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ASSESSING IF MOTIVATION IMPACTS GENERAL AVIATION PILOTS' PERSISTENCE IN VARYING WEATHER CONDITIONS

By

Sabrina Woods

A Dissertation Submitted to the College of Aviation
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy in Aviation

Embry-Riddle Aeronautical University
Daytona Beach, Florida
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ASSESSING IF MOTIVATION IMPACTS GENERAL AVIATION PILOTS' PERSISTENCE IN VARYING WEATHER CONDITIONS

By

Sabrina Woods

This Dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. Scott R. Winter, and has been approved by the members of the dissertation committee. It was submitted to the College of Aviation and was accepted in partial fulfillment of the requirements for the
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ABSTRACT

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Title: **Assessing If Motivation Impacts General Aviation Pilots' Persistence in Varying Weather Conditions**

Institution: Embry-Riddle Aeronautical University

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Continued flight under visual flight rules into instrument meteorological conditions is the predominant cause for fatal accidents by percentage, for general aviation aircraft operations. It is possible that a pilot's motivation or reason for flying will override other safer, more logical courses of action when a hazard presents itself. The decision appears to stem from a willingness to persist in a course of action despite factors that indicate an alternate and safer course is warranted. This research addresses what is currently presumed about the decision to continue flying under visual flight rules into instrument meteorological conditions and marries those ideas with the extensive studies on how motivation theoretically affects the decision-making process.

The research used a quantitative factorial experimental design and explored what bearing, if any, does type of motivation, or meteorological condition, or the interaction of the two have on a pilot's willingness to persist in visual flight rule into instrument meteorological conditions. The researcher applied fundamental motivation theory and aviation regulation in the development of scenarios that were used to assess a pilot's willingness to persist in unsafe weather conditions, and to determine what role motivation and the weather conditions might have played in that decision. A 3x3 factorial design was followed, and the method of analysis was a two-way mixed analysis of variance.

The independent variable meteorological condition indicated a significant effect on the dependent variable willingness to persist, and the independent variable motivation did not indicate a significant effect. The interaction between meteorological condition and motivation resulted in a significant effect on the dependent variable, particularly in the marginal weather condition, although with a low effect size. This result suggests that those who are motivated to fly for a specific reason or reasons might be more willing to persist over those who have no real reason to be flying. A recommendation for future research is that the experiment be replicated in a direct observation experimental design in either a full or partial motion simulator.

Further defining how motivation and meteorological conditions influence aeronautical decision-making can change the way aviation safety advocates, academics, regulators, and industry approach the issue. The results of this research could help determine what part of aeronautical decision making is objective and what is more subject to a person's base desires.

DEDICATION

It is said a mother walks in front of her child in times of peril, beside in times of uncertainty, and behind in times of triumph. My mother has been with me every step of the way. Without her there would be no triumph. I owe my mental wellness, willingness to continue, and overall perseverance to a mamma bear who knows just when to lead, when to push, and when to get out of the way. Thanks mom.

I also dedicate this to the family prayer warrior, my sister, who definitely knows how to “get them up” when needed. And boy, were they needed!

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Dr. Bartlett had the additional heavy lift of also serving as second-mom and has done so since I was twelve years old and first showed up at her door. She got a new babysitter, and I got a lifelong personal and professional confidant.

Susan Parson is probably The. Most. Fierce person I know in the entire Federal Aviation Administration. She, above all others, has taught me how to remain patient, strike when the iron is hot, and bend the situation to good by the sheer force of my will. There is absolutely no way I would be where I am in my career without her insight and wisdom which has always been dispatched with intellect, savvy, and a healthy dose of snark.

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CHAPTER I

INTRODUCTION

Each year, the Joseph T. Nall Report provides detailed analysis of general aviation (GA) accident data and safety trends. The most recent report indicated there were 1,163 non-commercial, fixed-wing accidents in 2014 (Kenny, Knill, Sable, & Smith, 2017). While less than three percent of all accidents occurred in instrument meteorological conditions (IMC), more than 70 percent of the accidents that occurred in IMC were fatal compared to 15 percent of those that occurred within visual meteorological conditions (VMC) (Kenny et al., 2017). As such, the National Transportation Safety Board (NTSB) has determined that continued flight into inclement weather is a major safety hazard within GA (NTSB, 2014). The following are all general aviation accidents selected from the NTSB's accident and incident database. The database contains preliminary and final factual information about civil aviation accidents and selected incidents within the United States.

In 2004, an aeromedical airplane collided with trees and mountainous terrain while attempting a cruise descent toward the destination airport. The three-man crew perished in the mishap. The flight, which was flying under visual flight rules (VFR) at the time, had departed to pick up a patient when the controller provided the pilot with the current weather, reporting a visibility of 1 and 3/4 miles in heavy rain and mist with scattered clouds at around 1,700 feet in altitude (NTSB, 2006). The NTSB determined the probable causes for the accident to be the pilot's disregard for the weather advisory, the likely encounter with marginal VFR or IMC, and the decision to persist in flight into those conditions (NTSB, 2006).

In 2011, shortly after departure for a VFR cross-country sightseeing flight over ocean waters, a Cessna A185F encountered IMC. Weather radar data and satellite imagery revealed that the tropical wave had produced thunderstorms with heavy rain and 47 knot winds (NTSB, 2012). The aircraft was eventually recovered from the ocean. It was not equipped for instrument flight nor was there any record of the pilot requesting a weather briefing at any time during the flight. The pilot and four passengers were killed in the mishap (NTSB, 2012).

Lastly, in 2015, a pilot attempted a solo VFR nighttime training flight despite the fact that the pilot's certified flight instructor (CFI) had not certified the pilot for this phase of training, believing the pilot needed more practice with a CFI onboard. The flight was conducted on a dark, moonless night, under an overcast ceiling, and over the ocean. About seven minutes into the flight, the pilot encountered IMC and requested assistance from air traffic control (ATC). Despite ATC's best efforts in trying to vector the pilot, the aircraft impacted the ground at a high rate of speed, and the pilot was killed (NTSB, 2016).

The three case studies vary slightly in circumstances. From the aircrews' knowledge of impending IMC, to the capability and certification status of the pilots and the aircraft, each differs in the sequence of events that resulted in the mishap occurring. What remains consistent throughout each of these cases, however, is that the pilots filed for and were operating under visual flight rules, encountered instrument meteorological conditions, and failed to navigate away from or land the aircraft after doing so.

Throughout history, motivation theory has been applied extensively to domains such as education, goal achievement, and job satisfaction, with the intent to quantify how human behavior and desires might translate into action and decision making. Foundational motivation theorists such as Maslow (1943, 1970), Reiss (2004), Herzberg (1966, 1967), and McClelland (1988) have demonstrated that the manner by which a person is motivated has a direct effect on his or her decision-making process. Their theories have been revalidated by further studies by

Estes and Polnick (2012) whose study investigated how motivation might impact productivity in the form of published works by tenured university professors. The pair determined that “declines in productivity can be attributable to the idea that faculty members simply do not value the outcomes from sustaining higher levels of productivity” (Estes & Polnick, 2012, p. 6) which in turn negatively affects their desire (motivation) to produce more works. Moore, Grabsch, and Rotter (2010) were able to conclude which incoming freshman students would be motivated to participate in voluntary leadership learning communities by applying McClelland’s Achievement Motivation Theory to responses from a survey. Lastly, Deci and Ryan’s (2000, 2014) self-determination theory (SDT) is built upon the understanding that human motivation must consider the innate physiological and psychological needs that Maslow (1943, 1970) first introduced.

While motivation theory has been applied to education, self-actualization, and job satisfaction studies with marked success, these theories have not often been directly applied to the aviation domain; therefore, knowledge is limited in how motivation might affect aeronautical decision making (ADM). Past research on VFR into IMC has largely focused on pilot skill level, the ability to maintain situation awareness, and risk assessment. Using fundamental motivation theories, the researcher has gathered attitudinal data from general aviation pilots about their willingness to persist in VFR into IMC in order to better understand the affect motivation and meteorological condition has on one’s willingness to persist.

Azjen and Fishbein (1980, 1991, 2005) have penned numerous studies establishing the link between a person’s attitude and their exhibited behavior. They determined that a higher correlation between attitude and behavior can be achieved so long as a particular level of specificity was met with regards to the subject. Fishbein and Azjen (1975) offered four factors to be taken into consideration by any researcher attempting to use the collection of attitudinal data to further hypothesize how the subject might actually act in reality. The factors ─ *action, time, context*, and *target* ─ are indicative of the behavior that is to be performed, when and for how long the behavior is to be performed, the location or circumstances surrounding the performance, and the object the behavior targets, respectively.

Using these factors, for the purpose of the study, attitudinal data was collected from the participants and focused on their perceived willingness to persist (*action*), on a cross country flight (*time*), in varying meteorological conditions (*context*), given a specific motivational category (*target*). Chapter 1 discusses the background, nature, and significance of the study. It delineates the problem, research questions, and hypotheses and examines what some of the delimitations, limitations, and assumptions associated with the study are. Chapter 1 also provides a ready reference for common acronyms and definitions used throughout the research.

Statement of Problem

Currently, continued VFR flight into IMC is one of the most fatal cause for accidents by percentage in GA aircraft. It is possible that the motivation or reason for flying is capable of overriding other safer, more logical courses of action when a hazard presents itself. Continued VFR into IMC appears to stem from a willingness to persist in a course of action despite factors that indicate an alternate and safer course is warranted.

In the three mishap synopses listed previously, there are indicators, as defined by Maslow (1943, 1970), Herzberg (1966, 1967), Reiss (2004), and Deci and Ryan (2000, 2008, 2014) of intrinsic and extrinsic motivators possibly influencing the decision-making process. One could presume the desire to rescue the patient, the desire to perform for the tourists, and the desire to achieve a certificate, respectively, overrode the pilots' ability to correctly assess and diffuse the dangerous situation. Risk-based decision making is considering all aspects of a situation in order to determine if the hazards present might cause harm (Slovic & Peters, 2006). An inherent part of risk assessment is the willingness to persist and ultimately in what motivates the individual. At this time, there has been relatively little research in what motivates pilots to proceed into inclement weather despite the danger. Further, due to the high propensity for fatal mishap, available data as to what motivated the individual is also limited.

Purpose Statement

Out of the 22 accidents that were attributed to VFR into IMC in 2014, 20 resulted in one or more fatalities. That is a lethality rate of 91 percent. This rate is consistent to the previous years which were recorded in the Joseph T. Nall Reports as 73 percent (2013), 95 percent (2012), and 93 percent (2011). Although much research has been done identifying VFR into IMC as a causal factor in mishaps, there are gaps in the research regarding studies that help determine what could have influenced the decision-making process. Researchers have not yet isolated what compels a pilot to persist. Further, theorists have not applied fundamental motivation theories to the aeronautical decision-making process. While several human factors and aviation safety researchers such as O’Hare and Owen (1999), Wilson and Sloan (2003), and Goh and Wiegmann (2001a) have identified motivation as a key part of the aeronautical decision-making process, their studies have not gone so far as to apply the behavioral subcomponents of motivation that other domains have had great success in developing.

The purpose of this study was to conduct a quantitative factorial experimental design on a minimum of 180 GA pilots to determine how different motivation and different types of meteorological conditions might affect a pilot’s willingness to persist in flight into meteorological conditions. The researcher applied fundamental motivation theory and aviation regulation in the development of scenarios that were used to assess a pilot’s willingness to persist in unsafe weather conditions, and to determine what role motivation and the weather conditions might have played in that decision.

Significance of the Study

Finding out whether or not the interactions of motivation and meteorological condition have an influence on willingness to persist VFR into IMC could change the way aviation safety advocates, academics, regulators, and industry approach the subject. It would add credence to the theory that aeronautical decision making is more subject to a person's base desires than previously realized.

Currently, much of the focus on mitigating the VFR into IMC phenomenon has been on developing new weather forecasting and dissemination technologies. The rationale behind this is that if a pilot were to have the tools necessary to better predict meteorological conditions, he or she might then avoid inclement weather. While the reasoning is well-founded, the fixed accident rates do not support the theory that better weather applications help decrease VFR into IMC mishaps. The current study suggests that the decision to continue is affected by more than just the available forecast at the time.

Understanding how different motivations might affect ones' willingness to persist will help to refocus and build new platforms for pilot education, training, outreach, and prevention with the ultimate goal of decreasing the amount of weather-related accidents and the fatality rate associated with them.

Research Question and Hypotheses

The literature does not support directional hypotheses, and therefore non-directional ones are proposed. The research sought to answer the following research questions and hypotheses:

RQ1: What bearing does type of motivation (intrinsic, extrinsic, or no motivation) have on a pilot's willingness to persist in VFR flight into IMC?

H_{01} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

H_{a1} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

RQ2: What bearing does type of meteorological conditions (visual, marginal, instrument) have on a pilot's willingness to persist in VFR flight into IMC?

H_{02} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

H_{a2} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

RQ3: What will be the possible interaction between type of motivation and type of weather conditions on a pilot's willingness to persist in VFR flight into IMC?

H_{03} – There is no significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

H_{a3} – There is a significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

Delimitations

When conducting research, sampling is a key challenge. In order to garner the largest sample size possible while remaining cost effective and efficient, it was determined a sample of convenience would be used. Participants were recruited via the Curt Lewis Flight Safety newsletter and *Federal Aviation Administration's Safety Briefing Magazine*, two popular online and print mediums whose main audiences are commercial and general aviation pilots. The delimitation allowed for the structured recruitment of participants, but it is acknowledged that it also limited the generalizability of the research to those types of pilots that subscribe to these two safety-related publications. In addition, only non-Part 121/135 pilots were asked to participate in the study to ensure the target audience — those who operate strictly as general aviation — was reflected.

The experiment scenario was purposefully delimited to VFR flight in an attempt to standardize responses and minimize the effects of pilots who may be instrument rated. This choice was made to ensure consistency in how pilots approach their decision-making in each scenario regardless of individual capabilities. The study has been delimited to collecting attitudinal data versus acquiring observational data. Ajzen and Fishbein (1980, 1991) theorized that human behavior is determined by a person's intentions, personal attitudes, and the perceived attitudes of others. Their theory was grounded in the idea that one can predict how a person will behave — given a specific set of circumstances and time — based on that person's attitude. Based on this theory, attitudinal data was determined to be sufficient for this study in assessing how the independent variables will interact and affect the dependent variable, and ultimately translate into pilot action. The use of a questionnaire instrument to convey a weather simulation was chosen because of its ability to garner the required number of participants and because it is cost effective.

Limitations

Experimental research is limited as it can create artificial situations that do not always represent real-life situations. The limitation is primarily due to fact that all other variables are tightly controlled which may not create a fully realistic situation. However, in an attempt to keep the experimental environment as controlled as possible and in order to be able to detect the causal relationship, the limitation is necessary. Because the situations are very controlled and do not often represent real life, the reactions of the test subjects may not be true indicators of their behaviors in a non-experimental environment. Bias can be introduced in that the participant will answer in the way they think is desirable, versus how they would actually answer if this were real. In order to minimize this type of bias, the instrument has been constructed and validated so as to keep the ability to hypotheses guess at a minimum and to ensure internal validity. While all participants receive all meteorological conditions, they were randomized in order of appearance and were only introduced one at a time. Each participant only received one motivation and had no knowledge that there were others, limiting their ability to accurately hypotheses guess. Without the ability to determine the true nature of the experiment, it is far less likely a participant will be able to deduce how to answer in a way they think would be desirable.

The researcher notes that a key limitation to the study was that participants might potentially answer the questionnaire in the way they believe is the most socially acceptable. The researcher assumes the participants answered the survey in an honest manner. Thus the potential for response bias was considered when analyzing the responses. The researcher has also considered the fact that the study is cross-sectional, and the information collected was from a very specific point in time.

Assumptions

Within any study, there are certain assumptions made about aspects of the research that enable the researcher to conduct said study. For this research, it was assumed that all participants responded honestly while indicating their willingness to persist in the scenarios. Every measure was taken to ensure participant anonymity and confidentiality, and each participant was made aware that their participation was strictly voluntary and that at any time they could have withdrawn from the experiment without fear of reprisal or repercussion.

It was assumed that the experiment and associated instruments were adequately designed to address the research problem, and this assumption was validated through a pilot study to ensure its efficacy. By using a convenience sample solicited from the Curt Lewis Newsletter and the *FAA Safety Briefing* the results might not be generalized to those who are not associated with those social mediums. It was assumed that those who do chose to participate are representative of the target audience. Basic demographic data was collected with the questionnaire. Those who do not fit the profile for the target audience had their data removed from the set. Certification and ratings data collected was compared to the Federal Aviation Administrations’ yearly pilot population distribution charts as an additional measure to ensure generalizability.

Given that this is an experiment conducted through an online questionnaire and not via direct observation, it is assumed the scenarios that have been presented contain enough information, and are accurate enough to depict a real situation. It is also assumed that the participants respond accordingly and correctly based on this previous assumption.

Summary

Persisted VFR flight into IMC remains a significant causal factor for aviation mishap and maintains an unyieldingly high fatality rate. It is possible that the motivation or reason for flying overrides other safer, more logical courses of action for the pilot, even when a hazard presents itself. The application of well-founded motivation theory principles to the aviation domain offers the opportunity to learn more about how these principles might affect aeronautical decision making. The question posed here, and what was explored throughout the balance of the proposal, is *what bearing does motivation and meteorological condition have* (if any) *on a pilot's willingness to persist in VFR flight into IMC*? The following chapter discusses the research and literature that was used to provide the foundation, framework, and background to this study, and gives a bit more insight into motivation theory and the decision-making process.

Definition of Key Terms

The following is a list of key terms, theorems, and ideas that will be used throughout the research.

Aeronautical Decision Making	A systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances (FAA, 2016).
Fatality Rate	Fatality rate is determined by how many people die in aviation accidents of a specific nature (Kenny et al., 2017).
Fundamentals of Motivation Theory:	
Extrinsic Motivation	Behaviors and decisions made based on external rewards (e.g., money, praise, fear of retribution) (Deci, Ryan, & Koestner, 1999).

Intrinsic Motivation	Behaviors and decisions made based on internal, personal rewards (e.g., sense of accomplishment, self-satisfaction) (Deci & Ryan, 1985, 2000, 2008, 2014).
No Motivation	No internal or external influences present.
General Aviation	All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire (ICAO, 2009).
Lethality Rate	Lethality rate is calculated by determining how many operations of a certain nature result in a fatality (Kenny at al., 2017).

