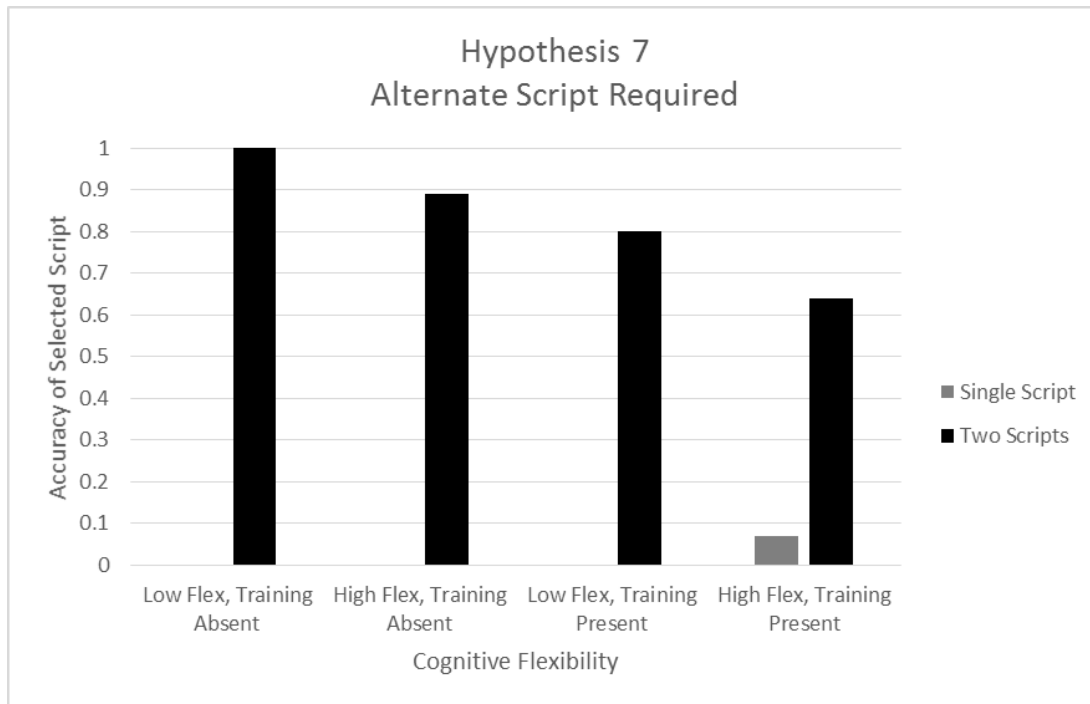


Figure 20. Three-way interaction between cognitive flexibility, script quantity, and alternate script required.

Hypothesis 7 was not supported given that the three-way interaction was not significant. On the standard scenarios, there were no significant differences between participants who learned a single script and were low in cognitive flexibility and participants who learned two scripts and were either high or low in cognitive flexibility. However, participants who learned two scripts and were high in cognitive flexibility performed better on items that required a switch to an alternate script in comparison to participants who learned one script and were either high or low in cognitive flexibility.

Scenario 13

The purpose of Scenario 13 was to present participants with a situation that was not part of their assigned script tutorial session. The goal was to understand how participants would

behave if something unexpected, untrained, and not learned occurred. In the previous 12 scenarios, if the participant continued to drive after the engine overheated, an auditory alert would occur, and if this alert was furthered ignored, then the engine would fail. When the auditory alert occurred on Scenario 13, the engine's temperature gauge had never increased to indicate overheating (i.e., the alert signified another unlearned type of problem). As a result, this change in environment created a situation the participant had not experienced before in the previous 12 scenarios or learned during their script tutorial session. Scenario 13 was analyzed independently because script accuracy was not assessed. The inclusion of this last scenario prompted the following questions:

- Would participants ignore the alert and continue to drive given that the engine temperature had not increased?
- Would participants continue to implement the learned scripts as in the previous scenarios?

Of the 48 participants, 44 (92%) performed the actions steps learned in their script tutorial session (i.e., turn off A/C, pullover to the side of the road, park, turn off/leave engine running). Additionally, 34 participants (71%) turned off the engine, while 14 participants (29%) left the engine running. To assess if there was a relationship between condition and response selection (e.g., turning off the engine or leaving the engine running), a Chi-Square (χ^2) test was conducted. The test was significant, $\chi^2(3, N = 48) = 10.08, p < .05$, indicating that there was a relationship between condition and response selection (see Table 9). Last, 35 participants (73%) continued to drive until the engine failed. It is worth mentioning that participants seemed to be

surprised by hearing the alert and not seeing the temperature gauge increase. This prompted comments such as:

- “Why is it doing that if it is not overheating?”
- “It is not overheating”
- “What was the chime for?”
- “I am not sure why the alert occurred but I am turning off the engine to be safe”

Table 9

Relationship between condition and response selection for Scenario 13.

Response	Overall	Single Script	Two Scripts	Single Script and Cog Flex Training	Two Scripts and Cog Flex Training
Turned off engine	34	8	9	12	5
Left engine running	14	4	3	0	7
Total	48	12	12	12	12

CHAPTER FIVE: DISCUSSION

The purpose of this research was to investigate the relationship between the theories of script-processing and cognitive flexibility by (a) evaluating the effectiveness of *possessing alternate scripts* to respond to situations, and (b) assessing the effectiveness of cognitive flexibility training on the *ability to switch between scripts*. It was expected that learning additional alternate scripts can influence adaptation to changes in the environment. Additionally, it was expected that cognitive flexibility training would facilitate the ability to effectively switch between scripts and as a result, avoid intransigence towards alternate solutions. Overall, the results suggested that for situations requiring a change or an adaptation to an alternate response, possessing two scripts facilitated correct decision-making, whereas cognitive flexibility training may have hindered decision-making.

Ambiguous Scenarios Interpretation

Exploring trends based on performance on each scenario revealed that participants with two scripts (with or without cognitive flexibility training) performed poorly during two standard scenarios (Scenario 2 and Scenario 7) in comparison to the rest of the standard scenarios. These two standard scenarios required participants to travel uphill (in low ambient temperatures), with the engine overheat occurring after the hill. Since participants with two scripts learned that an alternate script was required in high ambient temperatures and if the car was travelling uphill or on an incline (high load), the presence of the hill in those two scenarios created ambiguity and thus negatively influenced their decision-making.

Although these two scenarios were purposely designed in that manner to prevent that Scenario 9 (alternate script required) would be the first time participants perceived and travelled

uphill, they still reveal an interesting aspect about possessing two scripts. That is, if the situation is ambiguous, and multiple scripts are known, then it is possible that the incorrect script can be selected. This was supported after comparing accuracy performance between standard Scenario 1 vs. standard Scenario 2, and standard Scenario 6 and standard Scenario 7. The results indicated that for Scenarios 1 and 6, there were no significant differences between possessing a single script or two scripts (with or without cognitive flexibility training), but when these standard scenarios become ambiguous (Scenarios 2 and 7), possessing only the standard script benefits script selection accuracy, while possessing two scripts could make an individual less accurate in their script selection.

While these results were not surprising, they further support previous research on script processing (Gioia & Poole, 1984; Gioia & Manz, 1985), specifically Klein's RPD model (Klein et al., 1986). In the RPD model, when a situation is familiar and a matching script is already stored in memory, the decision is implemented effectively and automatically (Phillips, Klein, & Sieck, 2004). This type of behavior was elicited by standard Scenarios 1 and 6, which were situations that could be clearly identified as familiar to individuals in either the single script or the two script groups. The RPD model also illustrates that not all events are perceived as familiar, and thus ambiguity in the environment can elicit the need of additional information to understand the current makeup of the situation (script mismatch). This was the case for standard Scenarios 2 and 7, as participants with two scripts perceived an environment that was vaguely in line with what they learned during their script tutorial session (turn off the engine in low ambient temperatures while the overheat does not occur on an incline, or leave the engine running in high ambient temperatures while the overheat occurs on an incline). As stated by Leach (2004), when a solution cannot be formulated and a script cannot be retrieved, humans may experience states

of confusion or “cognitive freeze”, and this confusion about the makeup of Scenario 2 was likely the reason as to why participants with two scripts selected the incorrect script.

Switch to Alternate and Switch Back Scenarios Interpretation

Switch to Alternate Interpretation

The results for the “switch to alternate” scenarios (from standard Scenario 8 to alternate Scenario 9 and from standard Scenario 10 to alternate Scenario 11), indicated that possessing only one script (standard) was beneficial for standard situations (Scenario 8 and Scenario 10), but significantly less helpful when a switch to an alternate situation was needed (Scenario 9 and Scenario 11), regardless of cognitive flexibility training. Meanwhile, possessing two scripts was beneficial for standard situations (Scenario 8 and Scenario 10), and also beneficial for alternate situations (Scenario 9 and Scenario 11). However, cognitive flexibility training seemed to hinder decision-making when responding to alternate situations. That is, possessing only two scripts was significantly more beneficial when responding to a switch to alternate situation (Scenario 9) in comparison to having two scripts and cognitive flexibility training. This result indicated that instead of benefiting the ability to switch from a standard to an alternate script, cognitive flexibility training seemed to impair the ability to switch between scripts. This same result was not replicated for Scenario 11, possibly due to the fact that Scenario 11 was the second time the alternate script was needed, and thus participants could have been more certain about which script to select.

Recalling the findings from the literature on cognitive flexibility can shed some light about the results on the “switch to alternate” scenarios. When individuals are exposed to a constant environment, their script strength increases (they become less cognitive flexible) to the

degree that their responses are successful over many trials (Betsch et al., 2001; Bröder & Schiffer, 2006; Meyer et al., 1997). In fact, Cañas et al. (2003), demonstrated that responding to consecutive trials with constant environmental conditions helped develop a strong successful strategy, and negatively affected performance when a change in the environment demanded an adjustment in response. In this case, participants in the Cañas et al. study were expected to have difficulty in adapting to environmental changes presented in later trials, and show a tendency to continue to use the same strategy developed in earlier trials. In contrast, possessing a weak routine, or training in varying environments, benefits correct switching performance when a change in environment prompts an alternate response.

When I designed the engine overheat trials, I intended for participants to develop a strong successful script by requiring the standard script on the first eight overheat trials, in order to assess if participants with two scripts would have difficulty in switching to the alternate script (show a tendency to continue to use the standard script). However, ambiguous Scenarios 2 and 7 may have countered this effect. That is, the “lulling effect” of the first eight trials was not present, given participants with two scripts were prone to implement the alternate script on Scenarios 2 and 7. Nevertheless, the presence of these two ambiguous scenarios help support the notion that responding within non-constant varying environments benefitted correct switching performance. The fact that participants with two scripts were not “lulled” and perceived the first eight trials as a variation of standard and alternate scenarios led them to become more flexible, and as a result, they had the ability to correctly switch between scripts when an alternate script was required.

What was not expected was that cognitive flexibility training would negatively affect performance on the “switch to alternate” trials for participants with two scripts. Specifically, for Scenario 9, participants assigned to the two scripts only condition performed significantly better than participants in the two scripts and cognitive flexibility training condition, indicating that cognitive flexibility training may have impaired the ability to effectively switch between scripts. It is possible that cognitive flexibility training may have sparked indecisiveness, as opposed to not having cognitive flexibility training. One possible explanation may refer back to the ambiguity of standard Scenarios 2 and 7. As mentioned earlier, the presence of these two ambiguous scenarios removed the “lulling effect,” and consequently, participants with two scripts responded to what they perceived to be a variation of standard and alternate scenarios. Given this, the environment already provided a flexible and changing set of trials which when combined with cognitive flexibility training led to indecisiveness (influenced participants to become uncertain about which script to select). This explanation raises the following questions:

- Is training to respond in varying environments (environments that prompts a consecutive switch between scripts) better than solely training for cognitive flexibility (as described in the method section) in order to achieve cognitive flexibility, and improve the ability to switch effectively between scripts?
- Is training for cognitive flexibility (as presented in this study’s method section) better suited when responding to consecutive trials that provoke a lulling effect (trials that develop a strong successful script)?

Switch Back Interpretation

The results for the “switch back” scenarios (from alternate Scenario 9 to standard Scenario 10 and from alternate Scenario 11 to standard Scenario 12), indicated that possessing only one script was beneficial for situations in which a switch back to the standard script was needed (Scenario 10 and Scenario 12), but significantly less helpful in alternate scenarios that required an alternate script (Scenario 9 and Scenario 11), regardless of cognitive flexibility training. Possessing two scripts was beneficial for alternate situations (Scenario 9 and Scenario 11), and also for switch back situations (standard Scenario 10 and Scenario 12), whereas cognitive flexibility training may have hindered decision-making.