Meteorological Conditions/Flight Rules (14 C.F.R. § 91, 2018):

Instrument Flight Rules (IFR)	The set of regulations under which a pilot may operate an aircraft in IMC; ceiling is 1,000 feet above ground level or less and/or visibility is three miles or less.
Instrument Meteorological Conditions (IMC)	Weather conditions that require pilots to fly primarily by reference to instruments as separation from traffic, obstacles, and terrain is not achievable by visibility alone;
Marginal Visual Flight Rules (MVFR)	When the conditions are ceilings between 1,000 to 3,000 feet above ground level and visibility is between three and five miles.

Visual Flight Rules (VFR)	The set of regulations under which a pilot may operate an aircraft in VMC; ceilings are 3,000 above ground level or more, and visibility is five miles or more.
Visual Meteorological Conditions (VMC)	Conditions by which a pilot has sufficient visibility to fly the aircraft while maintaining separation from traffic, obstacles, and terrain.
Willingness to Persist	Consenting to the firm or obstinate continuance of action in spite of difficulty or opposition (In Merriam-Webster's dictionary for *willingness* and *persist*).

List of Acronyms

ADM	aeronautical decision making
ANOVA	analysis of variance
AOPA	Aircraft Owners and Pilots Association
ATC	air traffic control
ATP	airline transport pilots
CFI	certified flight instructor
DV	dependent variable
FAA	Federal Aviation Administration
GA	general aviation
HFACS	Human Factors Analysis and Classification System

IMC	instrument meteorological conditions
IV	independent variable
MVFR	marginal visual flight rules
NAS	National Airspace System
NASDAC	National Safety Data Analysis Center
NTSB	National Transportation Safety Board
UAS	unmanned aerial systems
VFR	visual flight rules

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

Currently, continued visual flight rules (VFR) into instrument meteorological conditions (IMC) is the most fatal cause for accidents in general aviation (GA) aircraft by percentage (Kenny et al., 2017). It is possible that the motivation or reason for flying is capable of overriding other safer, more logical courses of action when a hazard presents itself. Continued VFR into IMC appears to stem from a willingness to persist in a course of action despite factors that indicate an alternate and safer course is warranted.

The research investigated how intrinsic and extrinsic motivation and the meteorological condition might affect one's willingness to persist in flight. A willingness to persist, as defined by Merriam Webster's dictionary, refers to a willingness to continue in pursuit of a goal despite the contrary information indicating that doing so is no longer the optimum choice. Reynal, Rister, Scannella, Wickens, and Dehais (2017) highlighted this effect in their study on airline pilots' decision making in unstabilized approaches. In their study, Reynal et al. (2017) found that half of the pilots *persisted* in an erroneous decision to land (rather that initiate a go-around); therefore, the team sought to better understand what might affect that decision. To better understand a pilot's willingness to persist in VFR into IMC, the following literature review will discuss: the severity of the issue in terms of occurrence and lethality; what prevailing theories have found to be supported and what has not been addressed; the presence of cognitive biases and what effect they have on the decision-making process; and the theoretical foundations of motivation and how they have been applied to domains other than aviation.

Search strategies for querying scholarly internet databases for relevant literature included:

- Establishing the point that VFR flight into IMC is still a prevalent issue and finding reports and data to support that assertion;

- Determining who the preeminent researchers in general aviation safety, the decision-making process, and motivation theory are;
- Further refining the aforementioned researchers’ works to find relevance with this particular topic; and
- Due diligence to ensure the subject has not been investigated in a manner similar to what is being proposed and to provide additional gap analysis.

Key search terms are: VFR into IMC; general aviation accidents and incidents; aeronautical decision making; cognitive biases; motivation theory; fundamentals of human behavior.

Ongoing Problem of VFR into IMC

VFR into IMC is when a pilot who by rating or aircraft limitations is obligated to fly by visual references only, and either chooses to fly or inadvertently flies into weather conditions that require the use of instruments as a primary reference (NTSB, 2005; Rogers, 1994). Research focusing on general aviation VFR flight into IMC and the underlying causes for that decision has stagnated somewhat since 2005. This is despite the fact that the mishap rate for this oft-fatal decision has been relatively unchanged over the last several decades (Kenny et al., 2017).

The National Transportation Safety Board recorded VFR into IMC mishaps as being approximately 82 percent fatal in the years between 1975 and 1986 (Wilson & Sloan, 2003). O’Hare and Owen (1999) and Goh and Wiegmann (2001a, 2001b) reported similar VFR into IMC accident fatality rates of 75 percent and 72 percent, respectively, using various GA mishap datasets from the late mid-1970s to 1997. In 2017, the 26th Joseph T. Nall Report, a biennial review sponsored by the Aircraft Owners and Pilots Association (AOPA), examined the occurrences and suspected causal factors of GA mishaps based on 2014 data. The findings indicated that out of 1,163 GA accidents, 32 (3 percent) were attributed to weather-related causes

(Kenny, Knill, Sable, & Smith, 2017). Of the weather category, 22 (69 percent) were VFR into IMC; and of those, 20 (91 percent) resulted in one or more fatalities. The 2014 VFR into IMC mishap fatality rate for the weather category is consistent to the previous years, which were recorded as 73 percent (2013), 95 percent (2012), and 93 percent (2011). While weather-related issues have a relatively low occurrence rate of all the GA mishaps, the causal factor has a much higher fatality rate than any of the others, with the next closest being maneuvering (loss of control) at 55 percent (Kenny et al., 2017).

In response to these rates, research teams have sought to determine why it is a pilot might decide to fly into adverse weather conditions, particularly when he or she is flying under visual flight rules. The existing studies almost exclusively focus on risk assessment (O'Hare & Owen, 1999), skills self-assessment (Goh & Wiegmann, 2001a, 2001b), and the decision-making process (Goh & Wiegmann, 2001a, 2001b; Wilson & Sloan, 2003). While motivation is often mentioned as having a profound effect on the decision-making process, the theoretical components of motivation have not been mentioned within the texts.

Further, the focus has shifted away from the VFR into IMC phenomenon as other accident causal factors and the rather prolific introduction of unmanned aerial systems (UAS) into the National Airspace System (NAS) compete for attention. The current leading pilot-attributed casual factors for GA mishaps is loss of control during take-off, ascent, or landing sequence, followed up by fuel mismanagement (Kenny et al., 2017).

This research bridges the gap between what is currently presumed about persisted VFR flight into IMC and marries those ideas with the extensive studies in how motivation theoretically affects the decision-making process. Precedence has already been set in demonstrating how motivation effects the learning domains pedagogy and andragogy, and in how it has been consistently applied to decision-making in the workplace and in effective marketing strategies.

General Aviation Accident and Incident Archival Data Studies

Goh and Wiegmann (2001a) reviewed accident data specifically depicting VFR into IMC as the precursor to a series of experiments they conducted on the same subject. The analysis provided support for some of the prevailing theories for why one might end up flying VFR into IMC. Goh and Wiegmann (2001a) determined that *situation assessment, risk perception, decision framing,* and *social pressure* were the prevailing theories to be assessed.

Under *situation assessment*, a pilot likely persists into flight simply because he or she is unaware that they are doing so at the time. This concept considers a pilot's ability to correctly diagnose the weather and presumes that were a pilot to accurately assess the situation for the hazard it is, he or she wouldn't persist (Goh & Wiegmann, 2001a). Pilots who demonstrate overconfidence in their own abilities, underestimate the severity of the circumstances, or are unrealistically optimistic about their chances of safely navigating any hazard while flying, are the focus of the theories about *risk perception* (Goh & Wiegmann, 2001a). Under *decision framing*, how a pilot frames the decision to either persist in IMC flight or divert the aircraft heavily influences whether or not he or she will accept the risk (former) or be averse to the inherent risk (latter). Lastly, *social pressure* might have the effect of influencing a pilot to persist particularly when there are expectant passengers on board or the desire to perform in adverse conditions is present (Goh & Wiegmann, 2001a). Under this construct, social pressure most closely resembles motivation elements because the desire to please (extrinsic motivation) and the desire to perform (intrinsic motivation) become the basis for the decision to persist.

Goh and Wiegmann (2001a) used the National Transportation and Safety Board's classification system for VFR flight into IMC to further categorize their case studies into identifiable sub-factors. Of the 409 events from 1990 to 1997, 24 percent suggested that pilots may not have correctly assessed the weather and flew unknowingly into IMC. Just under 8 percent cited overconfidence in one's own ability, and decision framing was found to be inconclusive due to lack of key data. Perhaps most significant to the current study, a large portion of VFR into IMC accidents reported having passengers on board which lends some level of support to the argument that social pressure might have influenced the decision-making process.

This initial Goh and Wiegmann (2001a) study offers a rather high-level assessment of why a pilot might choose to persist in VFR flight into IMC based upon existing theoretical explanations for the problem. The study is wholly based upon post-accident (and therefore latent) data and only gathers evidence to support those prevailing theories rather than developing additional hypotheses. In this respect, Goh and Wiegmann established a pathway for current and future researchers to follow by helping to narrow the focus to just a few potential variables which still require further assessment.

In order to better understand the phenomenon, Wilson and Sloan (2003) offer a comprehensive look at the common aspects of VFR into IMC mishaps. They used NTSB archival data from 1983 to 1999 to generalize VFR into IMC accidents which overlaps and corroborates much of the data that Goh and Wiegmann (2001a) used in their own studies. The Wilson and Sloan (2003) study has the added dimension of including Canadian mishap data from the NTSB-equivalent Transport Safety Board of Canada, for the same timeframe. The comparable mishap rates indicate persisted VFR fight into IMC is a systemic issue for general aviation and not just a tactical issue for American private pilots.

The pilots of the mishaps tended to be individuals who flew for personal reasons rather than commercial, and just over 60 percent were flying their own aircraft. Pilot experience groupings (greater than 100 hours but less than 1,000; and more than 1,000) were fairly evenly dispersed throughout the mishap data. Although inclement weather was the most obvious precursor to a VFR into IMC mishap, additional environmental factors such as nighttime conditions, or topographical elements such as mountainous terrain, greatly increased the lethality of the events (Wilson & Sloan, 2003). Last, after reviewing all of the events, the researchers asserted that the decision-making processes were not always rooted in rationality. Rather, most pilots were subject to bias and unrealistic optimism in their aeronautical decision making (Wilson & Sloan, 2003). This acknowledgement is in direct concurrence with what Goh and Wiegmann (2001a) submitted in the *risk perception* discussion of their analysis.

While the Goh and Wiegmann (2001a) study attempts to assess the fundamental reasons why a person might persist in VFR flight into IMC, the Wilson and Sloan (2003) study focuses on the reasons why the act is considered a hazard, why attention is warranted, and what mitigative efforts had been put into effect at that time. The latter study does little to answer the question of *why*; however, it delineates a plan for positive change based on what has worked so far. Wilson and Sloan's (2003) proposals for change included VFR pilots being taught to determine their own personal minimums, added focus on the risks of flying into inclement weather, and encouraging pilots to request assistance when they feel the situation is becoming beyond their effective control. In spite of several of these recommendations being adopted in various safety outreach and pilot training campaigns, the mishap rate has stayed consistent.

In 2005, Wiegmann, Faaborg, Boquet, Detwiler, Holcomb, and Shappell applied the Human Factors Analysis and Classification System (HFACS) to 14,436 general aviation mishap reports collected from the NTSB and the Federal Aviation Administration's (FAA) National Aviation Safety Data Analysis Center (NASDAC) databases. The HFACS study applies a very broad stroke to analyzing aviation accidents and appears to be more focused on showing how the HFACS framework helps to determine the presence of human error, rather than uncovering the fundamental factors behind those errors. The selected mishaps were from an eleven-year period between 1990 and 2000, and the events that were selected specifically cited causal factors attributed to aircrew error and were not limited to just VFR into IMC as the Goh and Wiegmann (2001a) and Wilson and Sloan (2003) studies were. Using additional subject matter experts in the field, the research team classified and cross-verified the events using HFACS. It focuses only on those acts by the aircrew that were deemed to be unsafe and revealed that skill-based errors were associated with the majority of the accidents (Wiegmann et al., 2005). This was followed by decision errors, violations, errors in perception, and several combinations thereof.

It must be noted that the Wiegmann et al. (2005) study classified the persistence of VFR flight into IMC as a *violation* although it also noted that weather-related decision-making errors made up the majority of the decision error category. This distinction is significant because it inadvertently casts bias on the data. The causal factor becomes a simple matter of pilot negligence or willfulness, rather than an issue worthy of further research into the underlying components influencing the decision. The study does establish, however, that these "violations" are much more likely to result in fatality than other causal actions. A more revealing study would have been to refine the cases to just those that depict VFR into IMC, negate the use of *violation,* and proceed to process the cases using the HFACS error model. The results of this projected study could further identify the active and latent failures inherent in persisted VFR flight into IMC mishaps.

Factors that Affect VFR into IMC

“Psychologically, a decision is perceived as good when its expected value or utility of outcomes is judged to be more beneficial than the alternatives.”

— E. Tory Higgins (2000)

An objective-based decision is one where the outcome rewards the highest benefit while requiring the lowest costs (Higgins, 2000). Higgins (2000) argues that all human beings are motivated to make good decisions; however, remaining objective is not a simple matter. Rather, there are psychological influences which take into account not just the perceived gains and losses, but also social, moral, and emotional considerations. These additional considerations are subject to their own limitations and biases which can manipulate the resulting decision from being one that is purely objective.

Sunk cost bias. In a series of studies, different researchers have analyzed general aviation accidents and incidents and developed experimental approaches to determining the underlying causes for persisted VFR flight into IMC. O’Hare and Owen (1999) developed a computer-based software system designed to simulate scenarios in which pilots could make the appropriate in-flight decisions they would were they actually flying. The researchers then applied a host of different factors that could influence the decision-making process and recorded how the pilots performed because of those factors. Specifically, O’Hare and Owen (1999) used the components that make up *situation awareness, response selection*, and *risk assessment* as their measured variables.

In this unpublished experimental design, O’Hare and Owen (1999) subjected 20 VFR pilot participants of varying age and experience to a scenario in which the undesirable condition *marginal VFR* was introduced either within the first 15 minutes of flight or the latter 15 minutes prior to reaching the intended destination. Participants were to fly the established flight plan and were immediately assessed via a questionnaire once they either discontinued the flight or once marginal VFR was exceeded and the experiment was terminated by the researcher (O’Hare & Owen, 1999).

In terms of duration of flight prior to encountering IMC, the data showed that while it did not appear to directly affect the decision-making process, the timing of the inclement weather did seem to affect pilot situation awareness. *Sunk cost* is a fallacious decision where a person will continue pursuing an endeavor because he or she weighs the invested money, effort, or time that has been spent as having more value than a potential change in course (Garland & Newport, 1991; O’Hare & Smitheram, 1995). In the study, pilots flew longer because they perceived the risk of diverting the aircraft to be higher than proceeding into the unknown.

In the O’Hare and Owen experiment, there were notable differences in the participants’ analysis of continuing on in flight or terminating the flight somewhere other than the intended destination. This difference was based upon the timing of the introduction of inclement weather, which did not appear to affect the actual decision to divert or stay the course (O’Hare & Owen, 1999). More notably, the pilots who persisted VFR into IMC exhibited very little indication that they would even consider an alternative option. O’Hare and Owen (1999) believe this persistence is attributed to the pilot’s decision to proceed having been made far before the onset of inclement weather occurring. The willingness also indicates something else might more heavily influence the decision-making process. In order to determine the reason for staying the course, the entire sequence of events must be considered to include the reason for which the person was flying in the first place. Said another way, whatever motivated the person to take flight to begin with may have significant bearing on whether that person is willing to persist (O'Hare and Owen, 1999).

Plan continuation error. Goh and Wiegmann (2001b) used the colloquial term *get-home-itis,* more appropriately known as *plan continuation error*, in a study and argued that motivation can bias the pilot's decision-making process and interfere with risk-analysis. The desire to get home manifests in cognitive human factors errors such as confirmation bias and continuation error. Ideally, when confronted with a potentially hazardous situation such as rapidly deteriorating weather, a pilot should consider all available information prior to making a decision. Instead, limitations in the pilot's decision-making capacity manifest into systemic errors known as bias (Walmsley & Gilbey, 2016).

The Wilson and Sloan (2003) study broached the concept of plan continuation error as a potential factor biasing the pilot decision-making process. The studies by Orasanu, Martin, and Davison (2001) and an experiment by Muthard and Wickens (2003) isolate this concept for research. Orasanu et al. (2001) argued that plan revision is adopting a modified version of an original plan. Error is introduced when the pilot is unwilling to revise the plan despite being confronted by evidence that indicates a revision is necessary. One reason for the failure to change is that the pilot does not perceive that the environment has changed to a state where the original plan is no longer feasible (Orasanu et al., 2001). Orasanu et al. (2001) cite Goh and Wiegmann's (2001a, 2001b) link between plan continuation error and lack of situation awareness as a primary causal for the lack of perception. The former study continues by highlighting the loss of situation awareness which can induce cognitive error that is the result of insufficient flight monitoring (Muthard & Wickens, 2003).

Confirmation bias. Confirmation bias studies highlight the human compulsion to proceed with a task and subconsciously only look for information that validates the desire to persist (Heshmat, 2015). In aviation, confirmation bias manifests as a pilot seeks data that validates his or her goal and disregards any information that runs contrary. The cognitive error cycle forms from a lack of situation awareness. Wickens (2002) believes that deficient situation awareness is a direct result of task saturation. Once vital cues and pertinent information are missed, a pilot might default back to what he or she knows best (Bourgeon, Valot, Vacher, & Navarro, 2011). Instead of seeking additional information, the pilot focuses only on the information that will confirm his or her current perception. He or she fails to revise the plan and persists with the faulty course of action (Dehais, Causse, Vachon, & Tremblay, 2011). Muthard and Wickens (2003) and Dehais, Tessier, Christophe, and Reuzeau (2010) assert that the pilot's *inherent desire* to complete the task may be part cognitive attention switching impairment and partly indicative of the personality types most pilots portray.