Scenario 10 seems to be another example in which cognitive flexibility training negatively affected the ability to correctly switch between two scripts. In fact, participants with only two scripts were able to “switch back” to the standard script significantly better than participants with two scripts and cognitive flexibility training. As is the case with the “switch to alternate” results, participants with two scripts likely became too indecisive as a result of cognitive flexibility training. A deeper look at the data revealed that incorrect responses in Scenario 10 were more due to the fact that the engine failed before these participants made a decision and not because they had implemented the incorrect script. In fact, after the engine failed, only one participant in the two scripts and cognitive flexibility training condition implemented the incorrect script (left the engine running), while five participants correctly turned off the engine. Regardless, after the overheat occurred, the indecisiveness produced from cognitive flexibility training likely played a role in having these participants continue to drive as

they weighed which script to select. As a result of this indecisiveness, these participants were not able to make a decision in time to produce a positive outcome.

Hypotheses 1 Interpretation

Hypothesis 1 explored the effect of script quantity (single script vs. two scripts) on the situational requirement (standard script required vs. alternate script required). I predicted that there would be an interaction between these two variables and that (a) participants who learn a single script would perform better on test items that require maintaining a standard script, and (b) participants who learn two scripts (standard and alternate) would perform better on test items that require a switch to an alternate script than participants who learn a single script (standard script only). The results supported Hypothesis 1, given that only possessing one script was more beneficial than possessing two scripts when the standard script was required, and possessing two scripts was more beneficial when a switch to an alternate script was required. These results were largely due to the fact that the ambiguous scenarios (standard Scenarios 2 and 7) negatively affected the accuracy of the participants with two scripts.

Hypothesis 1 results further support the RPD model of decision-making (Klein et al., 1986). As mentioned in the ambiguous scenarios interpretations section, when a decision-maker recognizes a situation to be one that was experienced in the past (i.e., scripts already stored in long-term memory), the event is judged to be familiar, and the decision to implement the correct script becomes automatic. Participants who only learned the single standard script were able to recognize the standard scenarios as familiar and therefore had no problem implementing the learned script. Likewise, participants who learned both the standard and alternate scripts, were

able to judge both standard and alternate scenarios as familiar (except for the ambiguous standard scenarios), and thus were able to implement the correct script for both situations.

The RPD model also states that when an environment is unfamiliar or presents itself in a different context, the situation may not match an experience or script already stored in memory (i.e., script mismatch). This is the case for participants who only learned the single standard script and attempted to match the script to the scenarios that required the alternate script. Undoubtedly, the script was not available, and thus they implemented the only script they had available. This was also the case for participants who learned two scripts, as these participants perceived the ambiguous standard scenarios as unfamiliar, and given this script mismatch, they decided to implement one of the two scripts that closely matched the situation, yielding an incorrect response.

Hypotheses 2-6 Interpretation

The WCST to measure cognitive flexibility was only administered to collect baseline scores (pre-test), and was not administered as a post-test to assess if cognitive flexibility training improved or decreased WCST performance scores. As a result, Hypotheses 2 through Hypothesis 7 were not tested as proposed. In summary, Hypotheses 2 through 7 focused on the effects of cognitive flexibility on performance. As a whole these hypotheses predicted that cognitive flexibility would help participants correctly switch between scripts based on the situational requirement. Specifically, cognitive flexibility was predicted to facilitate performance on test items that required a switch to an alternate script than test items that required a standard script (no script switch required).

In an attempt to test these hypotheses, I merged cognitive flexibility (low vs. high pre-test groups) with cognitive flexibility training (absent vs. present) in order to at least consider how the combination of these variables affected performance on the standard and alternate scenarios. The results indicated that an interaction effect was not significant, as participants in all four groups did very well on the standard scenarios, and participants in all four groups did poor in the alternate scenarios. The overall lack of interaction and the poor performance in the alternate scenarios is very likely due to the participants with a single script, given that they did not possess the alternate script in memory. Based on this, the interpretation of Hypothesis 7 could shed some light on the effects of script quantity and these cognitive flexibility groups on performance.

Hypotheses 7 Interpretation

The purpose of Hypothesis 7 was to explore if a three-way interaction would occur between script quantity, cognitive flexibility, and the situational requirement. Although the interaction was not significant, there was a specific result that was similar to a previous trend noticed on the “switch to alternate” analysis described above. Specifically, on the alternate scenarios, participants who learned two scripts, were high in cognitive flexibility, and were also trained on cognitive flexibility did worse than participants with two scripts, low in cognitive flexibility, and not trained in cognitive flexibility. This trend was also present when I analyzed the “switch to alternate” scenarios, in which participants with two scripts performed better than participants with two scripts and cognitive flexibility training on alternate Scenario 9. Again, these results seem to indicate that too much flexibility (being high as well as receive training) can negatively affect performance by making individuals more indecisive in their responses.

Scenario 13 Interpretation

The purpose of Scenario 13 was to add a scenario to the end of the test trials that participants had not learned in their respective scripts tutorial sessions and/or seen during the testing session (i.e., unexpected scenario). During their assigned script tutorial, participants learned that if they continued to drive after the engine overheated, an auditory alert would occur, and if this alert was furthered ignored, then the engine would fail. When the auditory alert occurred on Scenario 13, the engine's temperature gauge had never increased to indicate overheating, resulting in an unexpected situation. This scenario was analyzed independently because script accuracy was not assessed (there was no correct or incorrect response) as I was only interested in how participants would behave. The results of performance from this scenario indicated that even when the engine had not overheated, 92% of the participants attempted to implement the action steps learned in their script tutorial sessions. In addition, 73% continued to drive (ignoring the alert) until the engine failed.

What is interesting about this result is that regardless of how many scripts learned, participants attempted to implement a response, even when the situation did not call for either script. For Scenario 13, the "lulling effect" seemed to have had an influence on responses. Specifically, for 12 consecutive scenarios participants had to respond to an overheating engine problem by implementing one of the two scripts learned. As a result, participants developed a strong expectation from these 12 test scenarios. When a change in context occurred in Scenario 13, participants continued to implement what they thought was still an adequate response, even when the unexpected nature of the scenario caused confusion, and even when they acknowledged that the engine had not overheated. The response to this scenario parallels the results of the

studies that explored the effects of developing a successful script over a number of trials (Betsch et al., 2001; Bröder & Schiffer, 2006; Meyer et al., 1997). These results also corroborate the “Einstellung effect” (Luchins & Luchins, 1959), which centered on the idea that when a strategy is successful over a number of trials, it is difficult to adapt or change to a more adequate strategy when a change in environment occurs.

Implications and Conclusion

Implications for Theory – Script Processing

The findings of this research contribute to the existing body of knowledge in script-processing by showing that having at least two scripts is essential for adequate decision-making, especially on situations that require a switch to an alternate script. Although this study only investigated the effects of possessing two scripts (a standard and an alternate), the findings supports the theory that a pre-set “library” of learned experiences benefits effective decision-making given that these experiences can be matched to a situation (as suggested by Klein, 1998). In addition, the findings furthered support the RPD model of decision-making, in that learned scripts stored in a mental database are helpful when responding to familiar situations. For example, participants who only learned the standard script, were able to match that script to standard scenarios, while participants who learned both the standard and alternate scripts were able to effectively match both scripts to their respective standard and alternate scenarios. Therefore, when a situation is familiar or has been experienced in the past, matching a script from the database to the situation becomes automatic and effective. In contrast, to respond to unfamiliar and/or ambiguous situations, individuals need additional information because they do not possess a matching script in their mental database that can be used as an effective response.

For example, participants who learned only the standard script performed poor on scenarios that required an alternate script because they did not have the correct matching script in their database, while participants who learned both the standard and alternate script, did not perform well on ambiguous standard scenarios, prompting them to select the incorrect script from their mental database.

Implications for Theory – Cognitive Flexibility

Although there is a limited amount of research on cognitive flexibility as a construct, research has explored human capabilities in adapting to changes in the environment. The majority of the research discussed in the literature review in this document focused on the difficulty of switching strategies when a strong strategy has successfully over time (Betsch et al., 2001; Bröder & Schiffer, 2006; Luchins & Luchins, 1959; Meyer et al., 1997). In these cases, the constant nature of the environment indicated that the same successful response should be implemented, making it difficult to revise a response (become less flexible) when a change requires a shift in decision. The opposite effect occurs if a strategy is not strong, or if the environment in which one is responding is changing and varies after responses. This then allows an individual to become more flexible as they are not developing a strong consistent successful script.

The current study attempted to replicate a constant environment that presented participants with eight consecutive scenarios that required the standard script (i.e., to develop a strong successful script). However, the ambiguity of Scenarios 2 and 7 affected this manipulation given that participants with two scripts perceived those two scenarios as ones that required the alternate script. As a result, during the first eight trials they perceived a varying environment of

standard and alternate scenarios which allowed them to be more flexible and accurate when responding to the script switching (alternate script) scenarios. Although I could not test how participants would have responded to an alternate script switch after developing a consistent standard script response, the results support the notion that individuals can switch between scripts more effectively (become more flexible) when a strong script is not developed over time.

This notion to become more flexible/inflexible depending on varying environmental conditions was also supported by the results on Scenario 13. Since in Scenario 13 participants perceived an environment never seen before in the previous 12 trials, their responses centered in what they had learned from experience. Responding to the 12 trials based on the scripts learned created a strong successful expectation of how to respond to these scenarios. When the environment changed (as presented by Scenario 13), participants had difficulty understanding the change, and thus continued to respond in the same way as in the 12 trials (by implementing a standard or alternate script), even when there was a mismatch between required response and script stored in memory.

The fact that cognitive flexibility training was detrimental to the switching performance of participants with two scripts may be due to two reasons: First, without considering the effects of the ambiguous scenarios, cognitive flexibility training may have simply impaired the ability to effectively switch between scripts by sparking indecisiveness and as a result augmenting uncertainty. Second, the switching ability may have been affected by the additional effects of perceiving the first eight scenarios as ones that varied between standard and alternate. As proposed in the literature, this variation can help one switch to another response when a change in environment occurs (improving their response flexibility). The addition of cognitive flexibility

training to these circumstances could have made participants more indecisive and less certain about which script correctly matched the situation. Regardless of these two reasons, the results support the notion that training for cognitive flexibility can make someone indecisive when it comes to switching between scripts.

Implications for Practice – Script Processing

The results of this study have implications on how to develop effective training that helps responding to unfamiliar, changing situations. Although not surprising, the results of this study supports the notion that a mental database of scripts facilitates decision-making, as matching a script to a perceived familiar event becomes easier. Since it is impossible to train for and learn all the types of situations that can be encountered, training designers should at the very least focus on collecting every possible piece of information that might affect responses. After this information is collected, individuals should learn these various pieces of information in order to begin developing a database of responses that can be used to match a given situation. However, even after training with every bit of information, a new and/or unexpected event can still occur, and based on previous research, and the results from Scenario 13, when a script is not available, an individual seems to struggle to respond effectively by implementing a solution from the script database that closely matches the current situation.

Implications for Practice – Cognitive Flexibility

One of the goals of this study was to assess if cognitive flexibility could be trained (through mental simulation), and although I was not able to conclude if cognitive flexibility training improved or impaired cognitive flexibility, it seemed, however, that cognitive flexibility training sparked indecisiveness, and as a result impaired performance when a switch to an

alternate script was needed. Given this, training for cognitive flexibility using mental simulation as described in this study, should not be the main focus in training design. Perhaps a more task-specific mental simulation training that would have had participants mentally simulate how they would respond if their engine overheat script were to fail would be more effective. However, for this study, that would have primed participants to expect that something may go wrong with their scripts during the actual test scenarios.

The results of this research demonstrate that cognitive flexibility can be trained, not by performing mental simulations about unexpected events, but by creating a varying/flexible environment during training that allows for multiple responses to be learned without creating one single successive response. For example, if a real-world situation typically calls for a standard script, and the implementation of an alternate script seldom occurs, it is likely that an individual could develop a strong bias towards implementing the script they perceive more often (standard script) even when a change in the environment requires the script that seldom occurs. To combat this problem, initial and recurrent training should provide training for both scripts with the same frequency to avoid intransigence towards the less occurring script.

Conclusion

In Chapter 1 of this document, the following research questions were put forth with the intent to finding an answer based on the results of this study:

(RQ1) Does possessing a repertoire of scripts facilitate adaptation to changes in the environment if cognitive flexibility training is provided (i.e., if the ability to switch between these scripts is learned)?

The results of this study clearly demonstrate that a database of scripts is beneficial on its own, and that switching ability may be an effect of possessing the correct scripts that match the situation. Training within an environment that does not allow the development of a single, strong and successful script is also beneficial to script switching ability.

(RQ2) Is simply owning one script and having an understanding that the script may fail, or may need to be revised in a different context (through cognitive flexibility training), enough to avoid overreliance to one standard solution?

Owning one script is not enough to avoid overreliance to one standard solution simply because when a script does not exist, there is no way to match it to the changing situation. As shown in this study, when only the standard script was learned, it was implemented as a response for all situations, even when cognitive flexibility training was provided.

(RQ3) What is the cost of cognitive flexibility? Could switching ability negatively affect decision-making when a standard script is required (no switch needed)?

Cognitive flexibility training affected responses when a switch was needed (Scenario 9) and when a switch was not needed (Scenario 10). The results from this study suggested that cognitive flexibility training can create indecision and uncertainty about which script is best when one has to *switch to* and *switch back* from standard to alternate and from alternate to standard.

Limitations and Future Research

Study Limitations

One of the focus areas of this study was to assess the impact of cognitive flexibility on the ability to effectively switch between scripts. Post-training scores for the WCST (cognitive flexibility measure) were not collected, and as a result, this limitation did not allow for proper assessment of the effects of cognitive flexibility on performance. In addition, WCST post-training scores would have made clear if the cognitive flexibility training improved, or worsened cognitive flexibility. As a result, the post-training scores would have yielded a better understanding of why the training produced indecisiveness (either it augmented total flexibility, or decreased total flexibility).

Another study limitation was the impact that the ambiguous scenarios had on the “lulling effect.” Although the ambiguous standard scenarios supported the notion that responding to situations that vary in response requirement facilitates script switching, it did not test for the effects of responding eight consecutive times with the standard response. It is possible that with the proper “lulling effect” participants with two scripts would have remained stuck, and thus had difficulty in switching to an alternate script on Scenario 9 (alternate script required). As a result of the “lulling effect,” it is possible that cognitive flexibility training could have then facilitated script switching for participants with two scripts.

Not presenting feedback to participants after each scenario may be another limitation. I did not elect to give feedback because I had administered the declarative knowledge test which tested whether participants had the correct information from their assigned script tutorial

sessions. However, presenting feedback could have facilitated the “lulling effect,” especially for participants with two scripts. Specifically, if participants would have received negative feedback when they implemented the alternate script in the ambiguous scenarios, they would have perceived the first eight scenarios as ones that required the standard script. Given this, participants could have then find it more difficult to switch to the alternate script in the alternate scenario, and perhaps cognitive flexibility training would have facilitated script switching. Additionally, participants with one script could have been surprised to learn that the standard script was actually incorrect for the alternate scenarios, but due to the unavailability of an alternate script in their mental database, they would have still implemented the standard script incorrectly on the second alternate scenario (Scenario 11).

Areas of Future Research

Future research should continue to investigate the effects of scripts and cognitive flexibility on decision-making. Since individuals rely on the familiarity of situations to implement scripts, responding to situations that are unfamiliar (i.e., situations in which a script may not exist) is of concern. As illustrated in these results, participants who only learned one script, continued to implement the standard script even in situations that called for a different/alternate type of response. More research should explore how to train/teach individuals to effectively and efficiently respond to situations that are unfamiliar or uncommon. Since in complex and dynamic worlds it is impossible to train and learn all situations that can occur, then individuals should train to *not* find the best/perfect response. Instead, when a situation cannot be matched to a script, individuals should be prepared to be flexible enough to find an adequate solution that can lead to achieving the least possible damage. For instance, in aviation, if a pilot

experienced confusion about how to respond to a certain situation, then he/she should focus on aviating and leading the aircraft towards safety. If the pilot instead becomes too focused about finding a solution to the situation that requires an unavailable script, the main goal of aircraft safety could be in jeopardy.

For situations in which a script is unavailable, training should focus on helping individuals have an understanding that due to the high complexity of dynamic environments, some learned scripts will not be able to be matched to specific situations. For these cases, future research should investigate how a cognitive flexibility training that is more relevant to an actual situation (as opposed to the generic cognitive flexibility training in this study). This might be simply leading individuals to understand that although there is a standard way to respond to some situations, there will be some instances in which that standard response will cease to work. This will prepare individuals to understand that a script will sometimes fail, and as a result, they need to learn how to switch to a more adequate solution. Although the correct alternate script may not be available from the script database, other experiences can be used to mold and restructure the standard script to find a more adequate albeit not perfect solution.

Script quantity is another aspect that may be in need of more research. For example, the concept of possessing multiple scripts based on past experiences has also been discussed in the literature in terms of analogies. Basically, analogies allow individuals to understand a novel situation by comparing it with a familiar one already stored in memory (Gentner and Holyoak, 1997). In addition, studies have found that individuals can formulate solutions by using analogous problems from a different domain (Gick & Holyoak, 1980). In the case of this study, a participant who may have had previous experience working on machines that also uses a cooling

process similar to that of car's engine could have used this experience as an analogy in order to make a decision. Future research should explore differences between using scripts based on analogous problems and using scripts that exactly match a problem. Also, future research should address these questions about the effects of possessing more than two scripts on decision-making performance:

- What is the effect of having more than two scripts to choose from?
- Would performance be poorer if more options are available, or would it benefit decision-making?
- What is the effect of script quantity in team dynamics?
- In a team setting, how would individuals interact if one team member only possesses one script and another team member possesses two scripts?
- How would individuals interact if one team member has higher cognitive flexibility than another team member?

APPENDIX A: IRB OUTCOME LETTER



University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Javier A. Rivera**

Date: **October 30, 2015**

Dear Researcher:

On 10/30/2015 the IRB approved the following minor modifications to human participant research until 09/10/2016 inclusive:

Type of Review: IRB Addendum and Modification Request Form
Modification Type: Both parts of the study are being condensed into on face-to-face session that will last approximately 2 hours and 30 minutes. A revised protocol and study instruments have been uploaded in iRIS and a revised Informed Consent document has been approved for use.

Project Title: Assessing the Effects of Cognitive Training on a Simulated Driving Task

Investigator: Javier A Rivera
IRB Number: SBE-15-11582
Funding Agency: Federal Aviation Administration
Grant Title:
Research ID: 1057417

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu>.

If continuing review approval is not granted before the expiration date of 09/10/2016, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the [Investigator Manual](#).

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

A handwritten signature in black ink that reads "Joanne Muratori". The signature is written in a cursive style with a large initial "J" and "M".

Signature applied by Joanne Muratori on 10/30/2015 11:13:41 AM EDT

IRB Manager

APPENDIX B: INFORMED CONSENT



Assessing the Effects of Cognitive Training on a Simulated Driving Task

Informed Consent

Principal Investigator: Javier Rivera, M.S.

Faculty Advisor: Florian Jentsch, PhD

Sponsor: Federal Aviation Administration

Investigational Site(s): University of Central Florida, Institute of Simulation and Training

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include about 200 people at UCF. You have been asked to take part in this research study because you are a student in a psychology class. You must be 18 years of age or older to be included in the research study.

The person doing this research is Javier Rivera, M.S., of the Institute of Simulation and Training of the Psychology Department at UCF. Because the researcher is a graduate student he is being guided by Florian Jentsch, Ph.D, a UCF faculty advisor in the Psychology Department at UCF. UCF students learning about research are helping to do this study as part of the research team. Their names are: Karissa Kasper, Samuel Resende, Andrew Talone, Camilo Jimenez, Elizabeth Phillips, Caitlin Faerevaag, Nastacia Smith, MiAmor Aguirresaenz, Amanda Matioli, and Lauren Haskin.

What you should know about a research study:

- A research study is something you volunteer for.



- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.

Purpose of the research study: The purpose of this study is to investigate cognitive training methods intended to improve decision-making performance in a driving task.

What you will be asked to do in the study: In this study, you will first complete a demographics form, and a mental imagery questionnaire. Then you will be randomly assigned to one of four study conditions. Then, you will complete two pre-training measures which include: cognitive flexibility (Wisconsin Card Sorting Test), and spatial ability (Spatial Visualization Test). Then, you will take part on your assigned study condition by reviewing information on a PowerPoint presentation. After the PowerPoint presentation, you will complete a declarative knowledge test to assess performance about the concepts presented during training, and then complete a post-training measure (training reactions questionnaire). After, you will begin the performance measure (driving scenarios). The performance measure will consist of a set of 15 driving scenarios (two practice trials, and 13 test trials). Lastly, you will complete the post-testing measures (Self-efficacy questionnaire and the Simulator Sickness Questionnaire), and be debriefed and dismissed. You do not have to answer every question or complete every task. You will not lose any benefits if you skip questions or tasks. The study will take approximately 2 hours and 30 minutes

Location: The study will be conducted in room 226 at the Partnership III building at the Institute of Simulation and Training.

University of Central Florida Partnership III Building
3039 Technology Parkway
Orlando, FL. 32826

Time required: We expect that you will be in this research study for approximately 2 hours and 30 minutes.

Audio or video taping:

You will be audio and video taped during this study. If you do not want to be video taped, you will be not able to be in the study. Discuss this with the researcher or a research team member. If you are audio and video taped, the tape will be kept in a locked, safe place. The tape will be erased or destroyed after data analysis is complete.

Funding for this study: This research study is being paid for by the Federal Aviation Administration.

Risks: Researchers believe that the likelihood of participant risk is very low. There is a small risk that people who take part will develop what is ordinarily referred to as simulator sickness. It occurs once in awhile to people who are exposed to prolonged continuous testing in simulated environments. Symptoms consist of nausea and a feeling of being light-headed. The risk is minimized as a result of the short duration of each session in the simulator. If you experience any of the symptoms mentioned, please tell the researcher and remain seated until the symptoms disappear. There may also be risks of side effects associated with prolonged computer usage including eye strain, dry eye, or fatigue.

Benefits: We cannot promise any benefits to you or others from your taking part in this research, other than it might augment your research experience.

Compensation or payment: Participants may expect to spend between 2 hours and 30 minutes in this study for which they will receive Sona Systems credit for the amount of time they participate (2.5 credits). There is no monetary compensation for taking part in this study.

Confidentiality: We will limit your personal data collected in this study to people who have a need to review this information. We cannot promise complete secrecy.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, please contact Javier Rivera, Graduate Research Assistant, Modeling and Simulation Program, Institute of Simulation and Training, (407) 405-3951, jrivera@ist.ucf.edu or Dr. Florian Jentsch, Faculty Supervisor, Department of Psychology at (407) 882-0304.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study:

Participation in this research study is completely voluntary. Refusal to participate or choosing to withdraw from the study at any time will involve no penalty or loss of benefits associated with the study. If you decide to leave the research study, you will receive credit in accordance with time spent in the study prior to withdrawal. For example, if you decide to withdraw from the study after 1 hour has passed, you will receive 1 Sona credit. If you decide to leave the study, contact the investigator so that the investigator can stop administering the survey instruments or stop the simulation. The researcher will then thank you for your time, explain how you will be credited for your time, and

instruct you to the exit. The person in charge of the research study or the sponsor can remove you from the research study without your approval. Possible reasons for removal include failure to follow instructions of the research staff, disorderly conduct, improper treatment of the research staff, other participants, research equipment, or if the research staff feels that the study is no longer in your best interests. We will tell you about any new information that may affect your health, welfare or choice to stay in the research.

APENDIX C. MENTAL IMAGERY QUESTIONNAIRE

**APPENDIX D. TRAINING REACTIONS QUESTIONNAIRE (AFTER
JENTSCH, 1997)**

Training Reactions Questionnaire

We are very interested in your honest reactions to the training you just received! Please answer the following items by indicating on a scale of 1 to 6 how strongly you agree or disagree each of them.