In their study, Goh and Wiegmann (2001b) subjected 32 non-instrument rated participants to a simulation in which they had to fly a Cessna 172 from one point to another. Unbeknownst to the participants, the flight scenario was programed for rapidly deteriorating weather and of the 32 participants, 22 continued with their flight. While this study focused more on evaluating a pilot's sense of self-confidence, risk-taking behavior, and hazard assessment, it also highlighted how both cognitive bias and motivation can interact with the decision-making process. Goh and Wiegmann (2001b) offered a discussion on the implications of confirmation and plan continuation bias; however, the study did not attempt to define or categorize what the motivations were.

Anchoring bias. Anchoring bias is the tendency to base final determinations upon one specific piece of information received during the decision-making cycle (Tuccio, 2011). Quite often it is the first piece of information received. An example indicative of the study would be if a pilot departs a location with a favorable weather forecast. Subsequent reports from other pilots and from air traffic control may not hold the same amount of value as that initial report with the decision maker. If the subsequent reports include information that the weather is deteriorating, this information may be disregarded leading to a VFR into IMC situation.

In the O'Hare and Owen (1999) and the Goh and Wiegmann (2001b) simulations, cognitive biases such as confirmation and availability bias likely reinforced the skewed perception as the participants adapted new information to the anchored piece instead of considering it objectively. Influenced by the anchor, only readily available information is included in the decision-making process, and new information can even be ignored completely (Tuccio, 2001).

Decision framing. In a parallel study to the Goh and Wiegmann (2001b) experiment, Wiegmann, Goh, and O'Hare (2002) used the same simulation to record how long pilots persisted in flight after the onset of adverse weather. In this scenario, the researchers found that pilots tended to persist longer if the adverse weather was introduced earlier in the simulation (Wiegmann et al., 2002). In addition, the length of time and the distance a pilot persisted had a negative correlation with the level of experience the pilot had in that type of weather. More specifically, the less experience with adverse weather the pilot indicated having, the longer he or she tended to persist in duration and distance of flight. While the correlation did differ slightly across the different groups, Wiegmann et al. (2002) attributed this behavior to subtle differences in risk assessment and in determining one's own capabilities.

The outcome of the Wiegmann et al. (2002) study indicates the point at which the adverse weather manifests in the flight directly influences the pilot's decision to proceed. This is slightly contrary to what O'Hare and Owen (1999) determined in the earlier study; however, it is similar to what Goh and Wiegmann (2001a) originally tried to support in their case study analysis for *decision framing* but lacked the scenario particulars to fully develop the argument. The finding contradicts the prevailing theories that *plan continuation error* is purely motivationally based and offers the idea that early on in a flight a pilot might be more willing to reconcile what he or she is experiencing to what he or she might have been expecting prior to taking off. Thus, the decision-making process shifts from a desire to persist influenced by motivation to a desire to assess the true nature of things for one's self.

In an experimental design, O'Hare and Smitheram (1995) manipulated pilots in a VFR flight into IMC scenario by changing the way the information was presented from that of anticipated losses to anticipated gains. First, they established a baseline by determining if a pilot's willingness to continue or to abort the flight could be predicted based on how they naturally frame the decision. Then, the researchers had the pilots classify all of the possible decisions into one of four categories: *tangible gains or losses to oneself*; *tangible gains or losses for others*; *self-approval or disapproval*; and *social approval or disapproval* (O'Hare & Smitheram, 1995). Although the concept of motivation was not actually used in this study, the respective categories draw close parallels to theoretical sub-components *intrinsic* and *extrinsic* motivation.

In the experiment, pilots rated their ability to handle the aircraft and potentially damaging it as the most important deciding factor for either continuing or diverting, and rated passengers' responses to that decision as least important. More importantly, a significant relationship was found between how the decision was framed and whether or not the participants chose to persist. Those that had to choose between a certain gain versus a risky gain tended to be more risk-averse than those who had to choose between certain loss versus a risky loss, using the same scenario (O'Hare & Smitheram, 1995). A shortcoming to this experiment is in the sample, however. Participants were largely homogenous in demographics, experience, and geographical location, and therefore were not truly indicative of the general aviation population.

Prospect theory. Whereas decision framing is the context in which humans will exhibit different behaviors, *prospect theory* is the application of that behavior. Kahneman and Tversky (1982) wrote that people will make very different decisions when taking into account the risk of perceived gains versus the risk of perceived losses. This loss-aversion theory presumes that if two choices are put before an individual, the option that presents the potential gains will be chosen over the option that focuses on the possible losses.

As exhibited in the O'Hare and Smitheram (1995) study, people were determined to be risk averse only when confronted with the possible gains of the scenario. When the potential losses were submitted, the decision makers suddenly became more risk tolerant. Prospect theory studies argue that one can manipulate the decision output of another by refocusing and reframing the reference point from which the decision must be made (Kahneman & Tversky, 1982). Thus, Goh and Wiegmann (2001a) and O'Hare and Owens (1999) theories about decision framing affecting one's willingness to persist VFR into IMC have merit.

Cognitive biases such as those delineated here influence the decision-making process in ways that, if left unmitigated, can directly affect the outcome of the thing that is being decided upon. These outcomes can result in either a desirable or undesirable state depending on the given circumstances. Understanding bias and its integral part in the decision-making process is crucial to developing mitigations that are effective and succeed in their intended purpose.

Theoretical Foundation of Motivation

Several theorists have sought to better understand human behavior by conducting phenomenological studies on the attitudes, beliefs, ethics, and motivations of different groups of people. While there are a few points on which they disagree, what remains constant throughout the studies is that the subject of motivation plays a powerful role in how people conduct themselves and make their decisions. The following are brief summaries of the most preeminent researchers in the field and their studies.

Hierarchy of needs. Maslow (1943, 1954, 1970) asserted that human behavior was derived from individuals seeking different levels of fulfillment. His theory of needs stands as one of the most commonly recognized for understanding human motivation and is the foundational reference for most motivation-oriented studies. Originally a five-tiered hierarchal concept, it was expanded in 1970. At the bottom of the pyramid-like structure are physiological needs; those needs Maslow determines to be the most necessary to life (Maslow, 1943, 1954). At the top is self-actualization and self-transcendence — the level by which a person achieves his or her full potential and personal growth, and helps others to do the same (Maslow, 1970).

The original five-tiered structure can be broken into two categories called deficiency needs and growth needs. The first four levels (physiological, safety, belonging, and esteem) are often referred to as *deficiency* needs. If these needs are not met or a person is deprived of these needs, the more motivated that person will be to pursue fulfillment of that need according to Maslow (1943). The last tier (self-actualization) is known as the *growth* or *sense of being* need. This need is different from deficiency in that a person has an inherent desire to grow rather than being deprived of something (Maslow, 1943). Maslow (1943) notes that the failure to obtain the lower level needs might stymie the acquisition of the higher needs. This premise is the basis for his “hierarchy.” For example, a person who is not well-fed or rested will be less likely to desire friendship and intimacy. Maslow’s theory has been hotly contested, however. Many psychologists have refuted the idea that a person cannot achieve love unless they are well-fed and offer people like Edgar Allan Poe and Vincent van Gogh as examples who historically are considered to be highly self-actualized but achieved that distinction while living in relative poverty (Geller, 1982). In the 1970s, *cognitive* and *aesthetic* needs were added to the structure as numbers five and six, respectively. While Maslow’s theories were hardly derived from scientific means — he developed his ideas from self-selected biographies of a largely homogenous sample — his works have had a profound effect on subsequent motivation studies.

Motives and desire. Since Maslow, several researchers have attempted to identify and isolate the behaviors, ideas, and characteristics that seem to affect how and why a person pursues an interest. Reiss (2004) argued that *motives* are the reasons by which a person will perform a voluntary behavior. In addition, these motives can have an effect on an individual’s perception, cognitive capability, and emotional state.

In his phenomenological research, Reiss (2004) systematically interviewed 6,000 people to determine common themes for what people desire and thus, pursue. He then further refined Maslow’s needs into 16 desires; fundamental needs that drive a person to perform. The 16 desires embody both inherently intrinsic and extrinsic traits; however, most relevant to this research is *independence,* the need to be distinct and self-reliant; and *power,* the need for control of will. The emotions Reiss (2004) associates with *independence* and *power* are a *sense of freedom* and *feeling competent,* respectively; and the associated behaviors most often exhibited are *self-reliance* and *achievement*. These basic desires establish a foundation by which the idea of motivation can be better understood.

Reiss (2004) asserts that all 16 desires manifest in every person; however, to what degree those desires present themselves are heavily influenced by both nature and nurture. Meaning, some traits might be more dominant than others strictly as a matter of individual personality and tendencies (nature), while others might be naturally suppressed or reinforced by the cultural environment (nurture).

In the aviation domain, many studies have been done on pilot's behavioral traits. A pilot is often portrayed as being self-confident, brave, dependable, and achievement-oriented (Ganesh & Joseph, 2005). These traits have historically been the most ideal portrayal of a pilot and directly align with Reiss' interpretation of competence, achievement, and self-reliance as behavioral manifestations of desire. The psychological backlash of these personality traits, however, can be over-confidence — as routinely alluded to in the multiple studies already presented within this literature — and the inherent desire to *get it done every time*.

Human motivation theory. McClelland's (1998) work was similar to that of Reiss. He penned the three biggest human motivators are *achievement*, *affiliation*, and *power*. He believed that people would exhibit different characteristics based on whichever motivator was more dominant and argued that the actual motivations were the result of learned behaviors (nurture) rather than something inherent to the person, as Ganesh and Joseph (2005) surmised.

Under the need for *affiliation*, a person is most concerned with being accepted or well-liked. These individuals thrive in teams, are excellent at projects that require cooperation, and do well at maintaining even casual relationships (McCelland, 1998). Under *power*, individuals tend to demonstrate a need to control a situation or other people, they can be argumentative, and crave leadership positions. Those who desire affiliation want the sense of belonging to a large group and value collaboration, while those who need power enjoy competition and the status and recognition it brings (McClelland, 1998).

More pertinent to this study, under *achievement*, McClelland (1998) argued a person would have a strong need to set and accomplish difficult goals, are wholly self-motivated, and can work in teams or individually so long as the goal is achieved. When viewed together with Ganesh and Joseph's (2005) assessment of typical pilot behavior and compared to Reiss's (2004) study of how desire affects behavior, one can begin to see how both the inherent and environmentally contrived motivations might influence decision outcomes.

Reiss and McClelland differ on the idea of *inherent desires* versus *learned needs*; however, both agree with Maslow that while *achievement* and *power* are not necessary to sustain life, these factors are key components to a person's willingness to persist. Additionally, these two motivations have the capability of manifesting as both intrinsic and extrinsic values and appear to be recurring themes throughout much of the research. Perhaps what is most important about McClelland's theories is the argument that a person can only be motivated based on their personal needs being met. Therefore, if one wants to change another person's decision-making process, he or she must be able to identify and assuage those needs into order to affect the behavior that drives the process.

Two-factor theory. Applied to a work domain, Herzberg's two-factor theory proposes that job satisfaction is the result of two basic categories: *hygiene* and *motivation* (Herzberg, 1996; Herzberg, Mausner, & Snyderman, 1967). *Hygiene* is the elements of a job that are necessary to encourage motivation in the workplace but are not enough to sustain job satisfaction over long periods of time. These elements include pay, policy and procedures, working environment, and job security. *Motivation* elements are the factors of a job that actually yield satisfaction and therefore ensure a desire to perform at a high rate of skill and engender employee loyalty. These include recognition, sense of achievement, belief in the work, and a sense of responsibility (Herzberg, 1996; Herzberg, Mausner, & Snyderman, 1967). The two-factor theory alludes that though people are influenced by both forms of motivation, intrinsic motivators such as a *sense of achievement* and *belief in the work* might affect one's willingness to persist more so than extrinsic elements (e.g., pay and benefits).

Self-determination theory (SDT). Ryan and Deci (2008, 2014) developed their self-determination theory based on the idea that the two types of motivation —intrinsic and extrinsic — are powerful forces in shaping how humans behave. While it may seem that the two are diametrically opposed — with intrinsically driven behavior fulfilling the need to adhere to one's inner desires and extrinsically driven behavior forcing one to conform to the standards of others — Ryan and Deci (2008, 2014) argued that the relationships are more nuanced. They further delineated motivation theory into two additional categories: *autonomous* and *controlled* motivation. Autonomous motivation is derived from internal sources; however, it also includes motivation from external sources that an individual has aligned with their own sense of self. For instance, a member of the armed services might choose to strictly adhere to the Uniformed Code of Military Justice under which he or she is also judged, but does so more because of a fundamental belief in what the code mandates.

Controlled motivation directs an individual's behavior through external rewards and punishment however it is reinforced through internalized weighted values such as the desire to avoid shame, seek approval, and protect the ego. Ryan and Deci (2008, 2014) posit that when an individual makes decisions by autonomous motivation, he or she feels self-directed and autonomous. Conversely, when the individual makes decisions due to controlled motivation, he or she feels pressure to behave in a certain way with little to no autonomy.

While researchers conclude motivation is a seminal component of the decision-making process, the studies presented here do not go further in determining what types of motivation have the most profound impact. Nor do they attempt to determine why. Further, while motivation in goal-achievement, education, and the workplace have been the subject of many past and current studies, refereed works, and trade articles, there is little literature applying motivation concepts to an aviation domain.

Motivation Applications in Aviation

Extrinsic. External pressure, or *extrinsic* motivation, can factor heavily in the pilot's decision to persist with a flight and therefore warrants additional research. Extrinsic motivation refers to when a person is driven to act by external influences such as financial reward, accolades, or the desire to avoid punishment (Deci, Ryan, & Koestner, 1999; Deci & Ryan, 2014). Perhaps the most infamous example of external pressure contributing to an aircraft accident, and in IMC, was the runway incursion at Tenerife of the Canary Islands. Two Boeing 747s, one operated by KLM Airlines and the other by Pan Am Airlines, collided on a runway covered in dense fog. The two aircraft had been diverted to the small island due to an incident at their intended destination, causing both flights to take significant delays (Roistsch, Babcock, & Edmunds, 1977). Under pressure, anxious to get back on schedule, and unwilling to exceed crew duty limits, the captain of the KLM aircraft misinterpreted clearances from air traffic control and attempted takeoff on the runway that was already occupied by the Pan Am aircraft (Roistsch, Babcock, & Edmunds, 1977). The aircrews, unable to see one another in the inclement weather, collided, killing 583 crew and passengers between the two aircraft. The incident still stands as the worse accident in aviation history.

Studies from various professional and academic fields have shown that money in particular is a powerful external motivator. With the case of the KLM crew in the Tenerife mishap, the flight was already behind schedule and was running the risk of being delayed on the island even longer with more inclement weather moving in (Roistsch, Babcock, & Edmunds, 1977). Further, the risk of the crew hitting their maximum time allowed for the duty day would mean the airline would be forced to ground the aircraft and accommodate the passengers for the night; all of which would equal loss of revenue for KLM. This was something that the popular airline captain and designated *face of KLM* was likely unwilling to have happen.

Intrinsic. While external pressures appear to be more readily understood and easier to identify, the second category — internal or *intrinsic* motivation — arguably has an even more profound and yet almost imperceptible effect on the decision-maker. For the purpose of this study, intrinsic motivation is when the act or behavior is driven by internal or personal reward (Deci & Ryan, 2000). HFACS lists intrinsic motivation as one of the reasons pilots incur violations (willful disregard for the rules); however, the fact remains that few studies have attempted to link this form of motivation to the decision-making process in aviation.

Madhavan and Lacson (2006) came close when they attempted to capture different decision-making process frameworks and incorporate them into one integrated model. In this new model, the researchers narrowed the focus to the psychological factors involved in the decision-making process. They divided them into cognitive and motivational categories, and then further delineated the latter into intrinsic and extrinsic elements.

The researchers used the Jensen's Judgment Model to describe the states of the decision-making process a pilot might undertake when confronted with the choice to continue flight into inclement weather. The decision-making model involves steps from *problem identification* all the way to *risk assessment* and applying an *action*. Information processing is routed through three sequential steps: *information acquisition, situation assessment*, and *choice of action* (Madhavan & Lacson, 2006).

Within the model, *choice of action* and applying the *action* are the stages most affected by background factors. Madhavan and Lacson (2006) argue that background factors are comprised of both cognitive and motivational components. The cognitive components were previously addressed by Goh and Wiegmann (2001a) in their assessment of event data and included poor *situation assessment* and *risk perception*, *social pressure*, and an *over-estimation of one's capabilities*. The motivational components refer to the perceived gains and losses associated with the outcome of the decision, also known as *prospect theory* (Madhavan & Lacson, 2006). Included in these gains and losses is the sense of social and personal pressure indicative of intrinsic and extrinsic motivation.

Madhavan and Lacson (2006) rely on a study from O'Hare and Smitheram (1995) as one foundation for their analysis about motivation in decision making. It, too, hinges on the idea of prospect theory. In the study, the researchers intended to determine if they could modify a pilot's decision based on how the framework for the decision was manipulated (O'Hare & Smitheram, 1995). For instance, when presented with an option of continuing on into inclement weather or diverting to an alternate location, if the latter option was framed as potentially being a waste of time and money, the pilot is more likely to continue regardless of the fact that diverting is actually less risky. O'Hare and Smitheram (1996) intended for the study to provide evidence that preferences for options can be manipulated due to framing — an assertion also made by Goh and Wiegmann (2001a) who lacked the additional data to support it. However, Madhavan and Lacson (2006) used the study to highlight how these other considerations maintain their influence despite a pilot being able to correctly perceive and diagnose the risks.

For the purpose of the study, the evidence supporting the idea that prospect bias can take precedence over risk assessment and aversion is important. The concept of perceived gains and losses closely parallels what Maslow, Reiss, McClelland, and Herzberg believe to be the driving factors in motivation, just framed a different way. Whereas Madhavan and Lacson (2005), O'Hare and Smitheram (1995), and Goh and Wiegmann (2001a) used the decision framing process to highlight cost benefit analysis as a motivating factor and to provide context, this study seeks to determine if a difference exists between the extrinsic and intrinsic aspects of that cost benefit. Madhavan and Lacson (2006) also acknowledge that the nearly infinite combination of human characteristics such as personality, morals, emotions, and behavior patterns make it almost impossible to accurately determine which factor has the most significant effect on the decision-making process. They agree that more work needs to be done isolating each factor for specific research.