STRONGLY DISAGREE		DISAGREE	AGREE		STRONGLY AGREE
1	2	3	4	5	6

1. This program presented information and ideas that were new to me.

2. I have enjoyed this program.

3. I believe that the ideas presented to me in this program will be useful to me.

4. I believe that I will be a more effective crewmember as a result of this program.

5. I found the information presented to me in this program interesting.

6. I plan to use the skills I have learned in this program when I fly in multi-piloted crews.

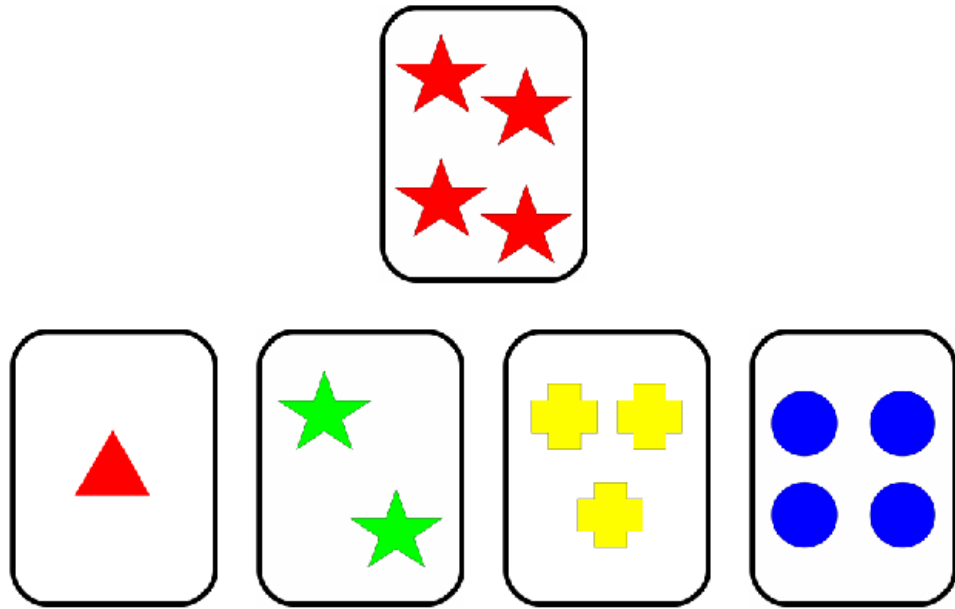
7. I would recommend this program to others.

8. I feel I am less likely to make mistakes in the cockpit after having participated in this training.

9. I feel that the instructor was effective at getting the points across.

10. I would be interested in participating in a similar course in the future.

APPENDIX E: WISCONSIN CARD SORTING TASK EXAMPLE



APPENDIX F: SINGLE SCRIPT TUTORIAL





Engine Overheat Training

- In the next slides you will be presented with a training tutorial that will focus on how to respond to an engine overheat that may occur on the particular car you will be driving in the simulator.
- To begin the training, please advance to the next screen.

1 of 9



Engine Overheat Training

- The purpose of this training is to familiarize you with how to respond to an engine overheat that may occur on the particular car you will be driving in the simulator.
- The first slides will give you background information about:
 - The cooling system
 - The signs that will help you know that overheating has occurred
 - The reason as to why an overheat may occur
- Your main focus is to learn how to respond to an engine overheat based on the steps presented on slide 8.
- If at any point you feel you need to revisit a topic, remember you can use the arrows ( ) at the top-right corner of the screen to go back.

2 of 9



Engine Overheat Background

- When a car's engine is turned on, it begins to produce heat that needs to be cooled continuously to avoid damage to the engine.
- The cooling system works to control the engine's temperature and helps to keep it at an optimal level to avoid overheating.
- Allowing an engine to overheat can completely damage the engine.

3 of 9



Signs of an Engine Overheat

- When an engine overheats you will see the following sign:
 - The temperature gauge, located on the dashboard, will rise towards the “hot area.”
 - **While driving, the temperature gauge should be frequently monitored to notice any indication of overheating.**



Normal Engine Temperature



High Engine Temperature

4 of 9



Signs of an Engine Overheat

- If as a driver, you are unaware that the temperature gauge has increased, the longer you continue to drive the car, the more damage will be caused to the engine.
- When major damage has been caused to the engine due to the overheat, an auditory alert (chime) will inform you that there is a problem with the engine.
- However, once this alert occurs, it is a sign that the engine has heated to the point where major damage has been done, leading to an unwanted engine failure.
- Engine failure can be avoided by keeping an eye on the temperature gauge as you monitor your speed through traffic.

5 of 9



An engine may overheat due to the following reason:

- A failure in the cooling system which can be caused by any of the following:
 - Loss of coolant
 - Coolant line blockage (impedes the coolant liquid to flow)
 - Faulty water pump
 - Cooling fan failure

6 of 9



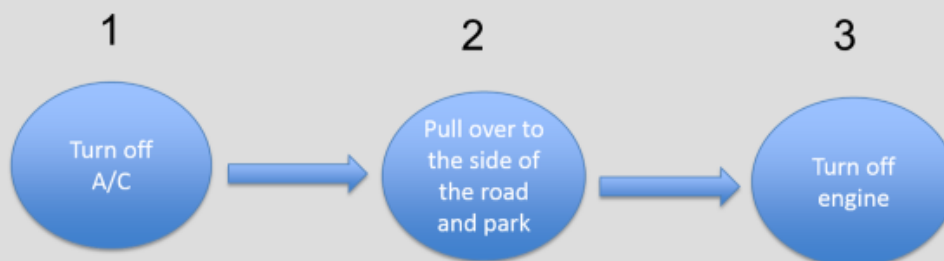
Failure in the Cooling System

- As you drive, you may not know if a failure in the cooling system is the cause of the overheat until the system is inspected after opening the hood of the car.
- However, when all of the following conditions are met, it is safe to assume that there is a failure in the cooling system:
 - Ambient temperature conditions are between 70-84 degrees Fahrenheit)
 - Driving on a flat surface that does not apply too much load on the engine (e.g., flat roads or non-incline roads)
- When all the conditions described above occur, and the engine temperature gauge has increased, the appropriate response would be to:
 - **Turn off the A/C, pull over to the side of the road, park safely, and turn off the engine.**
- If no appropriate response is taken, the car may become harder to drive (increased drag) and the engine will fail.

7 of 9



When an engine is overheating due to a failure in the cooling system, you should:



8 of 9



End of Training

- Please feel free to review the training slides again.
- Otherwise please inform your experimenter that you have completed the training.

APPENDIX G: TWO SCRIPTS TUTORIAL





Engine Overheat Training

- In the next slides you will be presented with a training tutorial that will focus on how to respond to an engine overheat that may occur on the particular car you will be driving in the simulator.
- To begin the training, please advance to the next screen.

1 of 11



Engine Overheat Training

- The purpose of this training is to familiarize you with how to respond to an engine overheat that may occur on the particular car you will be driving in the simulator.
- The first slides will give you background information about:
 - The cooling system
 - The signs that will help you know that overheating has occurred
 - The specific reasons as to why an overheat may occur
- Your main focus is to learn how to respond to two types of engine overheats based on the steps presented on slides 8 and 10.
- If at any point you feel you need to revisit a topic, remember you can use the arrows ( ) at the top-right corner of the screen to go back.

2 of 11



Engine Overheat Background

- When a car's engine is turned on, it begins to produce heat that needs to be cooled continuously to avoid damage to the engine.
- The cooling system works to control the engine's temperature and helps to keep it at an optimal level to avoid overheating.
- Allowing an engine to overheat can completely damage the engine.

3 of 11

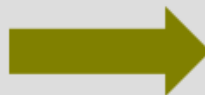


Signs of an Engine Overheat

- When an engine overheats you will see the following sign:
 - The temperature gauge, located on the dashboard, will rise towards the "hot area."
 - **While driving, the temperature gauge should be frequently monitored to notice any indication of overheating.**



Normal Engine Temperature



High Engine Temperature

4 of 11



Signs of an Engine Overheat

- If as a driver, you are unaware that the temperature gauge has increased, the longer you continue to drive the car, the more damage will be caused to the engine.
- When major damage has been caused to the engine due to the overheat, an auditory alert (chime) will inform you that there is a problem with the engine.
- However, once this alert occurs, it is a sign that the engine has heated to the point where major damage has been done, leading to an unwanted engine failure.
- Engine failure can be avoided by keeping an eye on the temperature gauge as you monitor your speed through traffic.

5 of 11



An engine may overheat due to one of the following two reasons:

1. A failure in the cooling system which can be caused by any of the following:
 - Loss of coolant
 - Coolant line blockage (impedes the coolant liquid to flow)
 - Faulty water pump
 - Cooling fan failure
2. High load
 - Occurs when an engine has to work harder than usual because of a car's interaction with environmental conditions.
 - Example: Climbing up an incline or hill on a hot day

6 of 11



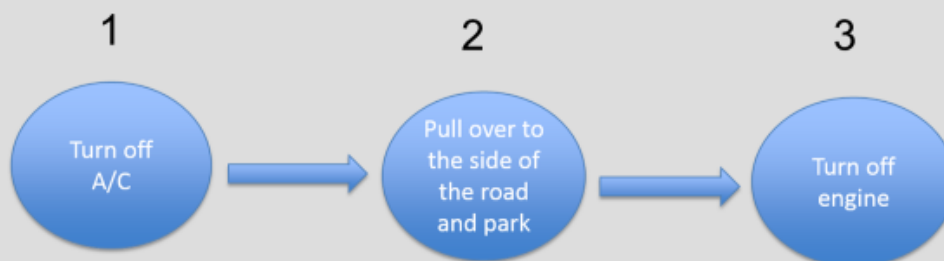
1. Failure in the Cooling System

- As you drive, you may not know if a failure in the cooling system is the cause of the overheat until the system is inspected after opening the hood of the car.
- However, when all of the following conditions are met, it is safe to assume that the engine overheat is due to a failure in the cooling system:
 - Ambient temperature conditions are between 70-84 degrees Fahrenheit
 - Driving on a flat surface that does not apply too much load on the engine (e.g., flat roads or non-incline roads)
- When all the conditions described above occur, and the engine temperature gauge has increased, the appropriate response would be to:
 - **Turn off the A/C, pull over to the side of the road, park safely, and turn off the engine**
- If no appropriate response is taken, the car may become harder to drive (increased drag) and the engine will fail.

7 of 11



When an engine is overheating due to a failure in the cooling system, you should:



8 of 11



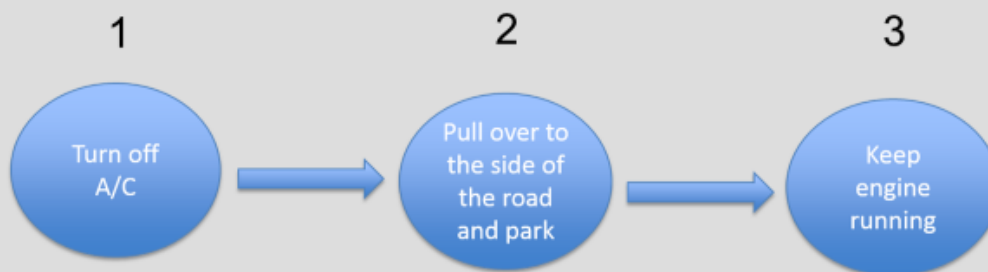
2. High Load

- While driving, there may be instances in which an engine has to work harder than usual because of a car's interaction with environmental conditions (high ambient temperature, hills or inclines). In this case, it is not likely that there is a failure in the cooling system but that the car needs to cool down due to high load.
- When all of the following conditions are met, it is safe to assume that the engine overheat is due to high load:
 - Ambient temperature conditions are 85+ degrees Fahrenheit (high heat weather)
 - Driving on a long steep incline or hill that applies too much load on the engine
- When all the conditions described above occur, and the engine temperature gauge has increased, the appropriate response would be to:
 - **Turn off the A/C, pull over to the side of the road, park safely, and leave the engine running (this allows the engine to cool down)**
- If no appropriate action is taken, the car may become harder to drive (increased drag) and the engine will fail.

9 of 10



When an engine is overheating due to high load, you should:



10 of 11



End of Training

- Please feel free to review the training slides again.
- Otherwise please inform your experimenter that you have completed the training.

APPENDIX H: MENTAL SIMULATION TRAINING

Mental Simulation Training

You are now going to participate in a mental simulation training in which you will be asked to imagine responding to a specific scenario. Please try to imagine yourself performing the actions you think are necessary to respond (e.g., moving, talking). Please continue when you are ready to begin.

Imagine that you are taking out your partner for dinner at a new 5-star fancy restaurant in town. You and your partner arrive to the restaurant and see the elegant architecture, the valet parking, and people dressed formally. When you enter the restaurant you begin to realize that it is not a common type of 5-star restaurant, as it presents itself differently from what you have seen in past experiences. As you scan the place for cues you observe the following items:

- Cash registers
- Large menu board on display behind cash register
- Servers Refreshment stations (e.g., Coke or Pepsi products)

You have five minutes to determine a course of action. Please describe, as detailed as possible, how you would respond in this situation using the items listed above. Specifically, talk about the sequence of actions (from the moment you walk in, to the moment you leave) you would take in order to have a successful dinner at this type of restaurant. Please inform the experimenter when you are ready to begin.

Please indicate why you chose to respond in this way:

1. What were your assumptions about the situation?
2. What is your biggest concern about your plan of action?
3. What items from the briefing were important to you and why?
4. What would you have done differently if other restaurant items/individuals were present or not present?

APPENDIX I: SINGLE SCRIPT DECLARATIVE KNOWLEDGE TEST

Declarative Knowledge Test (Single Script Condition)

Please answer the following items based on the information learned in the previous training slides.

Why is the cooling system important?

- a) Works to control the engine's temperature and helps to keep it at an optimal level to avoid overheating.
- b) Helps to produce more heat to improve the engine's efficiency.
- c) Continuously increases the engine's temperature to achieve overheating.

The temperature gauge rising towards the "hot area" is not a sign of an engine overheating.

- a) True
- b) False

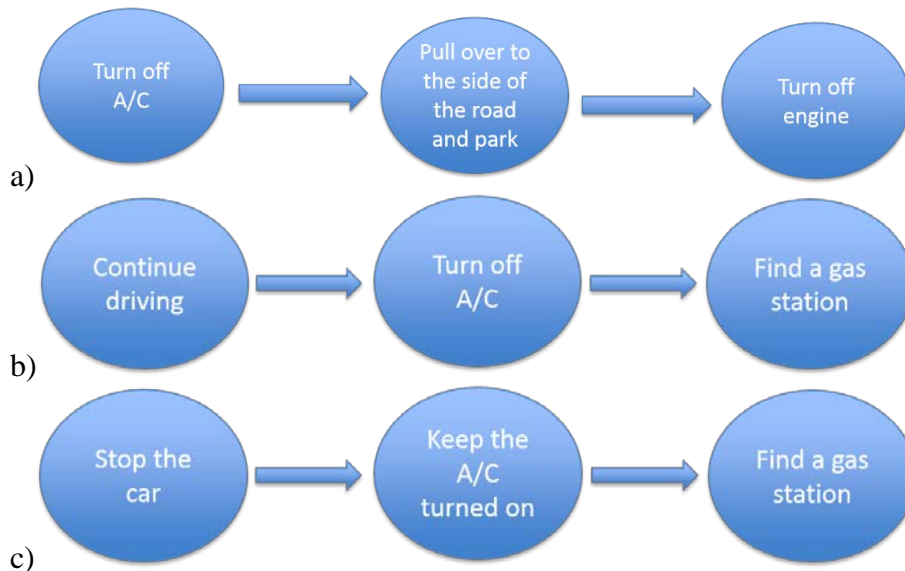
A car may overheat because of a failure in the cooling system.

- a) True
- b) False

It is safe to assume that there is a failure in the cooling system if the following conditions are met:

- a) Ambient temperature between 70-84 degrees Fahrenheit
- b) Driving on a flat road (no incline)
- c) All of the above

What actions steps should be performed when an engine overheats due to a cooling system failure?



APPENDIX J: TWO SCRIPTS DECLARATIVE KNOWLEDGE TEST

Declarative Knowledge Test (Two Scripts Condition)

Please answer the following items based on the information learned in the previous training slides.

Why is the cooling system important?

- a) Works to control the engine's temperature and helps to keep it at an optimal level to avoid overheating.
- b) Helps to produce more heat to improve the engine's efficiency.
- c) Continuously increases the engine's temperature to achieve overheating.

The temperature gauge rising towards the "hot area" is not a sign of an engine overheating.

- a) True
- b) False

A car may overheat because of a failure in the coolant system or due to carrying a high load.

- a) True
- b) False

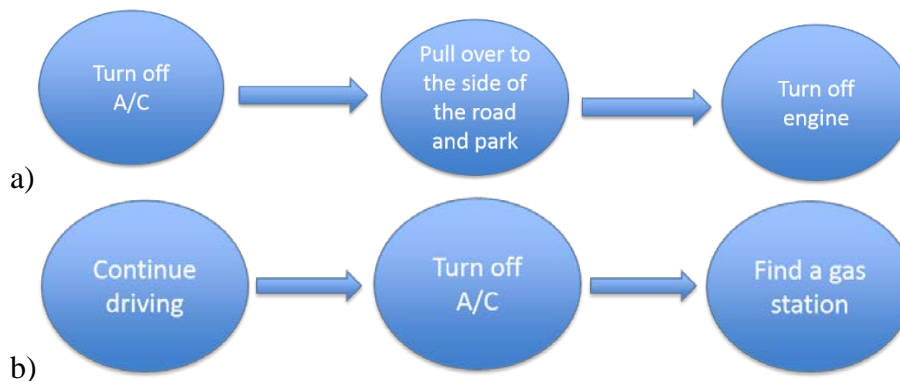
It is safe to assume that there is a failure in the cooling system if the following conditions are met:

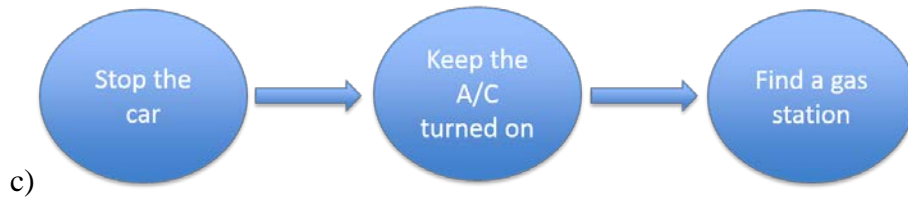
- a) Ambient temperature between 70-84 degrees Fahrenheit
- b) Driving on a flat road (no incline)
- c) All of the above

If overheating occurs due to high load it may be due to which of the following:

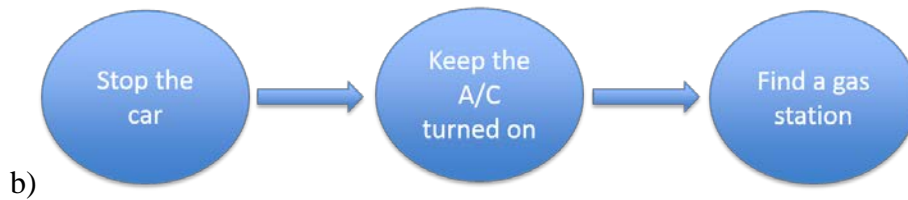
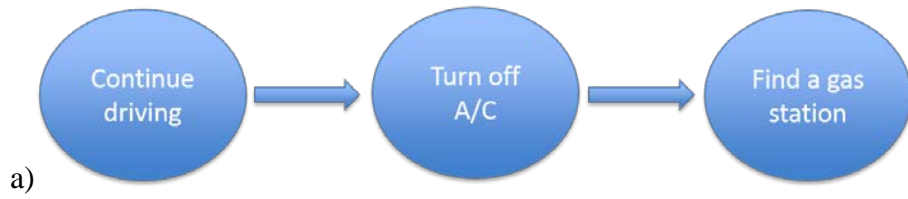
- a) Ambient temperature between 70-84 degrees Fahrenheit
- b) Climbing up a long hill or incline in high heat (85+ degrees Fahrenheit)
- c) Driving on a highway

What action steps should be performed when an engine overheats due to a cooling system failure?



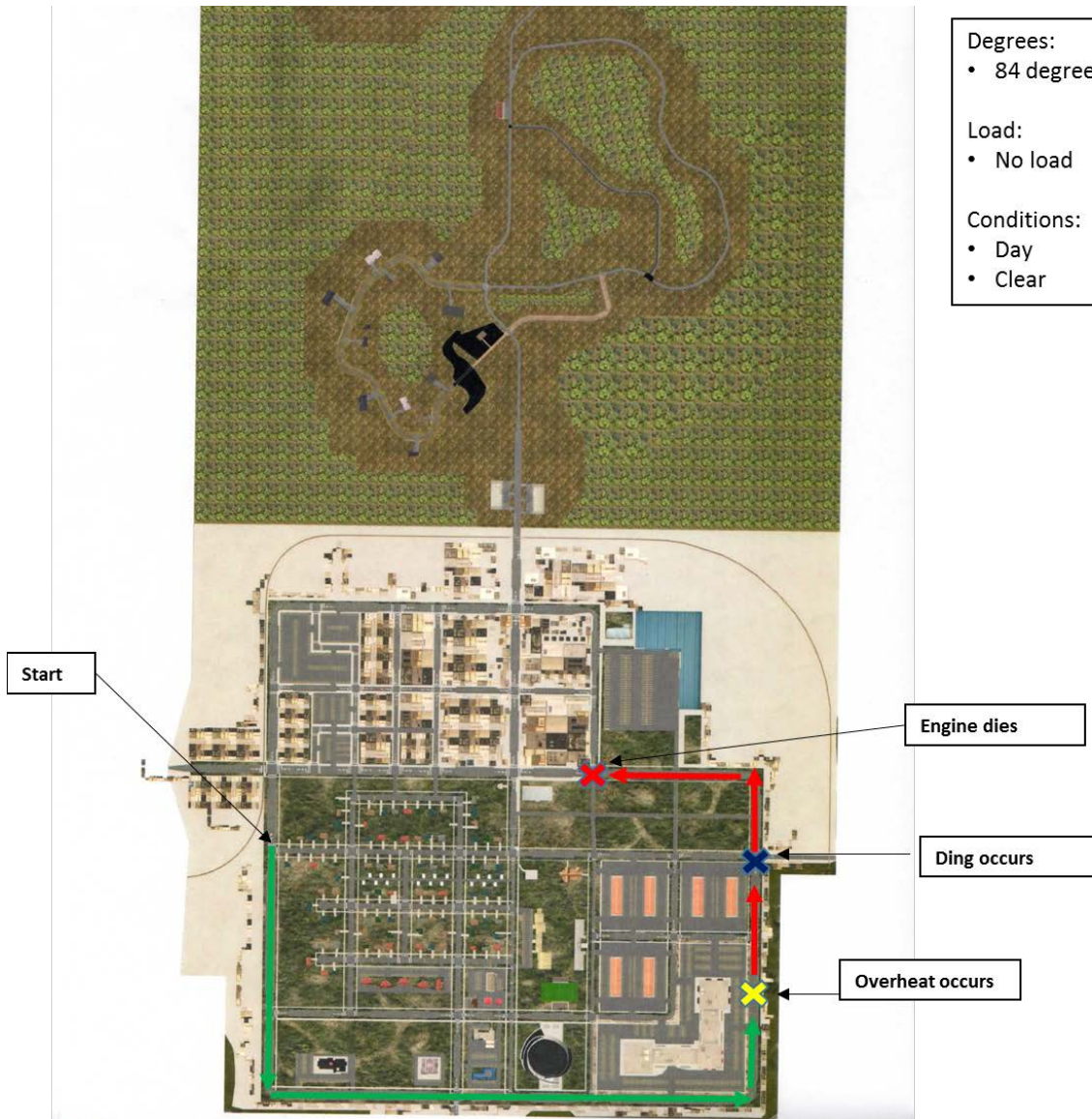


What actions steps should be performed when an engine overheats due to high load?