Causse, Dehais, Péran, Sabatini, and Pastor (2013) have attempted to further the research by conducting an experiment to determine how emotion disrupts the cognitive functions necessary to make effective decisions. In their study, they reasoned that strong negative emotional responses, in reaction to an undesirable decision, biased the decision-making process. Specifically, the undesirable condition was to execute a go-around instead of landing the aircraft, but in broader terms, the undesirable condition was being unable to proceed as planned. This deviation from the intended plan draws some parallel to those who proceed in VFR flight into

IMC. It could be argued the strong emotions were a result of motivational factors influencing the pilot to reach their intended destination. Another theory is perhaps the desire to avoid the strong negative emotion becomes the motivating factor (Causse et al., 2013).

The Results of Motivation-Affected Decision Making

Herzberg et al. (1967) believe achievement-oriented behavior can often be tied back to internal motivation which, in turn, acts as reinforcement for the behavior. The overall effect can be profound as it draws the unwitting pilot into a motivation-based decision-making loop that can lead to unintended and potentially hazardous consequences. Pauley and O'Hare (2008) made the same case by arguing that the more times a pilot encounters a hazardous situation, is determined to negotiate it, and is successful in doing so, the less likely that pilot is to retain implicit fear or aversion when encountering that scenario again. This is regardless of the fact that the danger itself does not change.

Summary

Despite a safety advocacy and outreach campaign targeting the phenomenon, visual flight rule into instrument meteorological conditions remains a consistent causal factor in general aviation mishap rates and is by far the most lethal in terms of percentage (Kenny et al., 2017). Several researchers have attempted to isolate and examine the behaviors and decisions that preempt persisted VFR flight into IMC using combinations of empirical studies on archival data and experimental designs to gather support for existing theories. In particular, these studies have developed a robust understanding of how human factors and cognitive limitations create biases that directly affect the decision-making process.

While much of the research presents motivation as having a profound effect on those biases and the entire decision-making process, theoretical components of motivation such as those developed by Maslow, Reiss, McClelland, and Herzberg have not been applied to the aviation domain. This research bridges the gap between the well-established existing theories on persisted VFR flight into IMC by such notables as Goh and Wiegmann, O'Hare and Owen, and Wilson and Sloan, to name a few, and incorporates prominent motivation theories to determine how the latter might affect the aeronautical decision-making process.

CHAPTER III

METHODOLOGY

The research followed a quantitative factorial experimental design to gather evidence to support the idea of motivation having an effect on a pilot's willingness to persist in VFR flight into IMC. An online questionnaire was used to collect attitudinal data from participants about their perceived willingness to persist based upon a scenario they have been presented. Continued VFR into IMC remains the highest fatal causal factor in general aviation mishaps despite an aggressive safety advocacy and outreach campaign highlighting the hazards of the act. The subject of motivation has been routinely associated with the pilot decision-making process. However, determining which fundamental element of motivation might affect the decision maker's willingness to persist has yet to be fully explored. The perceived effect of visual, marginal, and instrument conditions on a pilot's willingness to persist was also be assessed.

Currently, continued VFR flight into IMC is the most fatal cause for accidents in GA aircraft by percentage. Continued VFR into IMC could stem from a willingness to persist in a course of action despite factors that indicate an alternate and safer course is warranted. It is possible that the desire to achieve the reason for flying can override the pilot's ability to correctly assess and diffuse the dangerous situation. At this time, there has been relatively little research in what motivates pilots to proceed into inclement weather despite the danger. Further, due to the high propensity for fatal mishap, available data as to what motivated the individual is also limited.

The following chapter discusses the research methodology and design, as well as defines the research questions and hypotheses associated with this experiment. It identifies the intended population and how the sample was determined and collected; it describes the instruments that were used and details reliability, validity, and feasibility concerns with using this type of data.

Research Methodology

This research followed a quantitative factorial survey. Experimental quantitative research allows for the measurement and examination of the data in order to gain a better understanding of the relationship between a dependent and independent variable. It also allows for the research data to remain as objective as possible. As such, a quantitative methodology was selected as the most appropriate method to answer the research questions and address the hypotheses associated with the two independent variables and the dependent variable.

The analysis was conducted using IBM SPSS™ on data collected using a slider scale assessment. The slider scale allowed the participant to be far more specific in their responses than a Likert assessment might afford. The resulting analysis provided insight into a general aviation pilot's perceived willingness to persist in visual flight rule flight into instrument meteorological conditions.

Research Design

Design. The purpose of the experiment was to collect attitudinal data on how fundamental motivation categories (intrinsic, extrinsic, no-motivation) and meteorological conditions (VFR, MVFR, IFR) might affect a general aviation pilot's willingness to persist in flight. This 3x3 factorial design included both between and within subject variables (Howell, 2010). The primary purpose of a 3x3 factorial design is to understand if there is an interaction between the two independent variables on the dependent variable, therefore it is appropriate for use in the research. Type of motivation was the between-subjects factor, and the results from these three categories were compared to one another. Type of meteorological condition was the within-subjects factor. In addition to the scores of each category being compared to one another, they were also evaluated based on their interaction with the motivational category. These analyses, and their effect on the dependent variable should provide better information as to the nature of motivation theories and how they might affect aeronautical decision making.

Experimental design is research by which the variables are being manipulated. Experimental research is also the most appropriate way for drawing causal conclusions regarding interventions or treatments and establishing if one or more factors causes a change in an outcome. Within the experiment, the researcher applied motivational categories developed using motivation theory principles and meteorological conditions as defined by the aviation regulatory authorities; and measured the effect the two and their interactions have on the dependent variable *willingness to persist*. The subjects were randomly assigned to the motivational categories, all participants encountered each meteorological condition, and each effect was measured separately.

Experimental research can also create artificial situations that do not always represent real-life situations. This is largely due to fact that all other variables are tightly controlled, which may not create a fully realistic situation. Because the situations are very controlled and do not often represent real life, the reactions of the test subjects may not be true indicators of their behaviors in a non-experimental environment. Bias can be introduced in that the participant will answer in the way they think is desirable, versus how they would actually answer if this were real.

In order to assuage against hypothesis-guessing, each participant only received one motivation scenario and had no knowledge that there are other motivation categories. The instrument has been constructed so that all participants received all meteorological conditions, randomized in order of appearance and introduced one at a time. Without the ability to determine what the true nature of the experiment is, it is far less likely a participant was able to answer strictly based on what he or she believes might be desirable.

Aschengrau and Seage (2009) argued that mitigation of confounding variables should occur in both the design and analysis phase of the research. In particular, they advocated for restriction and randomization to reduce the possibility of results occurring by chance. In the design phase, the researcher ensured internal validity by restricting the introductory scenario so that each participant was only afforded the ability to make decisions from what was presented within the scenario and by randomization.

The research restricted participation in the study to a group of subjects who have similar levels of confounding factors. For the study, pilot experience had high potential to be a confounding variable. For example, an experienced Part 121/135 pilot who is accustomed to more technologically advanced aircraft and who is likely highly experienced in flying in IMC might become a confounding factor regardless of what motivation category they are assigned to. Therefore, the request for participants was limited to non-Part 121/135 pilots. If a participant indicated on the questionnaire in the demographics section that they do fall into this category, their responses were still be recorded, although isolated from the larger data file to be analyzed in seclusion.

Another potential confounder to the study was the capability of the aircraft; therefore, in addition to restricting the subjects, the scenario was controlled to a very specific make, model, avionics package, and certification. Restricting the scenario also ensured that all participants, regardless of skill level, experience, or training, were responding based on the same exact information.

The random assignment of subjects to the motivation categories worked to deter erroneous data resulting from any association between the potential confounder and the motivational category. The software was set to randomly distribute participants into motivational categories upon accessing the questionnaire, ensuring that each group likely had similar distributions of age, gender, certifications, behaviors, and geographical environment as confounding factors.

By using a representative sample of the general aviation (non-Part 121/135) population regardless of ratings, experience, or certification, external validity generalizability has been considered, although the latter is still restricted due to the use of a convenience sample. In addition, the literature review presents the prevailing theories on human motivation as it applies to the decision-making process. It should be applicable, regardless of it having been rarely applied specifically to aeronautical decision making in the past.

The experiment consists of a questionnaire describing a visual flight rule into instrument meteorological conditions scenario. It then recorded attitudinal data about a pilot's perceived decision making ─ operationalized as his or her *willingness to persist* ─ via a sliding scale ranging from 0 percent (completely unwilling) to 100 percent (completely willing). Rather than using a radio button to respond to online survey questions, slider scales allow for the researcher to offer the participant a larger range and breadth of answer than that of a typical Likert assessment (Roster, Lucianetti, & Albaum, 2015). Roster et al. (2015) argue that utilizing a slider is less repetitious and might make for a more interactive experience for the participant and therefore garner higher quality data. When following the prescriptions set forth by Azjen and Fishbein (1980, 1991, 2005), collected attitudinal data has shown to have a strong correlation to actual behavior.

The introductory scenario to the questionnaire was designed to be similar to the O'Hare and Owen (1999) study in which participants were to fly the established flight plan, encounter unfavorable meteorological conditions, and were immediately assessed via a questionnaire once they either discontinued the flight or once marginal VFR was exceeded. Subject matter experts from the Office of Aviation Safety, the Office of Accident Prevention and Investigations, and the Civil Aerospace Medical Institute (CAMI) from the Federal Aviation Administration aided in the development of the introductory scenario and in validating the meteorological descriptions.

Access to the scenario and its content was restricted to general aviation (non-Part 121/135) pilots to control for any confounding variable that might inadvertently skew the data. The introductory scenario restricted the participant to flying a Cessna 172, equipped with a Garmin G1000 avionics suite, from an imaginary fixed-base operator for a VFR cross country flight from Colonel James Jabara Airport (AAO) just outside Wichita, Kansas, to Lancaster Regional Airport (LNC), Lancaster, Texas. The participant was informed that they had a full tank of fuel with just over 40 gallons on board. The aircraft had a restricted certification for VFR flight only so that even if the participant was IFR qualified, the aircraft will not allow for that option (Figure 1).

The participant had a non-pilot passenger flying with them, and he or she had access to both paper and electronic navigation charts, an Electronic Flight Bag (EFB), and the aircraft was equipped with ADS-B In. The scenario introductory weather was: winds at departure airport are light with occasional gusts up to 10 mph, and visibility is 8 nautical miles with a 7,000-foot ceiling which is within the regulatory definition for VFR meteorological conditions.

In addition to the written scenario, a visual screenshot of the originating airport, the presumed route, and the destination airport accompanied the introduction. The participant was informed that anything not listed within the introductory scenery may be presumed unavailable for the purpose of this experiment. A copy of the instrument is available in Appendix I.

Through SurveyMonkey™, the participants were randomly assigned to different motivational categories (extrinsic, intrinsic, or no motivation), which immediately followed the introduction scenario. The motivational categories were based on theory and adapted from what Maslow (1943, 1970), Herzberg (1966, 1967), McClelland (1988), Reiss (2004), and Ryan and Deci (1985, 2000, 2014) have presented on how motivation affects decision-making in the job-satisfaction and education domains. Prevailing theory posits that human motivation is broken into two major categories: intrinsic and extrinsic; and for the study, an additional category of *no motivation* has been added to provide another level of control and measurement to the group. All participants were then given three weather scenarios depicting visual, marginal, and instrument flight conditions, randomized to prevent order effects. The weather scenarios were developed directly from the federal regulations dictating what constitutes visual flight rule, marginal visual flight rule, and instrument flight rule operations.

The pilots then annotated via the slider scale indicating to what percent they perceived they were willing to persist for each weather condition (Figure 2). The questionnaire also recorded basic demographics about each participant, restricting access to the scenarios based on the participants meeting the requirements necessary to ensure the effectivity of the research and to mitigate against confounding effects. A visual representation of the intended experiment flow is depicted in Figure 3.

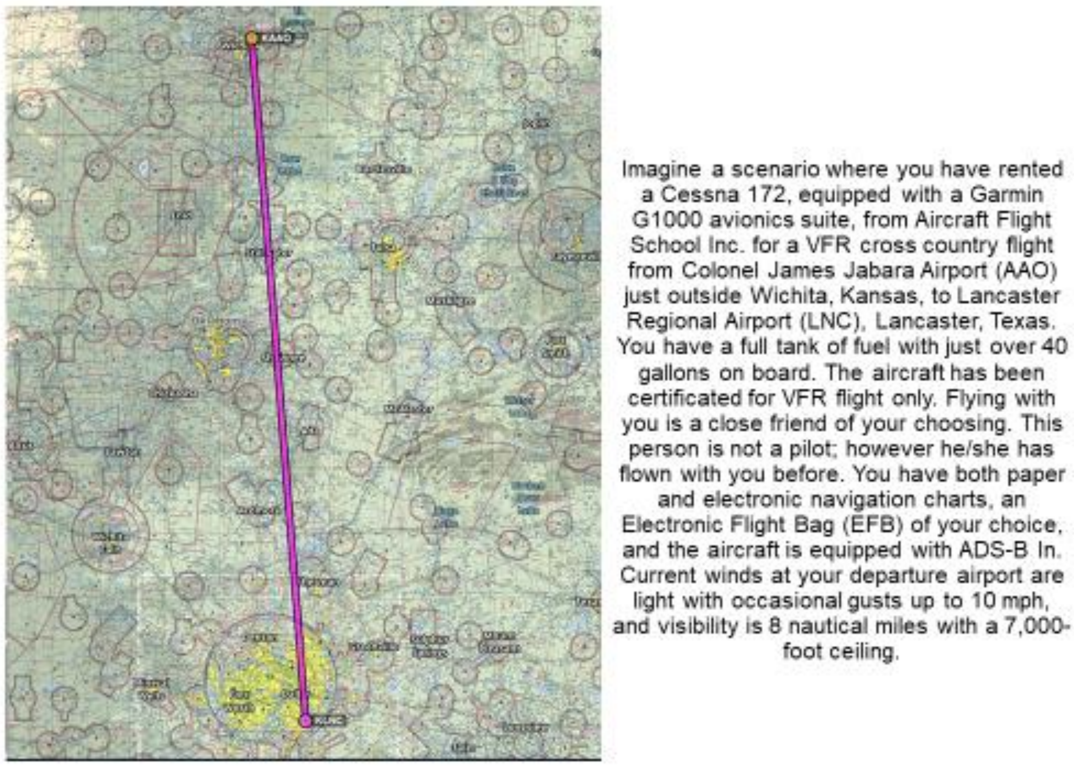


Figure 1. Questionnaire course depiction and main scenario.

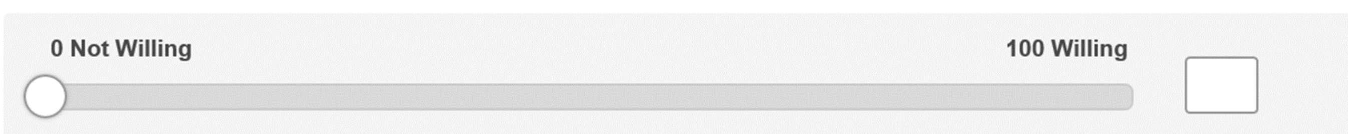


Figure 2. Example of slide scale used.

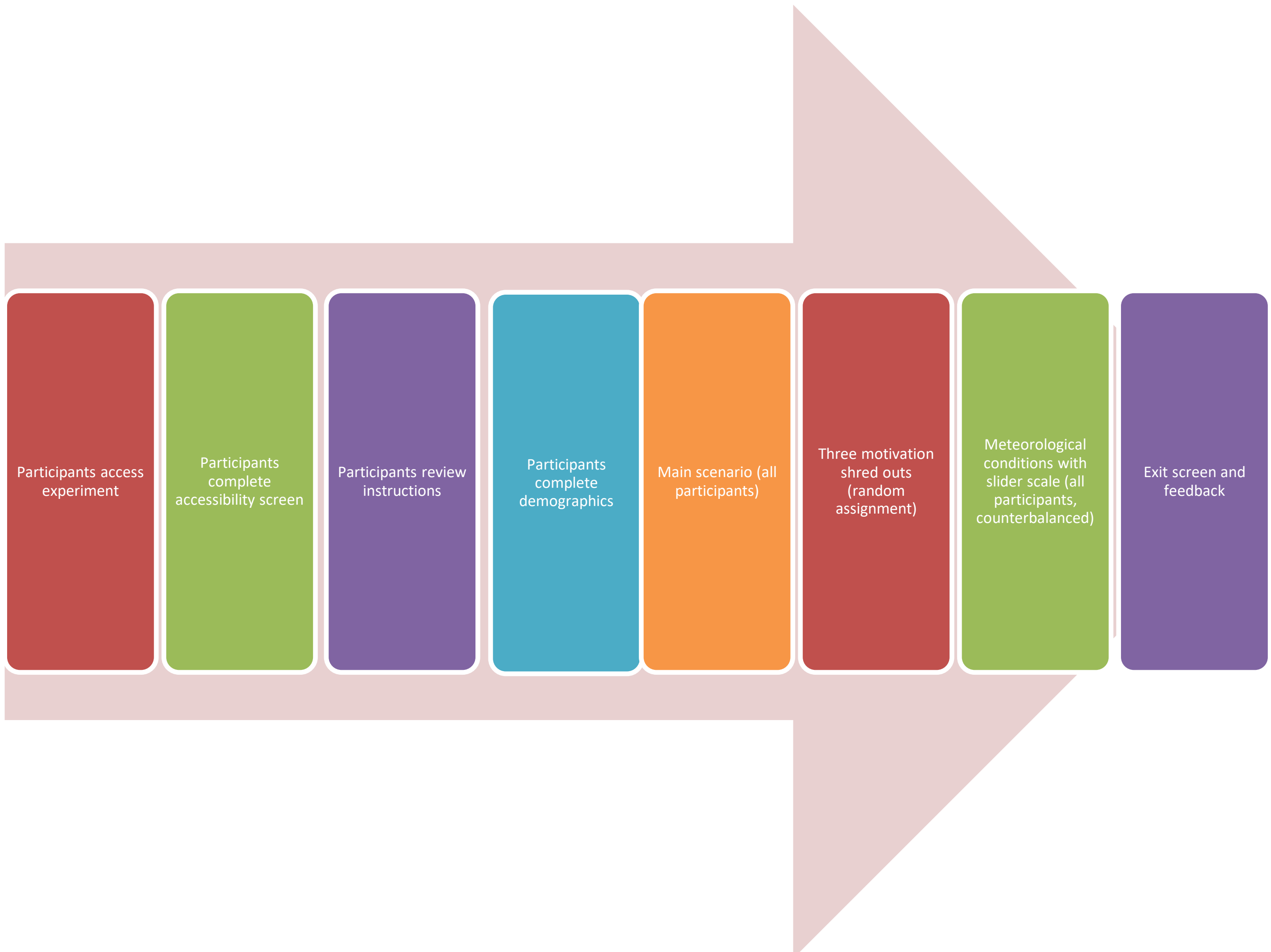


Figure 3. Process flowchart.