APPENDIX K: ENGINE OVERHEAT SCENARIOS

Scenario 1



Degrees:
• 84 degrees Fahrenheit

Load:
• No load

Conditions:
• Day
• Clear

Start

Engine dies

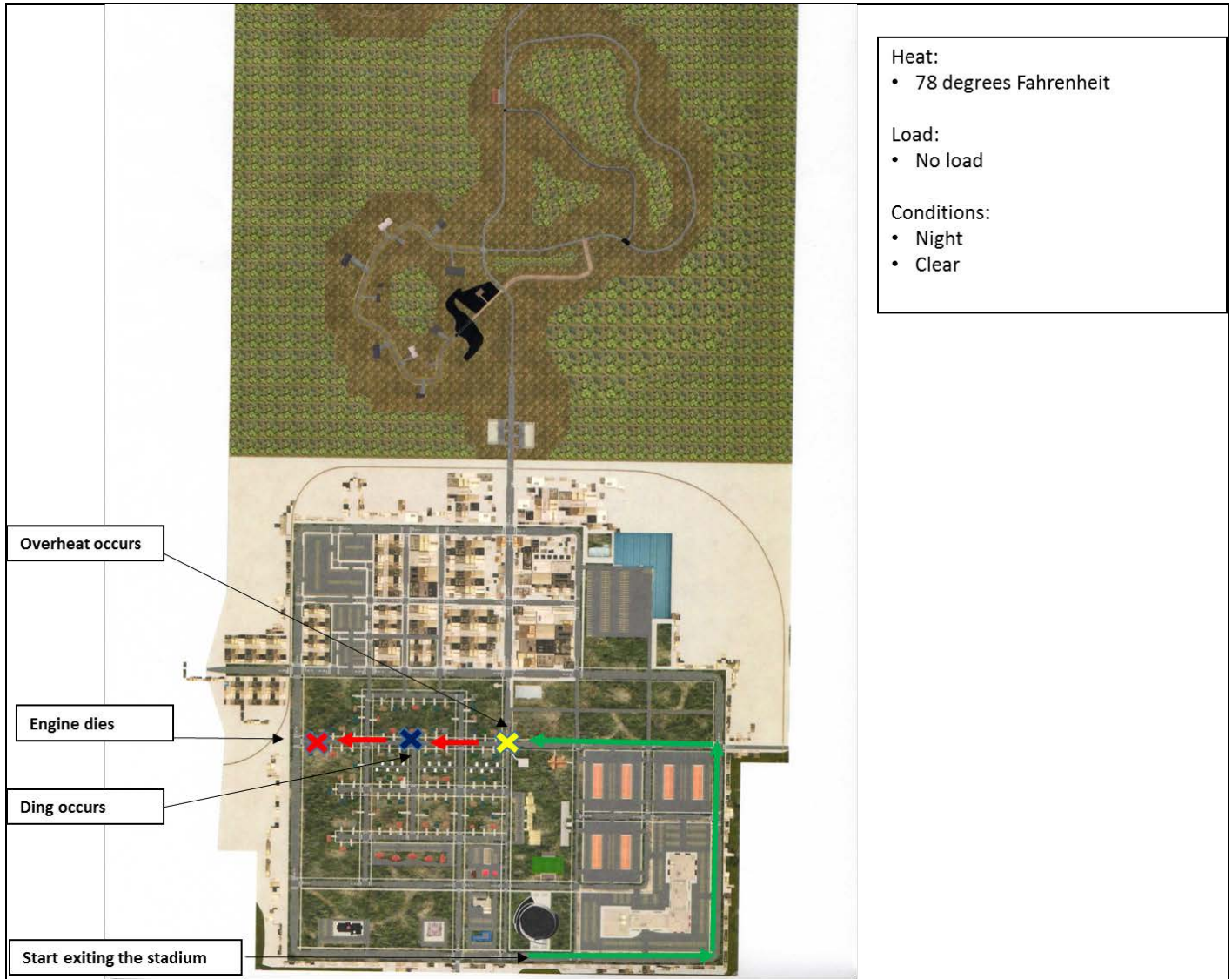
Ding occurs

Overheat occurs

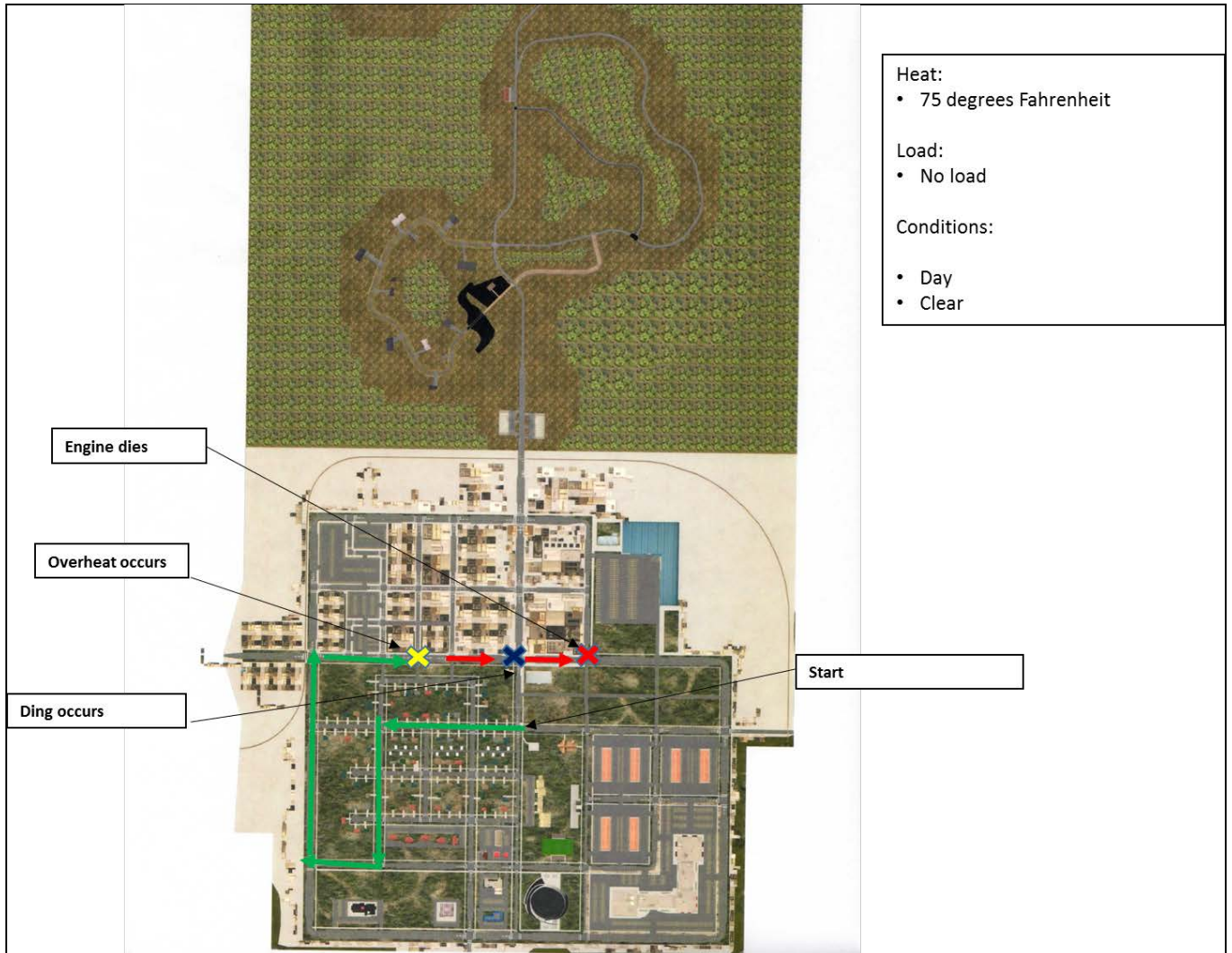
Scenario 2



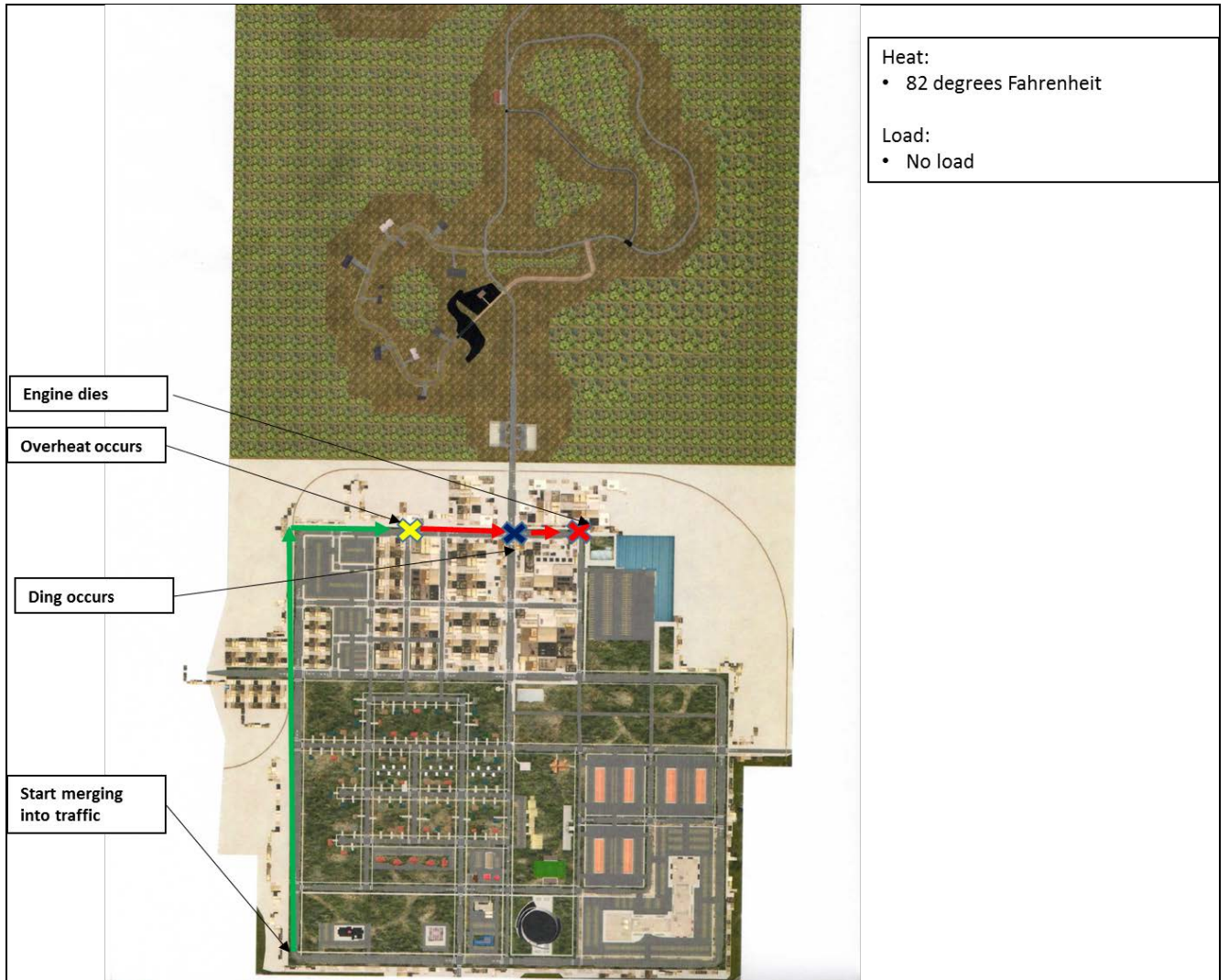
Scenario 3



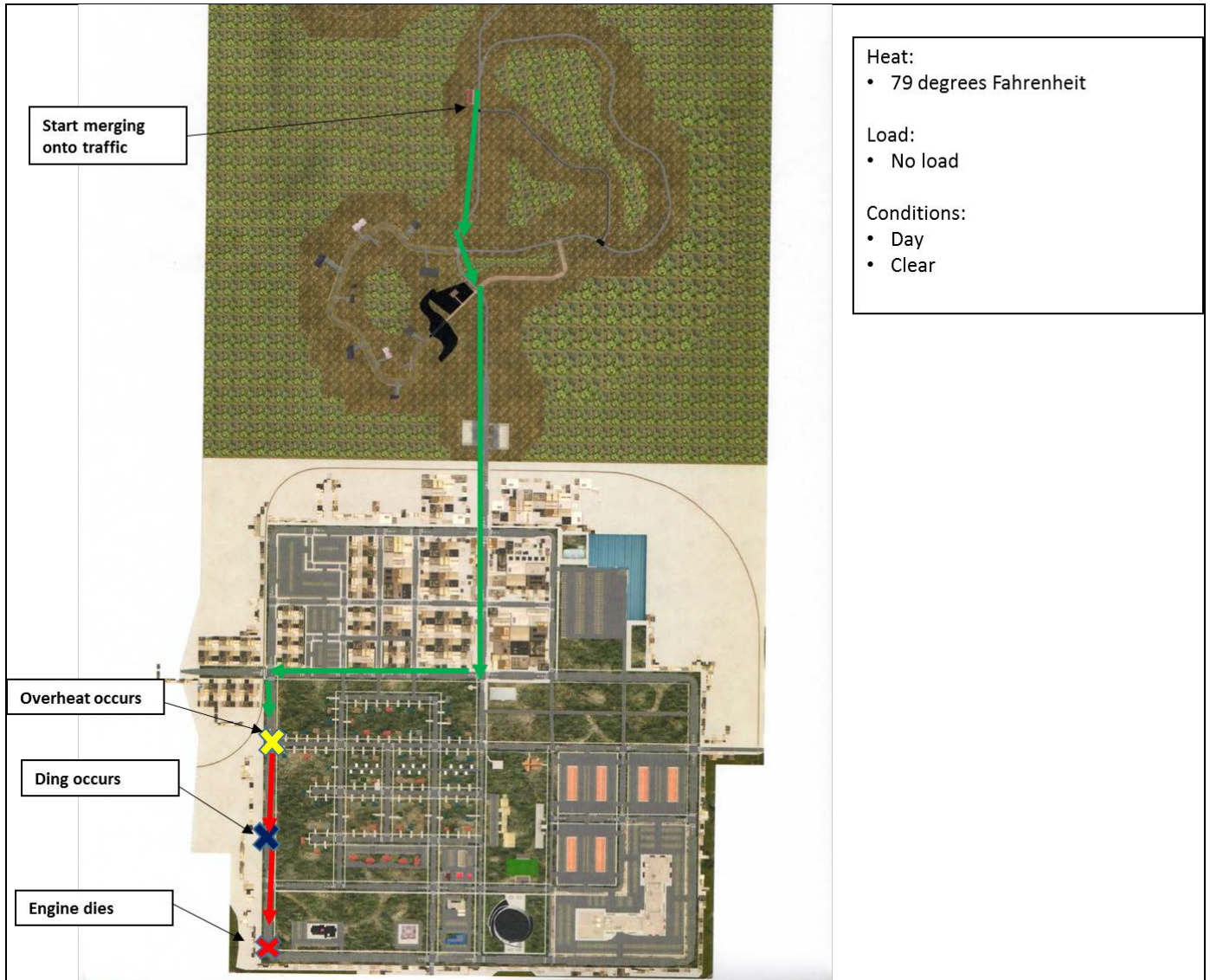
Scenario 4



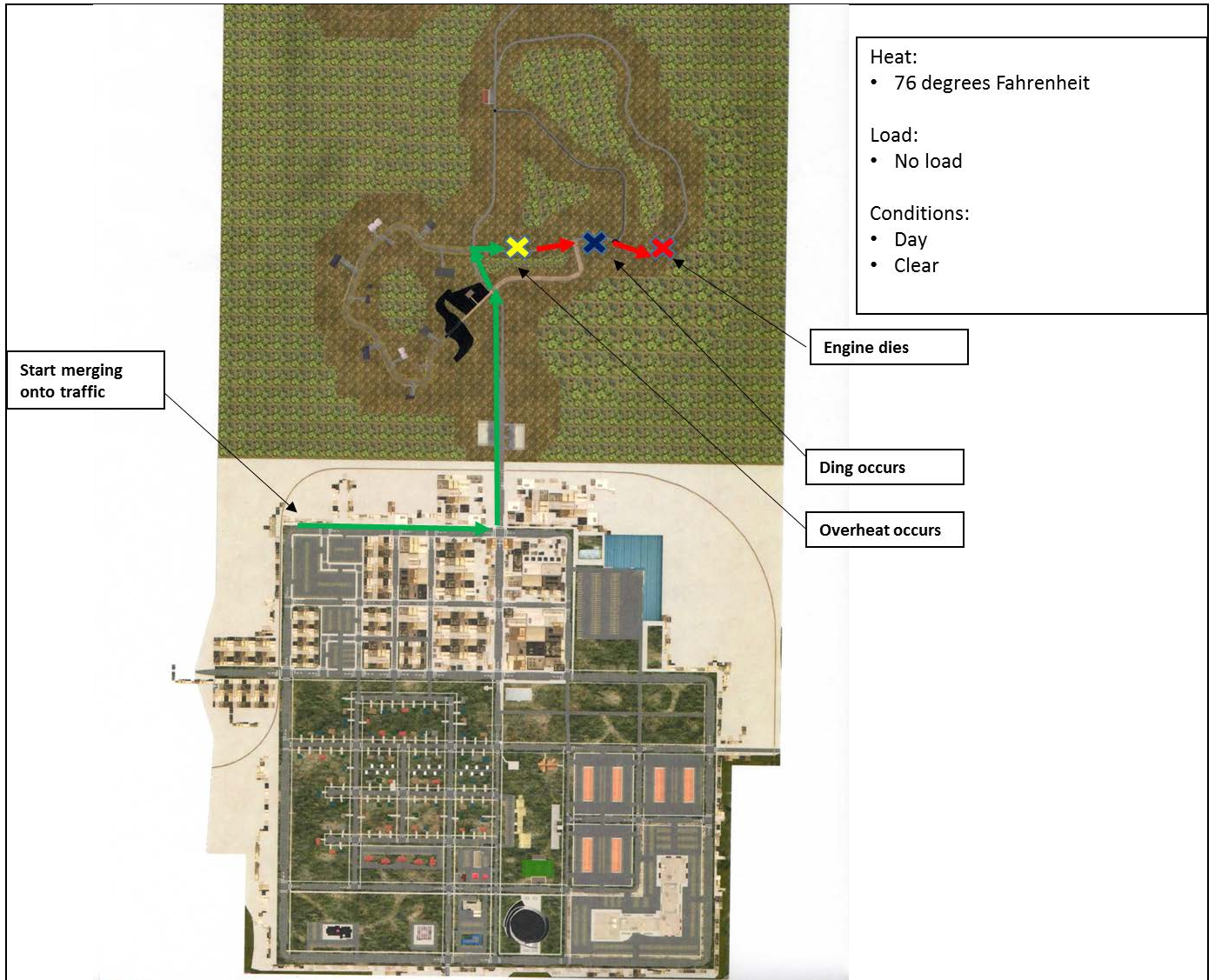
Scenario 5



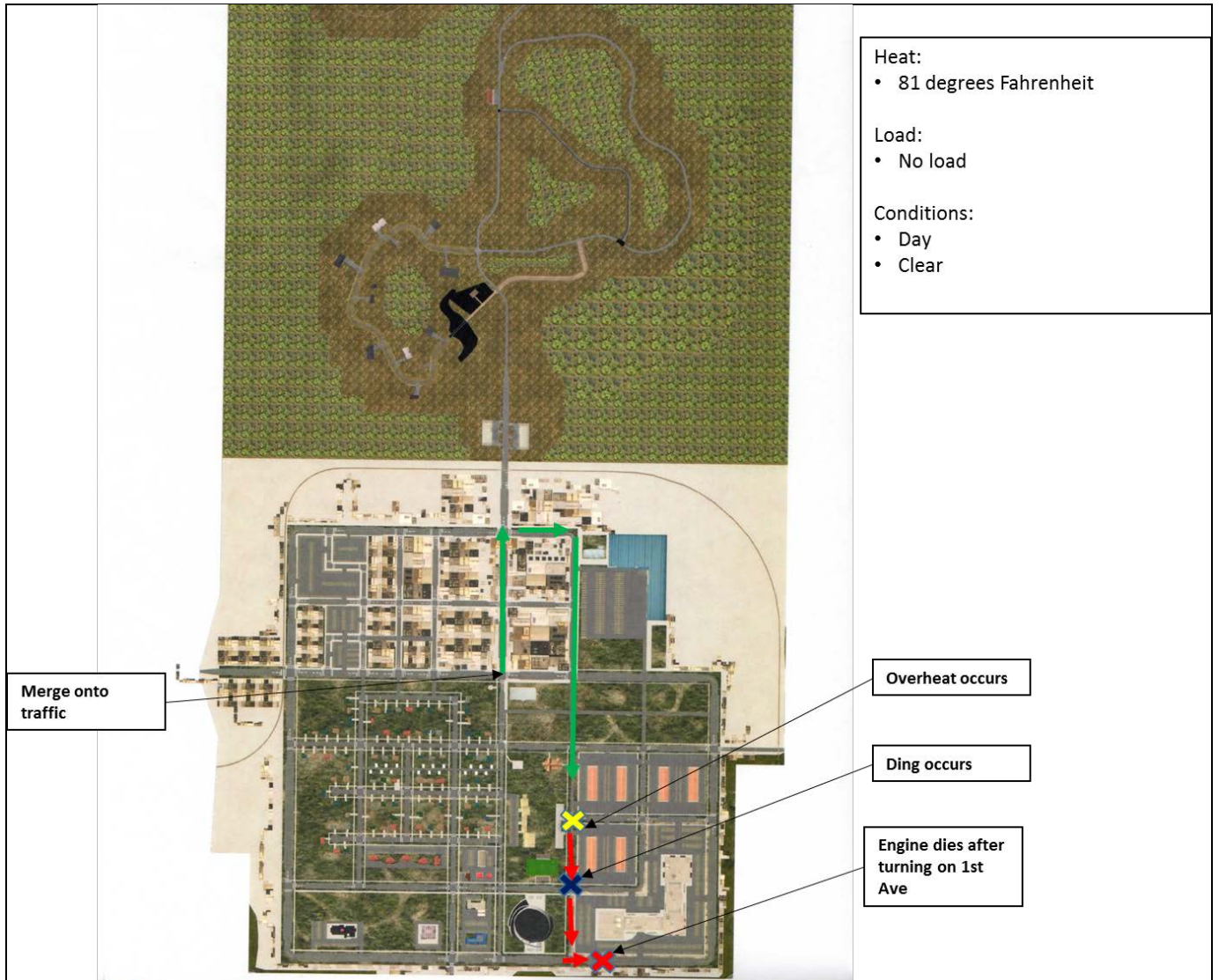
Scenario 6



Scenario 7



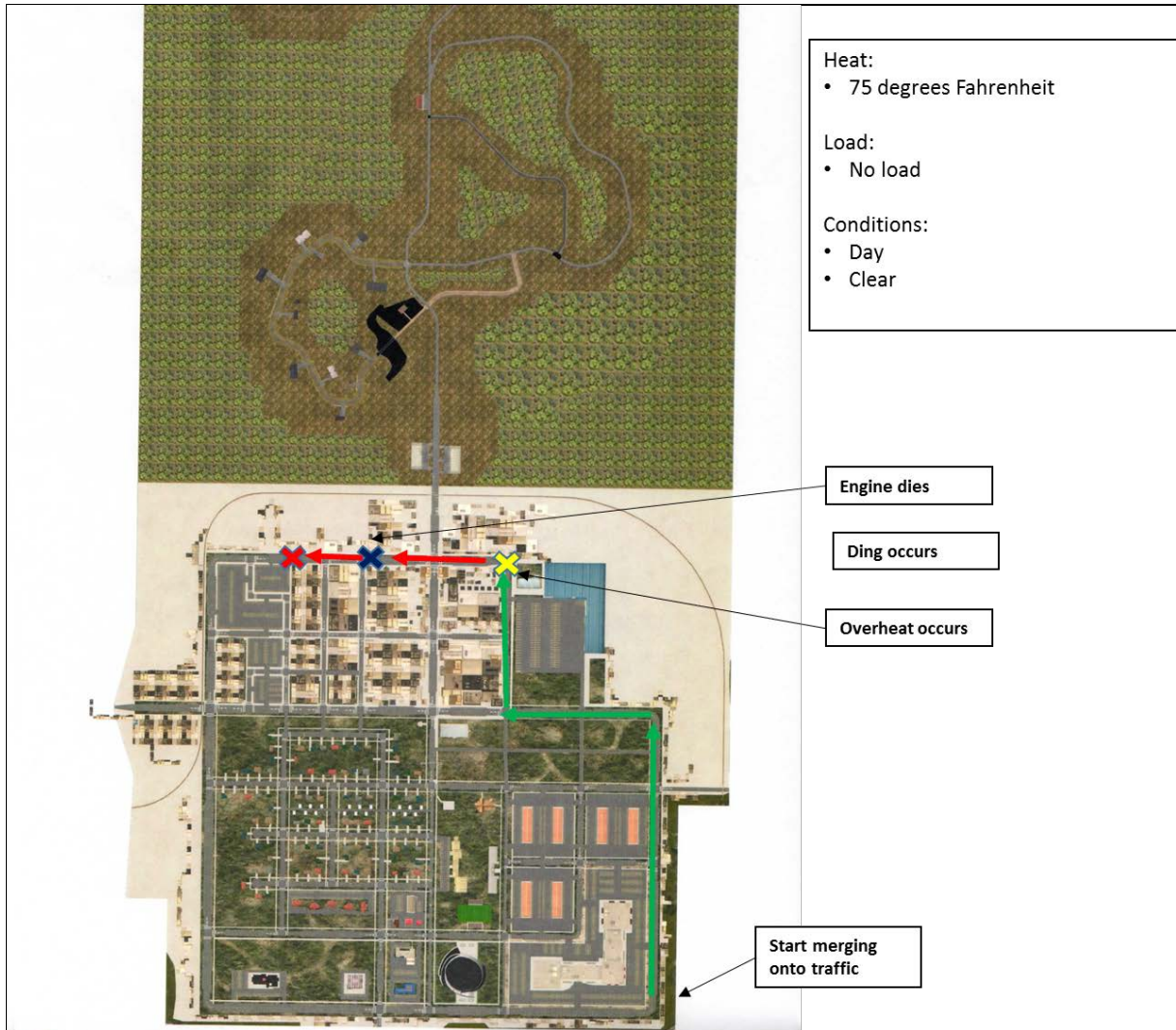
Scenario 8



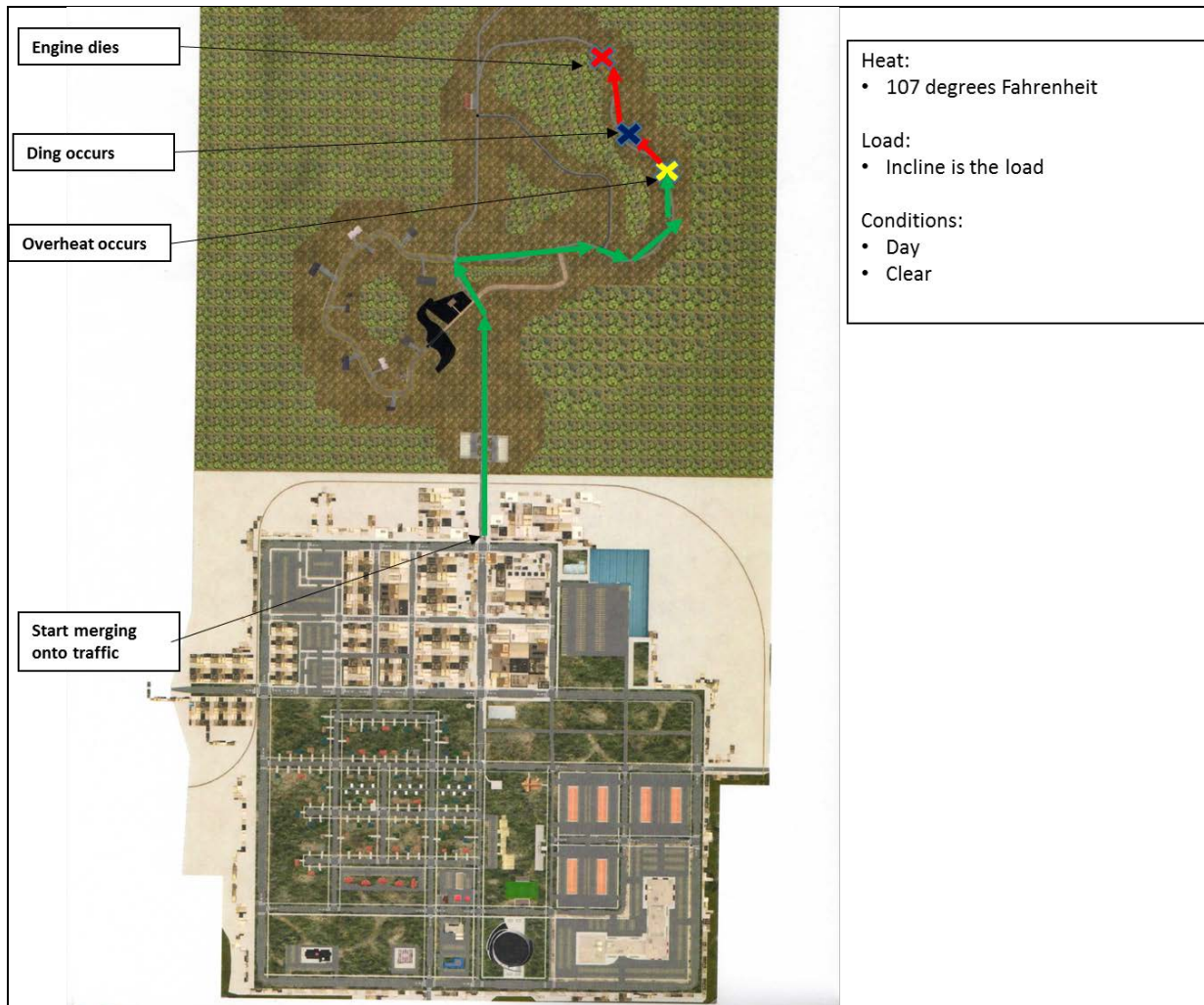
Scenario 9



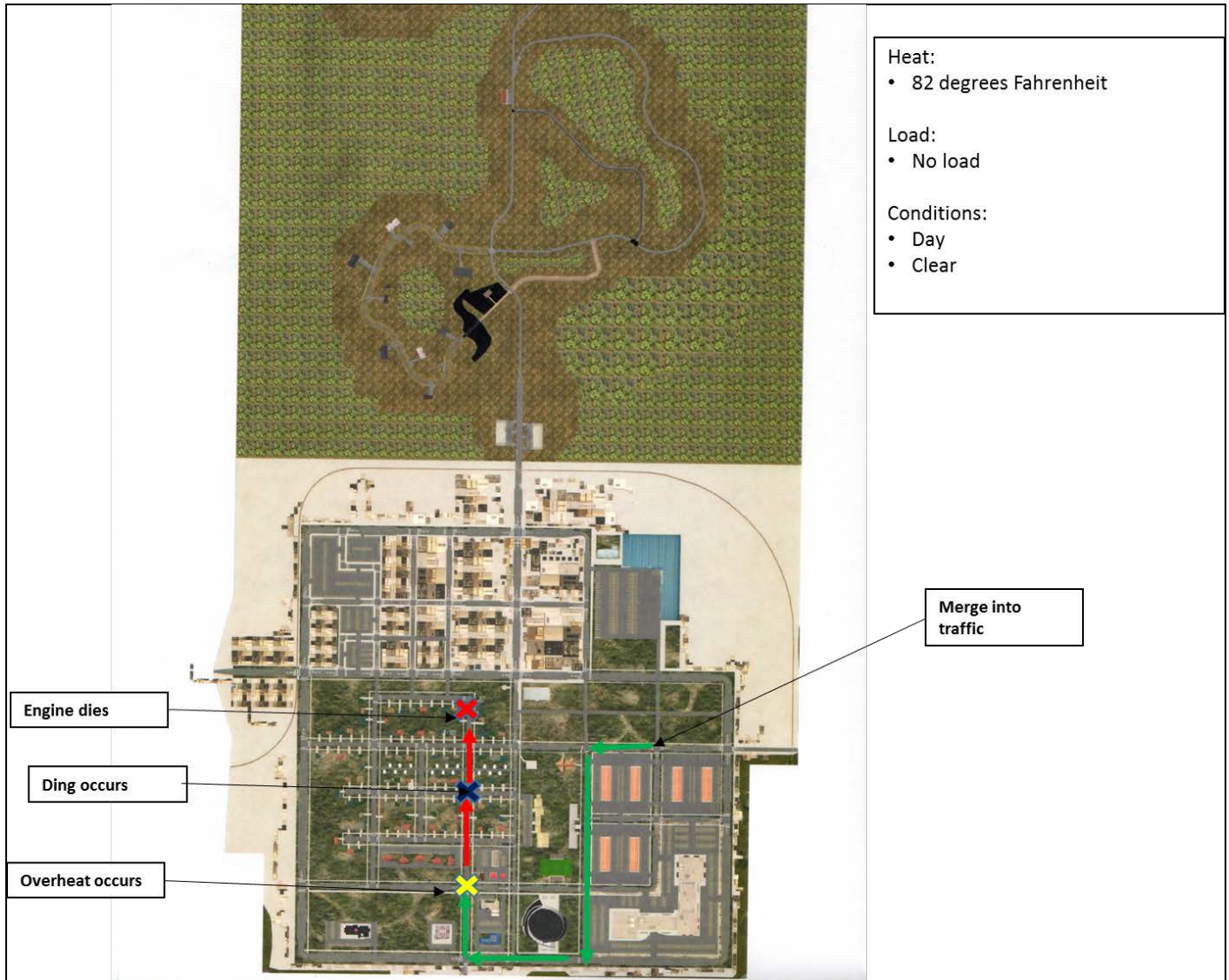
Scenario 10



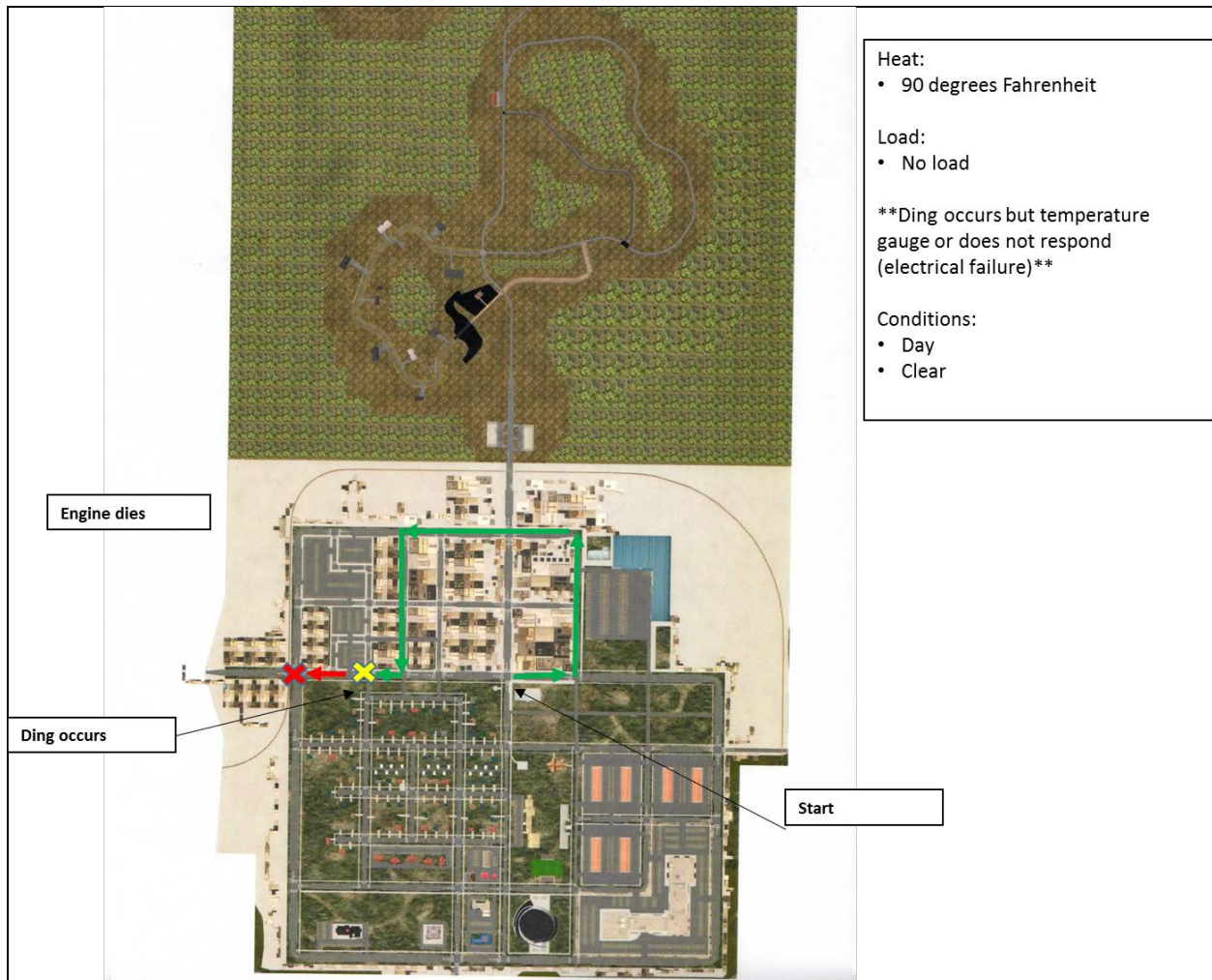
Scenario 11



Scenario 12



Scenario 13



APPENDIX L: SIMULATOR SICKNESS QUESTIONNAIRE

No _____

Date _____

SIMULATOR SICKNESS QUESTIONNAIRE

Kennedy, Lane, Berbaum, & Lilienthal (1993)***

Instructions : Circle how much each symptom below is affecting you right now.

1. General discomfort	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
2. Fatigue	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
3. Headache	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
4. Eye strain	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
5. Difficulty focusing	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
6. Salivation increasing	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
7. Sweating	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
8. Nausea	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
9. Difficulty concentrating	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
10. « Fullness of the Head »	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
11. Blurred vision	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
12. Dizziness with eyes open	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
13. Dizziness with eyes closed	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
14. *Vertigo	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
15. **Stomach awareness	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
16. Burping	<u>None</u>	<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>

* Vertigo is experienced as loss of orientation with respect to vertical upright.

** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Last version : March 2013

***Original version : Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lilienthal, M.G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology*, 3(3), 203-220.

APPENDIX M: SELF-EFFICACY QUESTIONNAIRE

Self-efficacy Questionnaire

Instructions. Please answer the following items by indicating on a scale of 1 to 7 how strongly you agree or disagree each of them.

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

- Strongly Disagree (1)
- 2
- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

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

- Strongly Disagree 1
- 2
- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

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

- Strongly Disagree 1
- 2
- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

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

- Strongly Disagree 1
- 2
- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

I expected to do well on this task.

- Strongly Disagree 1
- 2

- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

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

- Strongly Disagree 1
- 2
- 3
- Neither Agree nor Disagree 4
- 5
- 6
- Strongly Agree 7

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