Research Question and Hypotheses

The literature does not support directional hypotheses, therefore non-directional ones were used. The study sought to answer the following research questions and hypotheses:

RQ1: What bearing does type of motivation (intrinsic, extrinsic, or no motivation) have on a pilot's willingness to persist in VFR flight into IMC?

H_{01} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

H_{a1} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

RQ2: What bearing does type of meteorological conditions (visual, marginal, instrument) have on a pilot's willingness to persist in VFR flight into IMC?

H_{02} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

H_{a2} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

RQ3: What will be the possible interaction between type of motivation and type of weather conditions on a pilot's willingness to persist in VFR flight into IMC?

H_{03} – There is no significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

H_{a3} – There is a significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

Population and Sample

Population. The target population for this study was general aviation pilots who hold either a recreational, sport, private pilot, airline transport pilots (ATP), or commercial certificate. The sampling frame for the study was sourced via advertisement through social aviation mediums such as Curt Lewis' Flight Safety Information daily newsletter and the Federal Aviation Administration's *Safety Briefing Magazine*, that are both popular sources of information for the GA community. The resulting sample was one of convenience. Approval for conducting the experiment was requested and approved by the Embry-Riddle Aeronautical University's Institutional Review Board.

Sample. In order to ensure the sample is representative of the target: general aviation population; only those operating as general aviation pilots (i.e., non-Part 121/135) — regardless of whether they hold a private, sport, commercial, ATP, or recreational certificate — were asked to participate. Participants were randomly assigned to a motivational category under investigation. There were three groups of participants representing three motivation categories: intrinsic, extrinsic, and no-motivation. Regardless of the motivation he or she was assigned, each pilot encountered all of the meteorological conditions ─ VFR, MVFR, and IMC ─ to which each person expressed their attitudes toward his or her willingness to persist.

All participants provided demographic information. Any responses from non-GA or inactive respondents were subtracted from the study. Responses from Part 121/135 pilots were collected, although isolated from the main dataset. After completion of the study, participants were debriefed and dismissed. Data was analyzed based on the differences between the scores of each motivational category, the differences between the scores of each meteorological condition, and the interaction between both independent variables.

Power analysis. A G*Power calculation was used to compute statistical power and determine the sample size needed to detect a true effect when it actually exists (Faul, Erdfelder, Lang, & Buchner, 2007). A priori sample size assessment using G*Power suggests a minimum sample size of approximately 160 participants was needed using the following assumptions: effect size 0.25, alpha 0.05, power 0.80, number of conditions 9, number of measures 3. The experiment's two independent variables (motivation and meteorological condition) both have three levels resulting in a 3x3 factorial design yielding nine different conditions in which willingness to persist (DV) will be measured. However, in order to ensure the highest probability for an even sample size in each motivation category, the sample size was rounded up to 180 (60 in each).

Participant eligibility requirements. In order to participate in this online experiment, volunteers must be a minimum of 18 years old and in possession of an active recreational, sport, private pilot, ATP, or commercial certificate. Each person could only participate in the experiment once and could opt out of the questionnaire at any time during the process.

Participant protection. Participation in this research was completely voluntary and should have posed no physical or mental harm to any of the participants. The researcher acknowledges that when conducting human subject research, it is imperative to protect the participants as well as the data collected. The research does not require the participants to provide any confidential information to the researcher conducting the experiment, and at any time the participant may have opted out of the experiment with no fear of reprisal or repercussion.

Data Collection and Instrumentation

The proposed instrument was largely adapted from O'Hare and Owen's (1999) study on continued VFR flight into IMC. It was modified to ensure the number of participants required to research the topic was met, and because it was the most cost-effective solution for acquiring the data needed to test the hypotheses. O'Hare and Owen (1999) created an experiment consisting of a PC-based (desktop) flight simulator designed to replicate an out-of-the-cockpit view. It presented a variety of aircraft and control parameters and was designed to offer a number of potential decision-making scenarios, all involving various weather effects. O'Hare and Owen (1999) used this desktop simulation in conjunction with a questionnaire that captured demographic and flight experience measures, and had the participants self-report their level of situation awareness. While the O'Hare and Owen (1999) study recorded a series of other parameters such as fuel-burn rate and aircraft status, their primary focus was on the overall effect of weather on the decision-making process.

Although O'Hare and Owen (1999) used a PC simulation, the information they collected from the pilot questionnaires was the basis for their research. The observational data collected from actual simulation was used to support what was found in the data from the questionnaires. The instrument and scenarios in this study were developed to gather seminal information as to whether motivation has the potential to affect aeronautical decision making prior to conducting a full-scale simulation experiment.

An experimental design built into the form of a questionnaire (Appendix A) was the method that was used for securing information relating to the variables under study from the participants. The benefit of using a questionnaire as a mechanism for collecting the data is that it is a relatively inexpensive means of reaching many participants who can complete the instrument via the medium of their choosing and wherever they feel most comfortable. The GA population is highly varied, and a questionnaire is the best method to gain a representative picture of the attitudes and characteristics of a large group. Questionnaires also allow for the application of the between-subjects factors while also being consistent for the within-subjects factor as each participant answered the same exact questions, although randomized in order of appearance so as to decrease the chance for question order bias.

A questionnaire is an effective assessment tool for collecting data pertaining to the attitudes and potential behaviors of the subjects (Vogt, Gardner, & Haeffele, 2012). The questionnaire for the study was experimental in that the subjects were being introduced to different applications of the independent variables in order to determine their effect on the dependent variable. All participants received the three types of meteorological conditions, as this is a within-subjects factor.

The online questionnaire was modified from scenarios used in the O'Hare and Owen (1999) study. Subject-matter experts (a listing of SMEs and their credentials can be found in Appendix B) consulted on the scenarios to add a level of face-validity to the study. The questionnaire was divided into three major sections. The introductory section consisted of an accessibility screen, a review of the ethics, consent form, and legal ramifications of participating in the experiment, instructions for the participants, and acquisition of some demographic data. While most of these screens were print medium, the demographics section also consisted of a radio button style survey with a small free form section for providing flight hours.

The second and largest section of the instrument housed the main scenario, the motivation assignments (IV1), and the meteorological conditions (IV2) to which the participants then responded to indicating their willingness to persist. Perceived willingness was determined by a slider scale set by percentage from 0 to 100 percent, and indicated attitudinal information depicting everything from completely unwilling to completely willing. The last section of the instrument contained exit instructions and offered a chance for the participant to provide feedback via email should he or she wish.

The instrument was tested in a small-scale assessment using general aviation pilots from the FAA's General Aviation and Commercial Division, as well as general aviation pilots from a local fixed-base operator (FBO) and from the Civil Air Patrol. The purpose of the pilot test was to validate and garner feedback to improve the instrument prior to conducting the full-scale experiment. Feedback from the initial test warranted minor changes to the layout and presentation of the questions in the final questionnaire, which were subsequently reapproved by the Embry-Riddle Aeronautical University IRB process.

Procedures. Once the dissertation committee and the institutional review board approved the proposal, participants were sought through select social and print mediums to garner the required sample needed to represent the target population. The participants were on an entirely volunteer basis and accessed the questionnaire data using SurveyMonkey™, a mobile-friendly, online platform which automatically populates to products such as Microsoft Excel™. Collecting the data via SurveyMonkey™ prevents erroneous data accidently being introduced to the dataset due to excessive handling. This platform was chosen due to its ease of use, cost efficiency, and because it integrates easily with other software programs such as what comes with the Microsoft Office™ package.

Similar to the O'Hare and Owen (1999) experiment, the participants were given a hypothetical scenario in which they were all basing their decisions on the same exact model aircraft, with the same amount of fuel on board and same configuration, and in between the same destinations. In a divergence from the O'Hare and Owen (1999) study and in order to gather the data necessary to support or negate the hypotheses, participants were randomly assigned a different motivation condition (IV, between factor) for completing the scenario (Appendix A), and all participants received all weather conditions (IV, within factor).

The motivational categories were written depictions of the fundamental factors of human desire that result in action as introduced by Maslow (1943,1970), Herzberg, (1966, 1967), Deci et al. (1985), McClelland (1988), and Reiss (2004). For intrinsic motivation, behaviors and decisions are based on internal, personal rewards (Deci et al., 1985; Herzberg, 1966; Reiss, 2004). People are most heavily influenced by a sense of accomplishment, self-satisfaction, or doing things for pleasure. According to the literature, prevailing extrinsic motivators are fear of reprisal or retribution, monetary gain (or perceived loss), and desire for praise or accolades (Deci et al., 1985; Herzberg, 1966, 1967; Maslow, 1943, 1970). The scenarios are as follows:

Extrinsic – The two of you have bought nonrefundable VIP tickets to the "BIG" game and have a whole grand weekend planned out. In addition, you have won the "biggest fan" accommodations package that includes a stay at a 5-star luxury hotel. You will forfeit this if you do not show up on time.

Intrinsic – The two of you are looking forward to surprising friends and family whom you haven't seen in years. They are unaware you are flying in just to come see them. You are excited about the big traditional holiday gathering and are eager to show off your piloting skills.

No-motivation – The two of you have been given coupons to a famous aviation museum that has been getting good reviews online and by word of mouth. The coupons are good for free entry, and they do not expire. You have nothing else going on, so you decided to go check it out.

O'Hare and Owen (1999) were able to offer a visual representation of meteorological conditions on their desktop simulation; however, for the study, the participants were offered descriptions of visual, marginal, and instrument meteorological conditions to which they completed a slider scale assessment as to their willingness to persist (DV) based on percentage. The types of meteorological conditions were crafted directly from the federal regulations indicating what these conditions are, and were the same for each participant. Their appearance in the survey was randomized for each person to avoid order effects. The scenarios are as follows:

VFR – You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 10 nautical miles with a 6,000-foot ceiling.

MVFR – You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 3 nautical miles with an overcast cloud layer at 2,500 feet AGL.

IFR – You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 2 nautical miles with an 800-foot overcast cloud layer.

This design has the highest potential for gaining participants, while still managing to provide data to support the research question and obtain adequate sample size. The study used a convenience sample, and the data were collected electronically via the internet.

Instrument reliability. Reliability in an experiment is how well the test is actually capable of consistently measuring what it is designed to measure. The three factors that most affect reliability is the instrument length, level of difficulty, and the spread of the scores (Isaac & Michael, 1995). The full instrument is less than 10 full pages in length, and on average, took less than 10 minutes to complete. It was written to the seventh-grade reading level, which is standard for most public consumption. The spread of the scores will be further addressed in Chapter 4.

There are three types of tests for reliability. Test-test — where two successive measurements on the same test are correlated; equivocal forms — where two parallel tests are given in succession, and their scores correlated; and split-half — where one test is divided into two parts, and the scores from each are correlated.

Instrument validity. The instrument validity is the extent to which the instruments will measure what they are supposed to measure and perform how they are intended to perform in accordance with the design. In particular for behavioral sciences, there are four types of validity that must be met: criterion, content, construct, and face validity (Isaac & Michael, 1995).

Criterion (concurrent and predictive) validity. Criterion validity validates the intended instrument against an already-established measurement procedure in order to create a new measurement procedure that is theoretically relatable (Isaac & Michael, 1995). Using an already existing measurement procedure in order to develop a new measurement is concurrent validity. Whether or not a measurement procedure can be used to make predictions is predictive validity.

This experiment attempts to determine whether or not motivation influences and meteorological conditions affect one's willingness to persist in flight. This is in accordance with the theory that motivation affects human decision making and therefore would affect aeronautical decision making. How motivation affects other domains such as job satisfaction and academic performance has been heavily and routinely documented. To provide concurrent validity, these existing and validated measurements have been used to create the new measurement developed for this experiment.

Content validity: Scenarios. Content validity assesses the appropriateness of the content of an instrument being able to produce what the researcher wants to know. The questionnaire scenario, weather conditions, and subsequent slider scale will be assessed by a series of subject-matter experts and validated through literature review prior to use. The initial questionnaire scenario was assessed for face and content validity by three, high-time, general aviation certified flight instructors with multiple type ratings (a list of SMEs and their qualifications is in Appendix B). The SMEs were chosen for their experience flying, teaching student pilots, and because they represent a cross-section of aviation industry and regulation in employment. A separate group of SMEs validated the representations of the independent variables for visual, marginal, and instrument conditions, and the motivational category independent variable scenarios were validated through literature review.

Face validity. Face validity confirms at first glance whether or not the experiment test measures what it intended to measure. Face validity is ensured by comparing the methodology, method, design, and outcomes of the study to previous studies similar in scope, nature, and subject matter. The initial questionnaire scenario was assessed for face and content validity by four, high-time, general aviation certified flight instructors with multiple type ratings. The SMEs were chosen for their experience flying, teaching student pilots, and because they represent a cross-section of aviation industry and regulation in employment.

Internal Validity

Threats to internal validity are history, maturation and testing, regression, mortality, selection, and instrumentation (Cook & Campbell, 1979).

History. History becomes a threat when factors introduced via the passage of time have the opportunity to manipulate the participants in a manner not accounted for by the study.

The average duration for the completion of the experiment is not designed or likely to exceed more than 20 minutes in time, therefore history is not considered a threat to validity at this time. There is a low probability of an event occurring over the course of the entire data collection period that could provide a history threat, although as such events cannot be predicted, the potential threat was reassessed once the data collection period closed. The threat of history for internal validity was determined not to be an issue.

Maturation. For the same reasons, threats by *maturation* — when biological or psychological changes occur within subjects and have an unintended effect on the study — were also unlikely.

Testing. Experiment testing effects (also known as order effects) can result as a by-product of how long it takes to conduct the experiment, or in how the participants perceive the importance of the order of the questions (Lund Research, 2012). In order to mitigate against testing effects, the study was purposefully designed to be mobile-friendly on any device, to take less than 10 minutes to complete, and the questions were randomized in order of appearance. There were no repeated tests within this design; therefore, threats to *testing* validity were not a concern.

Regression and Mortality. The sample provided was one of convenience and was purely voluntary, therefore the *regression* threat was negated. The *mortality* threat was negated by ensuring a large enough sample size was collected to ensure valid results regardless that some of the data was found to be unusable due to incompatibility with the assessment or due to incomplete assessments. The threats most pertinent to this study were in selection and instrumentation.

Selection. The sample for this experiment was controlled for age (no one under the age of 18) and pilot certificate. Any participants not meeting these requirements on the demographics page were escorted out of the instrument. However, because the sample for this experiment was one of convenience, individual differences inherent to the sample might have the effect of creating an artificial bias, which can threaten internal validity. These differences can affect the dependent variable in a way that is not otherwise accounted for or purposely manipulated within the confines of the experiment.

Inherent differences cannot be completely eliminated; therefore, they were best mitigated by the random assignment of participants into the motivational categories. Random assignment offers the best opportunity to ensure the differences are evenly distributed throughout the motivational categories and establishes group equivalency.

Instrumentation. Instrumentation bias can be introduced when the measuring instrument that is used in a study changes over time thus threatening the confidence that any perceived differences in the dependent variable scores are affected by the independent variables. The instrument used for this experiment is stagnant; there was no pre or posttest, and the questionnaire did not take longer than 10 minutes to complete. The electronic-based platform for distributing the test did not degrade over time and was designed to remain consistent in how it handled multiple participants at a time and for a long period of time. Further, participant responses were recorded via a slider scale questionnaire and analyzed using statistical software, therefore removing researcher effects on instrument validity.

External Validity

External threats to the study include selection bias and ecological validity (Cook & Campbell, 1979).

Selection bias. Cook and Campbell (1979) postulated that because no two participants are exactly alike, one has to make sure the designated groups in the study are equivalent prior to experiment commencement. This is to avoid differences between the treatment groups and the control group that could inadvertently affect the dependent variable. If the sample is not representative of the population, bias has occurred, and therefore the results might not be generalizable to a larger population.

The target population for this study is general aviation pilots, and as such, only participants with a GA certificate were accepted to the study. The sample itself was one of convenience, however. Using the entire target population for this study is simply not fiscally or resourcefully possible. Therefore, the researcher accepts the fact that the sample of convenience might not be generalizable to the portion of the GA population that either a) does not engage in any sort of social or print aviation media accessible by either Curt Lewis or the FAA safety team, or b) is accessible but does not wish to participate. Certification and ratings data collected were compared to the Federal Aviation Administrations' yearly pilot population distribution charts as an additional measure to ensure generalizability.

Generalizability is the extent to which the results of the experiment can be generalized to similar situations and to the actual population. One limitation of the study is that while the sample were randomly assigned to the motivation independent variable, the sample itself was collected through voluntary means. This in itself limits the available sample to just those who would wish to volunteer, which the researcher notes could have the effect of creating an artificial bias. The researcher also acknowledges that the volunteer sample might behave in a manner that might not be commensurate of those that did not wish to participate, and took this consideration into account when reporting the findings.

Ecological validity. As the research was conducted and controlled in an experimental environment, there is potential for a level of artificiality to influence how the participants responded thus potentially decreasing the ecological validity of the experiment. Generalizability can be compromised if this change in how participants act influences the outcome of the study to the point where the results can no longer be extrapolated to the real world (Brunswik, 1956; Lund Research, 2012). However, increasing the level of realism in the experiment in order to ensure greater ecological validity might have the unintended consequence of introducing confounding variables into the experiment.

Variables

Independent variables. The independent variables (IV) in this study were:

IV_1 – Type of Motivation (intrinsic, extrinsic, no motivation), between-subjects factor, categorical. For this experiment, the types of motivation are derived from a synthesis of the prevailing foundational theories about human motivation that divide the subject into two main categories: external, or extrinsic motivation; and internal, or intrinsic motivation.

IV_2 – Type of Meteorological Conditions (visual, marginal, instrument), within-subjects factor, categorical. The types of meteorological conditions will be as defined by Title 14 Code of Federal Regulations, Section 91.155.

Dependent variable. The dependent variable (DV) in this study was:

DV – Willingness to Persist as indicated by percentage on a slide scale. Participants' indicated willingness to persist was captured by recording their answers on a slider scale following exposure to the independent variables.

Constructs. Constructs are mental abstractions used to express the topic of interest in a format that can be easily understood and categorized. They are considered abstractions because are often not directly observed, but rather are depicted by other associations, which must be defined (Lund Research, 2012). They are a means by which a broader, larger, defined topic can be further narrowed into something the experiment can actually measure. For the study, the broader construct of aeronautical decision making means the systematic approach used by a pilot to determine the best course of action given a set of circumstances (PHAK, 1980). The construct has been operationalized as the variable *willingness to persist*. The DV was measured by percentage on a slider scale questionnaire. Due to the high internal consistency anticipated with the instrument, the aggregate score between motivational categories and within meteorological conditions was used for the analysis.

Data Collection and Management

Participants for the questionnaire were solicited from two main sources: Curt Lewis' Flight Safety Newsletter (www.fsinfo.com) and from the Federal Aviation Administration's Safety Briefing magazine (https://www.faa.gov/news/safety_briefing/) social media page. The Flight Safety newsletter is sent daily (Monday-Friday) to approximately 36,000 subscribers nationwide. Its method of solicitation was through the newsletter complete with a link for anyone who wished to participate to access. The FAA's Safety Briefing magazine and respective social media sites is a bi-monthly product, specifically designed for general aviation audiences, and reaches over 7,000 readers monthly. Participants were solicited via advertisement in the magazine, and via the magazine's social media and email platforms. Both mediums are proven successful conduits for garnering survey participants. Participants were given two weeks (14 days) to access and complete the study.

The questionnaire data was collected using SurveyMonkey™, a mobile-friendly, online platform that uses and automatically populates to products such as Microsoft Excel™. Collecting the data via SurveyMonkey™ mitigated against erroneous data accidently being introduced to the dataset due to excessive handling. This platform was chosen due to its ease of use, cost efficiency, and because it integrates easily with other software programs such as what comes with the Microsoft Office™ package. Downloaded data was further analyzed using the IBM SPSS™ statistical software package.

Legal and Ethical Considerations

There were no expected or known risks associated with participating in this experiment other than those experienced through normal daily activities. The researcher required that the study did not include any minors and was constructed in such a way that completion of the experiment did not expose participants to any legal, physical, psychological, or social risks.

The researcher is committed to protecting the rights of and ensuring the safety of all participants in the study. The research proposal, methodology, design, and instrument was submitted for review and approved by the Embry-Riddle Aeronautical University Institutional Review Board for the Protection of Human Subjects in Research for the purpose of confirming the intended research is ethical and in order to protect the rights and welfare of the participants and their data (Appendix C).

Data Analysis

Once the data collection period lapsed and the data were compiled, they were screened for erroneous data such as participants who do not meet the participant requirements or incomplete or corrupted data. These data were removed from the dataset. Two datasets were compiled: one pertaining to descriptive statistics collected on the participants, and the other specifically pertaining to the results of the slider scale. Both datasets were further analyzed using

IBM SPSS™ statistical software package. Once the analyses were run, inferences were made, and the hypotheses were either supported or not supported.

Initial data analysis. Prior to statistical analysis and in order to minimize the risk of misleading results, the dataset was checked for anomalous, missing, or corrupted data. Next, the data was checked for consistency and accuracy. If issues were found, those data were removed from the set or cleansed so as not to let erroneous information affect the experiment. The data was scrutinized to ensure that all assumptions were met, and the results of the initial data analysis were recorded and preserved to refer back to during formal analysis and for the post analysis account.

Demographics. Basic demographics were solicited and collected via the survey mechanism. Information recorded included pilot certificates held, type ratings, flight hours (experience), whether or not they own an aircraft, gender, and age. The demographics were used to provide context as to the basic features of the study and to better define the target population. They served as the foundation for the research's quantitative analysis.

Hypothesis testing. It was assumed that the data will meet the assumptions of normality, homogeneity of variance, and sphericity prior to conducting analysis of variance. To ensure even distribution in normality, a Shapiro-Wilk test was conducted. If normal distribution was not confirmed, data transformation was considered. A Levene's test was also conducted to determine if the groups have the same variance. If a violation of this assumption was found to be present, the researcher considered conducting a Conover squared ranks non-parametric test. Lastly, to ensure equality in the variances of the differences between the meteorological conditions and the motivational categories, a Mauchly's Test of Sphericity was conducted. Sphericity violations were corrected by either the Greenhouse-Geisser or the Huynh-Feldt correction, respectively. Any significant outliers detected within the data were also investigated.

A two-way mixed analysis of variance was conducted. The results of the testing were expressed in the F ratio, which determines the level of variability between the groups' scores and compares them to the level of variability within the groups' scores (Vogt et al., 2014). The p value (significance is $p < .05$) was calculated from the F ratio and the degrees of freedom (df1 and df2) using SPSS. ANOVA also examined the possible interaction between independent variables. Post hoc tests were completed where necessary.

Although prevailing theories dictate intrinsic motivation maintains a stronger influence on human behavior than extrinsic, the research assumes non-directional hypotheses in order to fully explore all effects the independent variables have (if any) on the dependent variable, as well as what might result in a significant interaction. Likewise, logic and safe aeronautical decision-making practice would presume that there would be a significant difference in willingness to persist between the VFR and IMC meteorological categories, regardless of motivation. However, the mishap rate for this causal factor has remained relatively fixed, indicating that what is presumed is not always indicative of reality. Lastly, the interaction between fundamental motivation theory categories and aviation meteorological conditions has never before been analyzed in this manner resulting in a gap in the body of knowledge this research hopes to alleviate. Because of this, investigating the phenomenon in a non-directional manner is appropriate.

Summary

The experiment was designed for ease of use to ensure a high response rate in order to gather the data needed to determine what, if any, effect motivation and meteorological conditions have on one's willingness to persist in VFR flight into IMC. The statistical method selected tested for differences between the two independent variables while subjecting the participants to repeated measures. In analyzing the data, the mixed ANOVA offers the best opportunity to understand if there is any interaction between motivation and meteorological condition on willingness to persist. All considerations have been made to ensure the collection of the data is ethical and legal and that the data are protected.

CHAPTER IV

RESULTS

This chapter delineats the findings of the study. The goal of the research was to examine the effect of motivation and encountering different meterological conditions might have on a general aviation pilot's willingness to persist. A volunteer sample of convenience was used and was representative of the target general avation population. The questionnaire was accessed online through the Federal Aviation Administrations's General Aviation Safety social media website and through the Curt Lewis Foundation's online daily newsletter. The scenarios and questions were administered through and the data was collected by SurveyMonkey™.

Participant Demographics

The survey was open to access for approximately one month. During that time, 529 responses were recorded resulting in 454 usable sets of results after incomplete and non-qualifying data were removed. Of the participants, 226 (49.7%) held a private certificate, 140 (30.8%) held a commercial, 81 (17.8%) held a airline transport pilot, 6 (1.3%) held a sport, and 1 (.2%) participant held a recreational certificate. These results were compared to and found to be similar to the certificate numbers for 2018 provided by the Federal Aviation Administration's U.S. Civil Airmen Statistics website (FAA, 2019).

Experience level, recorded in hours, ranged from 40 to over 34,000 with an average of 3,443 hours (*SD* = 5698) and median flight hours of 1,100. Categorically, the respondents were 92% male, 7% female (with 1% choosing not to answer); and with an ethnicity breakdown of 89% white/Caucasian, 2% Latino/Hispanic, 1.5% Asian/Pacific Islander, less than 1% listed being Native American, 1% identified as *other*, and 6% chose not to answer.

Descriptive Statistics

The participants were provided the same scenario. In it, they were to imagine they were flying with one person of their chosing, set between two imaginary destinations. The software automatically and randomly sorted the participants into different motivation categories (IV-1) with the breakdown equaling *N* = 145 participants for the extrinisic motivation category; *N* = 167 for the no-motivation category; and *N* = 142 for the instrinsic motivation category.

The scores for the dependent variable willingness to persist were recorded via sliding scale by percentage. The mean scores recorded by the participants, for each weather condition, across all motivational categories, was 96.65 (*SD* = 11.79) for VFR, 56.95 (*SD* = 34.37) for MVFR, and 13.30 (*SD* = 24.48) for IMC, as shown in Table 1. The extrinsic group (*N* = 145) recorded an average of 95.96 (*SD* = 13.60) for the VFR category; 59.77 (*SD* = 32.74) for MVFR; and 15.83 (*SD* = 25.46) for IMC. The no-motivation group (*N* = 167) recorded an average of 97.37 (*SD* = 10.32) for the VFR category; 51.69 (*SD* = 34.92) for MVFR; and 10.23 (*SD* = 22.15) for IMC. The intrinsic group (*N* = 142) recorded an average of 96.51 (*SD* = 11.45) for the VFR category; 59.21 (*SD* = 34.90) for MVFR; and 14.32 (*SD* = 25.81) for IMC.

Table 1

Mean Scores and Standard Deviations for Dependent Variable

	Motivations	Mean	Std. Deviation	*N*
VFR	Extrinsic	95.96	13.609	145
	No Motivation	97.37	10.323	167
	Intrinsic	96.51	11.453	142
	Total	96.65	11.794	454
MVFR	Extrinsic	59.77	32.745	145
	No Motivation	51.59	34.924	167
	Intrinsic	59.21	34.907	142
	Total	56.59	34.376	454
IMC	Extrinsic	15.83	25.466	145
	No Motivation	10.23	22.157	167
	Intrinsic	14.32	25.817	142
	Total	13.30	24.482	454

Note: The summary of the mean, standard deviation, and sample size (*N*) for the dependent variable: willingness to persist.

Initial Data Analysis and Assumptions Testing

Initially, 529 responses were recorded from the online platform. Four hundred and fifty-four usable sets of results remained after incomplete and non-qualifying data was removed. There were 38 sets of non-qualifying and 36 sets of incomplete data. Incomplete data consists of any sets of results in which the participant either stopped part way through the survey or did not respond to any of the scenario questions resulting in an "*" in the datafile. Non-qualifying data consisted of any results from individuals who indicated they were not over the age of 18 or did not have a valid or active pilot certificate.

Six assumptions were considered prior to running a mixed ANOVA on the respondent data. They were: the presence of outliers within the data, symmetry, normal distribution of the data, homogeneity of variances, homogeneity of covariances, and the assumption of sphericity (Laerd, 2018).

Outliers. According to Osborne and Overbay (2004) outliers are data points that do not follow the usual pattern and fall outside the norm for a variable. They have the potential to affect an ANOVA. An inspection of boxplot values greater than 1.5 box lengths from the edge of the box revealed there were multiple outliers in the data within the VFR and IMC weather conditions and across all motivations. Outliers are typically the result of a data entry or measurement error or are indicative of truly unusual values within the dataset. It is highly unlikely the outliers were the result of error as the data was recorded directly from the participants, aggregated and downloaded by the SurveyMonkey™ software system, and analyzed by SPSS without any additional human interference or manipulation. The only additional input by the researcher was to delete the data points that were incomplete or did not qualify for the research. Further, there were many outliers within the dataset (76/454, Figure 4). It is more likely the outliers are truly representative of unusual values within the dataset. Transformation of these outliers had no appreciable effect on the outcome, and therefore they were not removed from the dataset.

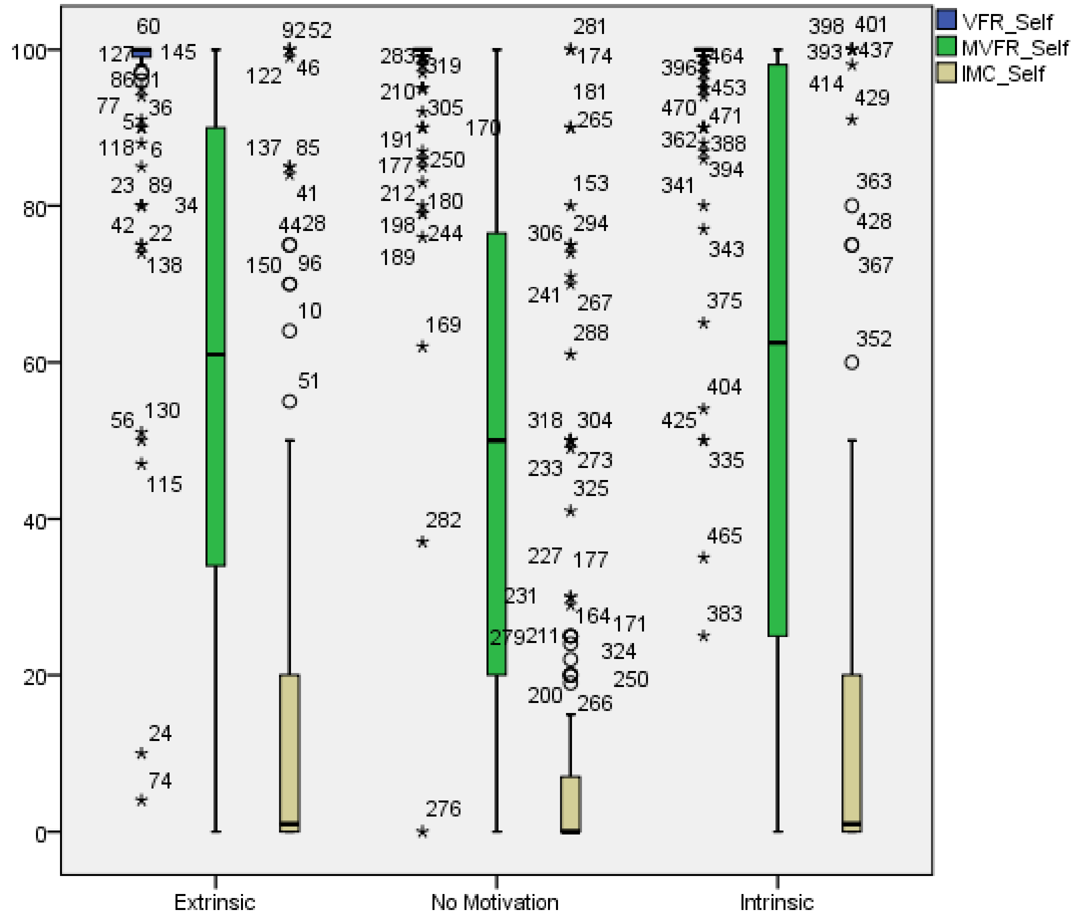


Figure 4. Boxplot of outliers featured in the dataset.

Symmetry. The VFR condition indicated negative skewness of -5.373 (standard error = .113) and kurtosis of 33.0111 (standard error = .225) across all motivations, as indicated in Figure 5. The MVFR condition indicated is symmetrical with a skewness of -.227 (standard error = .113) and kurtosis of -1.265 (standard error = .225) across all motivations, as indicated in Figure 6. The IMC condition indicated positive skewness of 2.156 (standard error = .114) and kurtosis of 3.899 (standard error =.228) across all motivations, as indicated in Figures 5-7.

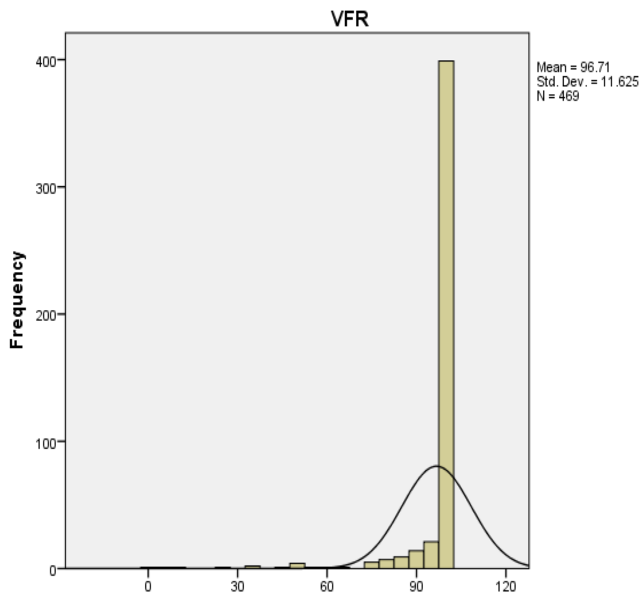


Figure 5. Skewness and kurtosis for VFR condition.

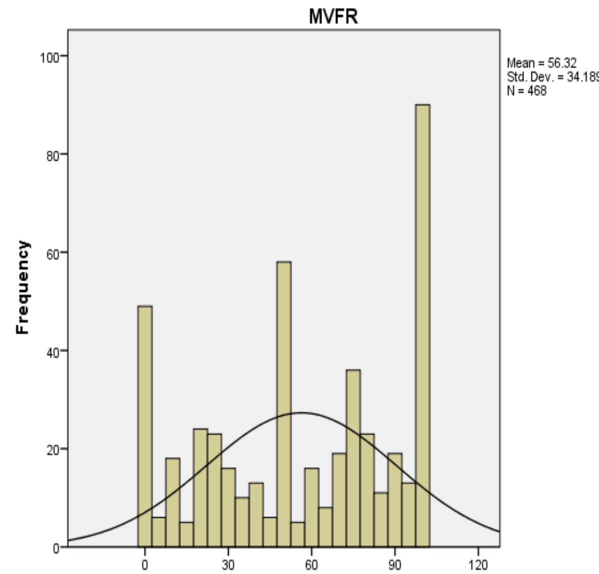


Figure 6. Skewness and kurtosis for MVFR condition.

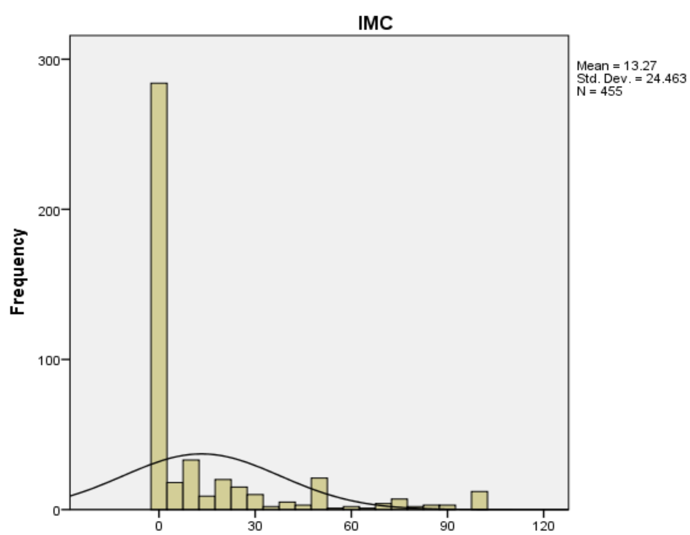


Figure 7. Skewness and kurtosis for IMC condition.

It is possible that the scaling of the participants' responses from 0 to 100 might have induced an unintentional ceiling and floor effect in the VMC and IMC conditions, respectively. While the intention was for participants to indicate their willingness rating in terms of *very reluctant* to *very likely*, the use of a slider scale might have artificially skewed the responses so that the majority of values obtained for each condition hit the upper (VMC) and lower (IMC) limits of the scales used in the measurements. This is part of the reason that the resulting violation of normality was observed, which is discussed in the next section.

Normality. A Shapiro-Wilk test for normality (Table 2) and Q-Q plots were developed for this data (Figure 8). The results of the tests were significant ($p < .05$); therefore, the data do not meet the assumption of normal distribution.

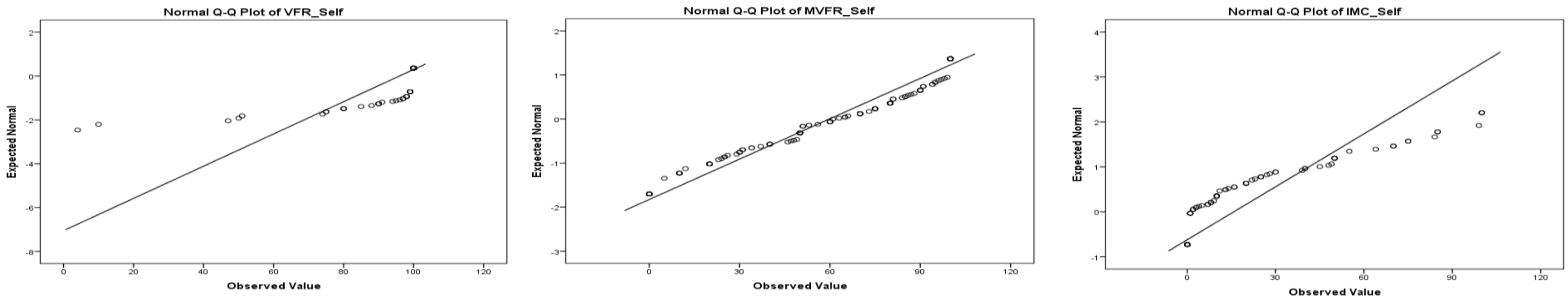
Table 2

Tests of Normality

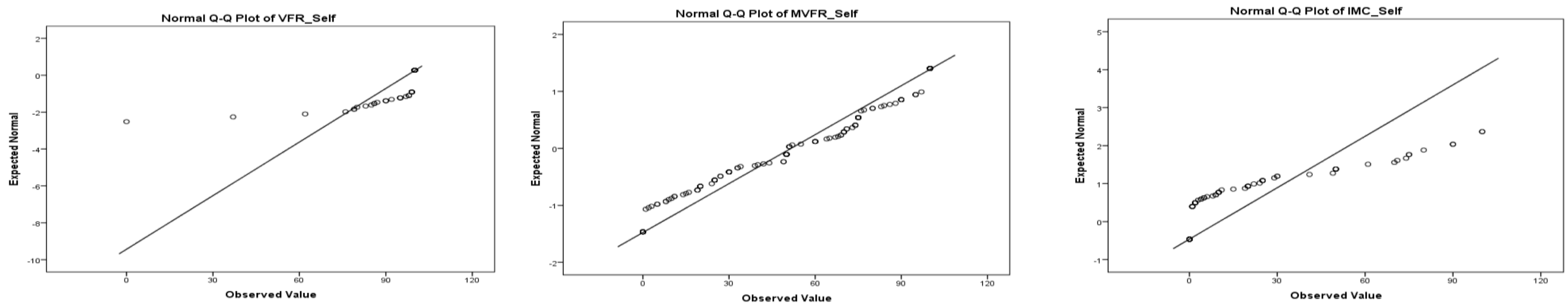
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Motivations	Statistic	df	Sig.	Statistic	df	Sig.
VFR_Self	Extrinsic	.402	145	.001	.332	145	.001
	No Motivation	.419	167	.001	.273	167	.001
	Intrinsic	.396	142	.001	.344	142	.001
MVFR_Self	Extrinsic	.118	145	.001	.914	145	.001
	No Motivation	.104	167	.001	.910	167	.001
	Intrinsic	.139	142	.001	.890	142	.001
IMC_Self	Extrinsic	.267	145	.001	.678	145	.001
	No Motivation	.357	167	.001	.534	167	.001
	Intrinsic	.303	142	.001	.619	142	.001

a. Lilliefors Significance Correction

Q-Q Plots for Extrinsic Motivation Group



Q-Q Plots for No Motivation Group



Q-Q Plots for Intrinsic Motivation Group

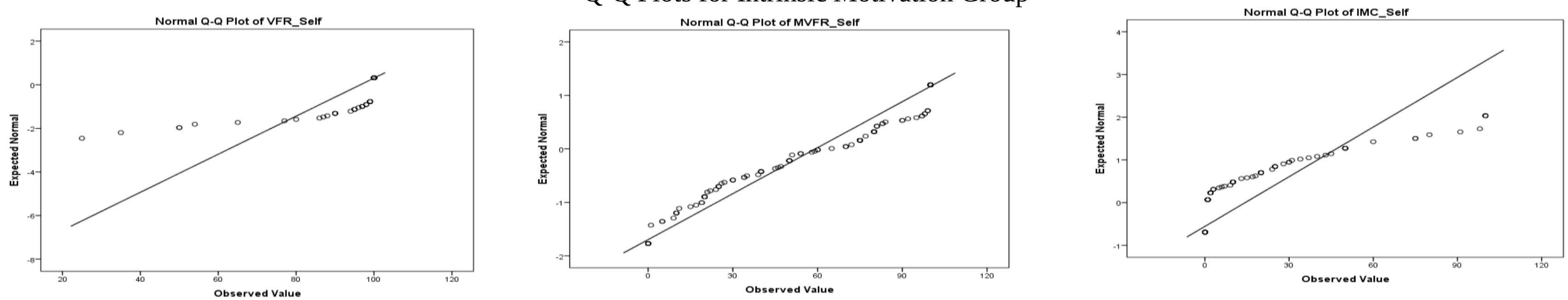


Figure 8. Q-Q Plots indicating distribution for all motivational categories across all meteorological conditions.

Normal, or Gaussian distribution, is a distribution that is based on two parameters: the mean and standard deviation. The mean is the central tendency or *peak* of the distribution. The standard deviation is a measure of variability. It defines the width of the normal distribution. Most measurable scientific variables tend to be balanced and normally distributed; therefore, most statistical calculations are based on that assumption. If the variables exhibit normal distribution, the ability to forecast their behavior or the probability of events can be done with a higher degree of accuracy. When dealing with ANOVA, if the assumption of normal distribution is violated, it could result in an increased chance of a Type 1 error.

With the present data, 529 attitudinal responses were recorded resulting in 454 usable sets of results after incomplete and non-qualifying data were removed. The data were the result of the interaction between two independent variables: motivation and meteorological condition. This appears to be a result of the data itself being skewed, as evidenced by the number of outliers represented in each category. Because the data is attitudinal and therefore representing the participants opinions at the time, regardless of how extreme, none of the outliers were removed from the dataset (Figure 9). Additionally, it was decided that since over 76 cases were classified as outliers, this outcome may have also been attributed to the floor and ceiling effects discussed in the previous section.

Further, the outlying responses have bearing on the purpose of the study which is to determine to what extent an individual might be willing to pursue a dangerous course of action despite logic dictating an alternate path to be a better choice. Several people indicating a willingness of 60 to 100 percent in continuing flight into IMC conditions, regardless of motivational grouping, is very telling regardless of the fact that a large majority of the participants indicated they were unwilling or had a low willingness.

In order to deal with the violation of normality, a number of other procedures were considered. Figure 9 shows the flowchart for all of the attempts to rectify the deviation to normality.

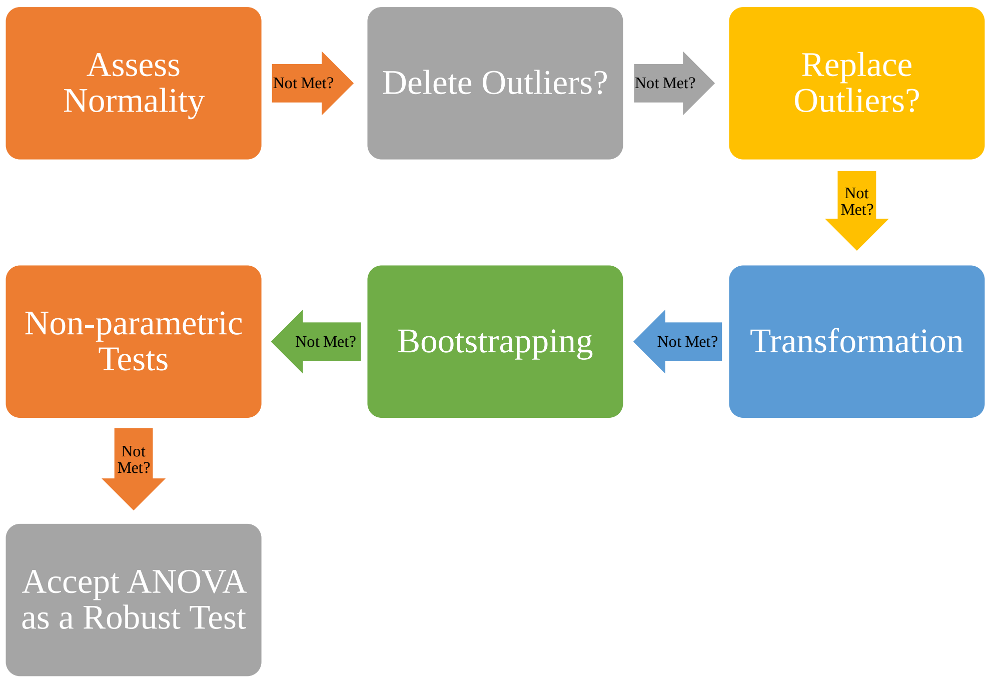


Figure 9. Flowchart to rectify normality violation.

After reviewing outliers, the next step was to transform the data using a log transformation (Table 3), square root transformation (Table 4), and reverse log transformation (Table 5). The transformations also resulted in non-normally distributed data.

Table 3

Log Transformation Table of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Motivations	Statistic	df	Sig.	Statistic	df	Sig.
TrVFR	Extrinsic	.436	78	.001	.228	78	.001
	No Motivation	.413	57	.001	.321	57	.001
	Intrinsic	.371	73	.001	.373	73	.001
TrMVFR	Extrinsic	.228	78	.001	.738	78	.001
	No Motivation	.228	57	.001	.730	57	.001
	Intrinsic	.253	73	.001	.775	73	.001
TrIMC	Extrinsic	.109	78	.023	.926	78	.001
	No Motivation	.120	57	.041	.930	57	.003
	Intrinsic	.138	73	.001	.903	73	.001

a. Lilliefors Significance Correction

Table 4

Square Root Transformation Table of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VFR_SQRT	.405	454	.001	.253	454	.001
MVFR_SQRT	.155	454	.001	.857	454	.001
IMC_SQRT	.319	454	.001	.534	454	.001

a. Lilliefors Significance Correction

Table 5

Reverse Log Transformation Table of Normality

	Motivations	Kolmogorov-Smirnov[a] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
RVSLOGVFR	Extrinsic	.447	145	.001	.113	145	.001
	No Motivation	.498	167	.001	.054	167	.001
	Intrinsic	.412	142	.001	.233	142	.001
RVSLOGMVFR	Extrinsic	.450	145	.001	.353	145	.001
	No Motivation	.412	167	.001	.473	167	.001
	Intrinsic	.425	142	.001	.355	142	.001
RVSLOGIMC	Extrinsic	.314	145	.001	.712	145	.001
	No Motivation	.408	167	.001	.656	167	.001
	Intrinsic	.323	142	.001	.734	142	.001

a. Lilliefors Significance Correction

The next step in the flowchart was to consider bootstrapping. However, since one variable was repeated-measures, IBM SPSS Statistics does not allow for the use of bootstrapping, and thus this was not an option. The next step would be to use a non-parametric statistic. However, for factorial ANOVA, a non-parametric statistic does not exist, so this option was not feasible. Lastly, without a sufficient non-parametric test to use, the robustness of the ANOVA was considered. With large sample sizes and particularly those over 100 (in this study $N = 454$), deviations from normality are not considered to have an influence on the results and result in only minor deviations in the findings (Field, 2009; Oztuma, Elhan, & Tuccar, 2006). This deviation has not been shown to affect the results of a parametric test (Pallant, 2007; Oztuma et al., 2006), and, therefore, many researchers accept the use of ANOVA whatever non-normal distribution exists within the dataset as long as this limitation is clearly disclosed (Carifio & Perla, 2008; Norman, 2010).

Further, de Winter and Dodou (2010) did a comparison on attitudinal data by running both parametric and non-parametric tests. Like Oztuma, Elhan, and Tuccar (2006), they too determined that there is very little appreciable difference in the results of either test when regarding Type I error rates. Lastly, the different research teams of Schmider, Ziegler, Danay, Beyer, and Bühner in 2010, and Blanca, Alarcon, Arnau, Bono, and Bendayan in 2017, each ran Monte Carlo simulations on equal and varying distribution groups and found that the *F*-test was robust enough against Type 1 errors in each of the cases. Blanca et al. (2017) asserted that given the results, the ANOVA remains a valid statistical test even for non-normal distribution. As a final step, the researcher conducted a single, manual bootstrap sample in an effort to validate the findings of the study. The output for this assessment is located in Appendix D.

Homogeneity of variances. The mixed ANOVA assumes that there are equal variances between the categories of the independent variable motivation at each meteorological condition for willingness to persist. If the Levene's Test of Equality of Error Variances is not statistically significant ($p < .05$), there are equal variances, and the assumption of homogeneity of variances has been met. There was homogeneity of variances, so this assumption has been met, $p = .185$ for VFR, $p = .282$ for MVFR, $p = .057$ for IMC.

Homogeneity of covariances. The Box's Test of Equality of Covariance Matrices tests if there are similar covariances. According to the Laerd Statistics (2018) website by Lund Research Ltd, if this test is not statistically significant, the assumption of homogeneity of covariances has not been violated. There was homogeneity of covariances, as assessed by Box's test of equality of covariance matrices ($p = .033$), so this assumption has been met.

Sphericity. Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the two-way interaction, $\chi^2(2) = 31.309$, $p < .001$; therefore, results of the test were interpreted using the Greenhouse-Geisser correction.

Inferential Statistics

The purpose of the study was to gather data in order to determine if any main effects or interaction exists for a general aviation pilot's willingness to persist in VFR flight into IMC as based upon motivation and meteorological condition.

Results of the two-way mixed ANOVA indicated no statistically significant main effect, where $p < .05$, existed for the between subjects variable motivation on the dependent variable $F(1, 451) = 2.428$, $p = .089$, partial $\eta2 =.011$. This means that the type of motivation alone had no significant effect on participants' indicated willingness to persist.

Results of the ANOVA indicated that a statistically significant main effect with a large effect size existed for the within subjects variable meteorological condition on the dependent variable, $F(1.874, 845.195) = 1704.242$, $p <.001$, partial $\eta2 = .791$. This means that the weather conditions alone had a significant effect on the participants' indicated willingness to persist, highlighted in Table 6.

Results of the ANOVA indicated that the main effects were qualified by a statistically significant interaction with a small effect size between motivational category and meteorological condition on the dependent variable, $F(3.748, 845.195) = 2.524$, $p =.043$, partial $\eta2 = .011$. The ANOVA table is depicted in Table 6.

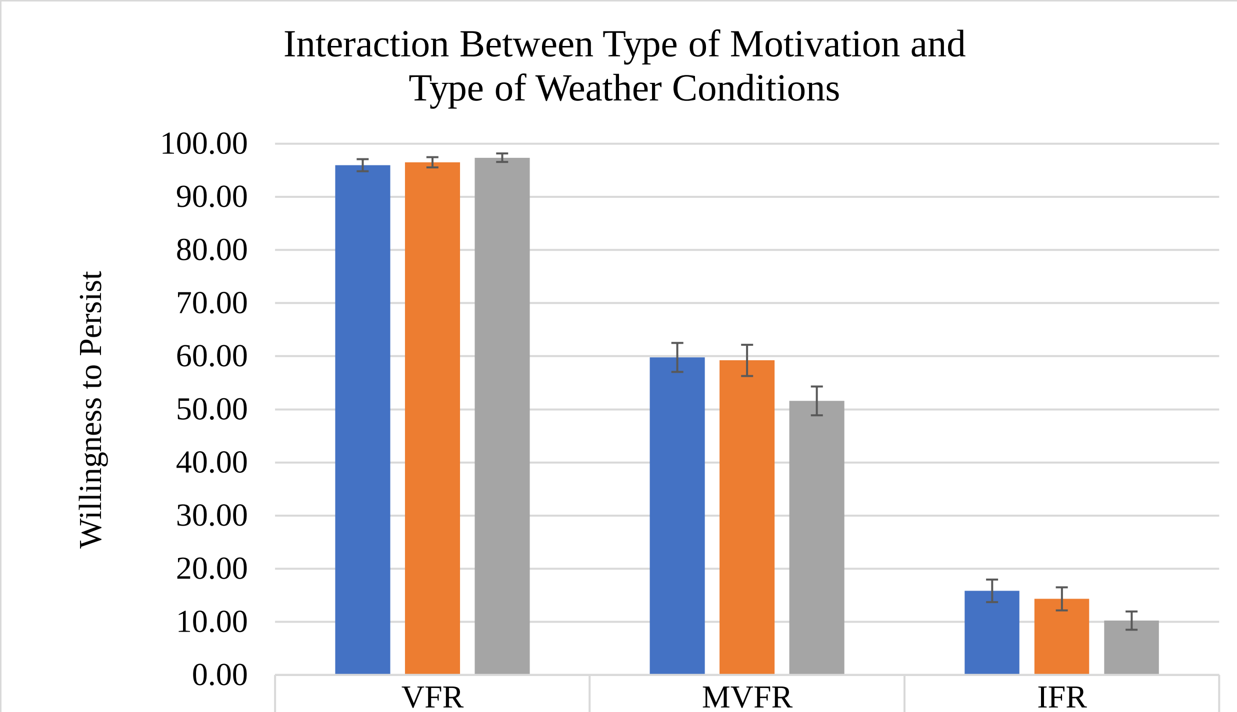
Table 6

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Weather	Sphericity Assumed	1562353.712	2	781176.856	1704.242	.001	.791
	Greenhouse-Geisser	1562353.712	1.874	833679.632	1704.242	*.001	.791
	Huynh-Feldt	1562353.712	1.890	826672.673	1704.242	.001	.791
	Lower-bound	1562353.712	1.000	1562353.712	1704.242	.001	.791
Weather *	Sphericity Assumed	4628.270	4	1157.068	2.524	.040	.011
Motivations	Greenhouse-Geisser	4628.270	3.748	1234.834	2.524	*.043	.011
	Huynh-Feldt	4628.270	3.780	1224.455	2.524	.043	.011
	Lower-bound	4628.270	2.000	2314.135	2.524	.081	.011
Error	Sphericity Assumed	413451.476	902	458.372			
(Weather)	Greenhouse-Geisser	413451.476	845.195	489.179			
	Huynh-Feldt	413451.476	852.359	485.068			
	Lower-bound	413451.476	451.000	916.744			

Note. Because the assumption of sphericity was violated for the two-way interaction, the results of the test were interpreted using the Greenhouse-Geisser correction. Significance is at the $p < .05$ level.

Three subsequent separate tests for simple main effects were accomplished on the data to determine which might be significant. The test for between-subject effects on willingness to persist in VFR and IMC indicated there were no statistically significant differences: $p = .542$ and $p = .111$, respectively. There was a statistically significant difference in willingness to persist in the MVFR condition, $F(2, 465) = 3.193$, $p = .042$, partial $\eta 2 = .014$. An error bar chart depiction of the interaction is in Figure 10.



	VFR	MVFR	IFR
Extrinsic	95.96	59.77	15.83
Intrinsic	96.51	59.21	14.32
No Motivation	97.37	51.59	10.23

Figure 10. Pilot willingness to persist scores based on weather conditions and the type of motivation. The graph highlights the significantly greater willingness to persist of extrinsic and intrinsic motivation compared to no motivation within the MVFR category. Standard error bars depicted.

Two post hoc tests were then completed to determine which means were significantly different from each other within the MVFR category. According to Williams and Abdi (2010), the Least Significant Difference (LSD), has more power to compute post-hoc comparisons but with an inflated Type I error risk. Using the LSD post hoc test, the extrinsic and intrinsic motivation categories indicated a statistically significant difference in mean scores ($p = .032$ and

p = .030, respectively) from the no-motivation category in indicated willingness to persist, as highlighted in Table 7.

The Tukey's Honest Significant Difference was designed to adjust for pairwise testing and control of family-wise error rates, thus decreasing the likelihood of a false positive (Williams & Abdi, 2010). The calculations are based on the assertion that all statistical model assumptions have been met, however. The Tukey's test indicated there was no statistically significant difference in willingness to persist between any of the motivational categories, as highlighted in Table 7.

Table 7

Post Hoc Tests (Tukey HSD and LSD) for Multiple Comparisons

						95% Confidence Interval	
	(I) Motivations	(J) Motivations	Mean Difference (I-J)	Std. Err	Sig.	Lower Bound	Upper Bound
Tukey HSD	Extrinsic	No Motivation	8.22	3.821	.081	-.77	17.20
		Intrinsic	-.08	3.949	1.000	-9.36	9.21
	No Motivation	Extrinsic	-8.22	3.821	.081	-17.20	.77
		Intrinsic	-8.29	3.814	.077	-17.26	.67
	Intrinsic	Extrinsic	.08	3.949	1.000	-9.21	9.36
		No Motivation	8.29	3.814	.077	-.67	17.26
LSD	Extrinsic	No Motivation	8.22*	3.821	.032	.71	15.72
		Intrinsic	-.08	3.949	.984	-7.84	7.68
	No Motivation	Extrinsic	-8.22*	3.821	.032	-15.72	-.71
		Intrinsic	-8.29*	3.814	.030	-15.79	-.80
	Intrinsic	Extrinsic	.08	3.949	.984	-7.68	7.84
		No Motivation	8.29*	3.814	.030	.80	15.79

Note. Comparison of motivational groups means to one another within the willingness to persist MVFR condition. Significance is at the p <.05 level.

Decision on Hypotheses

Three research questions and a series of six non-directional hypotheses were proposed in the study. The first question posed was: what bearing does type of motivation (intrinsic, extrinsic, or no motivation) have on a pilot's willingness to persist in VFR flight into IMC? The results indicate there is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation alone $F(1, 451) = 2.428$, $p = .089$, partial $\eta 2 = .011$; therefore, the research fails to reject the null hypothesis, and H_{01} is supported.

The second question posed was: what bearing does type of meteorological conditions (visual, marginal, instrument) have on a pilot's willingness to persist in VFR flight into IMC? The results indicate there is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions, $F(1.874, 845.195) = 1704.242$, $p < .001$, partial $\eta 2 = .791$; therefore, the research rejects the null hypothesis, and H_{02} is supported.

The last question that was posed was: what will be the possible interaction between type of motivation and type of weather conditions on a pilot's willingness to persist in VFR flight into IMC? Upon interpretation of the data, there was a statistically significant interaction with a small effect size between motivational category and meteorological condition on the dependent variable, $F(3.748, 845.195) = 2.524$, $p = .043$, partial $\eta^2 = .011$, $\varepsilon = .937$. Therefore, H_{a3} is supported. Two different approaches to post-hoc tests determined a statistically significant difference in mean scores between the extrinsic and intrinsic motivation categories from the no-motivation category in indicated willingness to persist ($p = .032$ and $p = .030$, respectively) for LSD, and no statistical significance ($p = .081$ and .077, respectively) for the same categories for Tukey's HSD. In addition, regardless of the ambiguities in the post hoc test, the significant result was still a relatively small effect size. Because of this, it has been determined that more research is needed; however, at this time, the null hypothesis has been rejected.

Summary

The purpose of this study was to gather data to support the idea that motivation may have an effect on a general aviation pilot's willingness to persist in VFR flight into IMC. The data was analyzed using a quantitative factorial experimental design. Of the three research questions and associated hypotheses, one null hypothesis failed to be rejected, and the other two null hypotheses were rejected. Specifically, the results indicate that meteorological condition has a significant effect on whether or not a pilot is willing to persist in flight. Motivation by itself did not indicate a significant effect on willingness to persist; however, the interaction between both meteorological condition and motivation indicated there might be a significant effect, although with a low effect size. Applying different post hoc tests in order to determine at which point the interaction might be significant resulted in both significant and non-significant results, therefore, further research is warranted. Understanding how different motivations might affect ones' willingness to persist will help to refocus and build new platforms for pilot education, training, outreach, and prevention with the ultimate goal of decreasing the amount of weather-related accidents and the fatality rate associated with them.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to conduct a quantitative factorial experimental design on general aviation pilots to determine how different motivation and different types of meteorological conditions might affect one's willingness to persist in flight. Specifically, the research investigated how intrinsic and extrinsic motivation and meteorological condition might affect one's aeronautical decision making. Although motivation is often mentioned as having a profound effect on the decision-making process in various other research into the VFR into IMC phenomenon, the theoretical components of motivation have not been mentioned within the texts. The researcher has applied fundamental motivation theory and meteorological conditions in the development of scenarios that were used to assess a pilot's willingness to persist in unsafe weather conditions, and what role motivation and the weather conditions might play in that decision.

A two-way mixed ANOVA for willingness to persist was conducted in order to determine if there were any significant interactions between: the two independent variables (IV) motivation and meteorological condition on the dependent variable (DV) willingness to persist; the interactions of the two IVs on the DV; and to what effect, if any. The study sought to collect data to answer the following research questions and non-directional hypotheses:

RQ1: What bearing does type of motivation (intrinsic, extrinsic, or no motivation) have on a pilot's willingness to persist in VFR flight into IMC?

H_{01} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

H_{a1} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of motivation.

RQ2: What bearing does type of meteorological conditions (visual, marginal, instrument) have on a pilot's willingness to persist in VFR flight into IMC?

H_{02} – There is no significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

H_{a2} – There is a significant difference in indicated willingness to persist in VFR flight into IMC based on type of meteorological conditions.

RQ3: What will be the possible interaction between type of motivation and type of weather conditions on a pilot's willingness to persist in VFR flight into IMC?

H_{03} – There is no significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

H_{a3} – There is a significant interaction between type of motivation and type of meteorological conditions on pilots' indicated willingness to persist in VFR flight into IMC.

Discussion

First research question. The first research question addressed was "what bearing does type of motivation (intrinsic, extrinsic, or no motivation) have on a pilot's willingness to persist in VFR flight into IMC?" The data indicate that motivation by itself did not indicate a significant effect on willingness to persist; therefore, the null hypothesis failed to be rejected. This question was posed because, while motivation is often mentioned by researchers as having a profound effect on the decision-making process, the theoretical components of motivation have not been specifically mentioned or applied to this domain.

When attempting to quantify academic success or job satisfaction, researchers such as Maslow (1943, 1954, 1970), Herzberg (1996), McClelland's (1998), and Reiss (2004) have bisected motivation into intrinsic and extrinsic components and have applied each to different domains both together and in isolation. In particular, Herzberg's (1967, 1996) two-factor theory proposes that job satisfaction, or satisfaction of any kind, increases so long as a person remains motivated to perform. Motivation in this reference is a result of the factors of a job that give the employee what he or she needs to survive (income, benefits, etc.), coupled with what is needed to engender a sense of satisfaction and a desire to perform (Herzberg, 1996).

Herzberg was one of the first to clearly identify the two different fundamental components of motivation ─ intrinsic and extrinsic ─ and their relative effect on the decision-making process. In this case, the decision was whether or not to stay working at one particular place based on the level of satisfaction working there gave (Herzberg et al., 1967). Those that had their intrinsic desires satisfied tended to stay longer and produce better quality work than those that just had their extrinsic needs met.

The two-factor theory further suggests that though people are influenced by both forms of motivation, intrinsic motivators affect one's willingness to persist more so than extrinsic elements (Herzberg, 1996). Although it was ultimately not corroborated within this research, there was some expectation that the trend of intrinsic motivation having more influence might reflect in the effect of motivation on the dependent variable. This would have resulted in those participants assigned to the intrinsic motivation category indicating a higher willingness to persist that those of the other two categories.

What resulted instead was a condition that only proved to be significant when interacting with the MVFR meteorological condition. This implies that on some level, motivation can be a factor in willingness to persist. Particularly when the ability to make an accurate assessment of the weather condition becomes challenged. To what level motivation can be a factor still has to be defined.

Second research question. The second question proposed was, “what bearing does type of meteorological conditions (visual, marginal, instrument) have on a pilot’s willingness to persist in VFR flight into IMC?” The data indicate that meteorological condition had a significant effect on willingness to persist; therefore, the null hypothesis was rejected.

Higgins (2000) postulates that all human beings are motivated to make good decisions and that an objective-based decision is one where the outcome achieves the highest benefit while requiring the lowest costs. Therefore, it makes sense and is expected that the participants’ willingness to persist in flight decreased as the meteorological condition decreased.

The result is a significantly higher percentage of the overall sample wanted to fly in VFR conditions over MVFR or IMC. Applying Higgins’ (2000) theories to this outcome, a pilot likely perceives that he or she has the greatest chance at a highly desirable outcome under the best possible conditions in VFR. Conversely, the pilot has the least likely chance for a highly desirable outcome in the IFR category. While the data were representative of Higgins’ (2000) ideas, were predictable, and aligned with what one would assume are the preferable circumstances for flight, the fact that VFR into IMC remains a constant causal factor in general aviation accidents indicates that this result is not as straightforward as it seems.

Higgins (2000) continues by stating that there are psychological influences which take into account not just the perceived gains and losses, but are heavily influenced by social, moral, and emotional considerations as well. These *additional considerations* have their own limitations and biases that manipulate the resulting decision so that it no longer remains purely objective. Higgins' (2000) analysis provides a good argument for why VFR into IMC situations might still exist despite the data indicating a willingness to persist in predominately just the VFR condition.

Third research question. The last research question was, "what will be the possible interaction between type of motivation and type of weather conditions on a pilot's indicated willingness to persist in VFR flight into IMC?" Motivation, by itself, did not have a significant effect on willingness to persist; however, the interaction between meteorological condition and motivation had varied results with the initial analysis, indicating there might be a significant effect within the marginal visual flight rule (MVFR) condition, although with a low effect size.

Specifically, intrinsic and extrinsic applications seemed to reflect a difference from the no-motivation application. The former categories reflected a higher willingness to persist over no motivation, within the marginal VFR weather condition. This suggests that some motivation might affect willingness to persist over no motivation at all. Further complicating the analysis was the application of different post hoc tests resulted in both significant and non-significant results.

The potential for the effect of some motivation over no motivation on willingness to persist aligns with what Higgins (2000) has said about how an objective-based decision can suddenly become decidedly less objective. In addition, it also supports what researchers Goh and Wiegmann (2001b), Walmsey and Gilbey (2016), and Orasanu et al. (2001) have determined about plan continuation error and the biases that interfere with a pilot's decision-making process and risk analysis. Goh and Wiegmann (2001b) argued that the motivation to proceed manifests as confirmation bias and continuation error. Walmsley and Gilbey (2016) concluded that limitations in the pilot's decision-making capacity manifest into bias. This limitation is a direct result of the desire to continue and the unwillingness to revise the plan despite a rapidly mounting hazardous situation (Orasanu et al., 2001).

Additionally, the inability to perceive the inherent risk an MVFR situation might present reinforces what Goh and Wiegmann (2001a) and Wilson and Sloan (2003) determined about pilots who unwittingly enter the undesirable situation due to lack of situation awareness, or because he or she underestimates the severity of the circumstances. Wilson and Sloan (2003) specifically asserted that the decision-making processes is not always rooted in a rational, risk-averse approach, and Higgins (2000) would agree. The data presented in these studies help to define why the MVFR condition for motivated pilots results in a more ambiguous decision-making path than that of just VFR or IMC conditions, or in comparison to those who have no real motivation to fly.

Conclusions

The results of the study were interesting; however, they fell just short of presenting a clear picture of how motivation and the interaction of motivation and meteorological condition affects aeronautical decision making and the willingness to persist. There was some expectation that the motivations alone would present differently on the dependent variable following the trends already established by research in education performance and job satisfaction. In the aforementioned domains, those were intrinsically motivated to perform resulted in higher test scores and graduation rates and more job satisfaction over their extrinsically motivated contemporaries. The fact that motivation has not affected the dependent variable in the same manner under this specific experimental construct does not preclude the idea that a differently designed experiment might produce divergent results.

As for the interaction between motivation and meteorological condition on the dependent variable, the initial results are promising despite the fact the post hoc tests proved to be ambiguous. Additional research would help clear up some of the ambiguity so that a clearer depiction of which variables have a significant interaction could come to fruition. Understanding at what point each variable interacts, and to what effect, could have great theoretical and practical implications on the subject of aeronautical decision making.

The violation of normality and the continued use of parametric statistical testing is a limitation to the study. Violations of normality in ANOVA could result in an increased chance of a Type 1 (false positive) error. The researcher acknowledges and accepts this limitation to the study and to the findings. This type of situation is not uncommon in research, and in particular when conducting psychological-based experiments to where a person’s attitudes or opinions are used as the primary data source. Because the hypotheses and the experiment are dependent upon an analysis of within and between subjects testing, and because there is no non-parametric test suitable of producing the desired results, the researcher maintains that the two-way mixed ANOVA was still determined to be the best decision for use in this study.

Theoretical contributions. Humans have a limited amount of mental energy to devote to actually making choices. In a highly dynamic environment such as piloting an aircraft, that mental energy is likely to flag even quicker, while the need to respond very quickly is likely to be quite high. When confounders such as motivation and desire are introduced, the ability to select the decision that renders the most desirable outcome is challenged. Motivation directs a person’s behavior toward specific goals, determines how much he or she is willing to persist, and therefore affects the choices he or she makes.

Continuing research on how human beings approach the decision-making process and what influences that process is necessary so that preconditioning and education can occur before the moment for decision making happens. The current research only provides a preliminary attempt at interpreting how motivation affects aeronautical decision making. The results of this research show that there could be a link between the motivation to fly and the willingness to persist, versus having no real motivation to fly. Additional research and replicating this experiment in a higher fidelity construct could theoretically pinpoint the exact interactions between motivation, meteorological condition, and the willingness to persist VFR into IMC, and to what effect. A better understanding of these interactions could help determine what part of aeronautical decision making is purely objective and what is more subject to a person's base desires.

Practical contributions. Further defining how motivation and meteorological conditions influence aeronautical decision-making can change the way aviation safety advocates, academics, regulators, and industry approach the issue of VFR into IMC. The results of this research could help GA advocates such as the FAA Safety Team, the Aircraft Owners and Pilots Association, and the Experimental Aircraft Association, who have already contributed significant resources and research on the subject, an opportunity to refine their processes. Each of these organizations, as well as many others, produce seminars, courses, online content, and case studies developed to educate the flying community. Understanding how different motivations might affect ones' willingness to persist will help to refocus pilot education, training, outreach, and prevention. In order for pilots to make better decisions, they have to be educated about their own limitations and fully informed about the contributing factors affecting that decision. The ultimate goal is to decrease the amount of weather-related accidents and therefore the fatality rate associated with them.

Limitations of the Findings

A fundamental limitation of this type of experimental research is that it represents an artificial situation that does not always depict real-life situations. A consequence of tightly controlling all variables so as not to inadvertently incur a confounding variable is a scenario that is not as realistic as what might be afforded in a direct observational study. It is acknowledged and understood that the test subjects might have deviated from true indicators of their behaviors in the experimental environment. While some of these risks have been mitigated by random assignment and by randomizing the order of the questions, another key limitation of the study is that participants still might answer the questionnaire in the way they believe is the most socially acceptable.

The finding of motivation having no significant effect on indicated willingness to persist is limited because, although types of motivation are typically categorically divided into one of two types, what motivates any one human being is still deeply personal and unique to that individual. Further, these motivations are heavily influenced by fundamental humanistic social constructs such as culture, beliefs, perceptions, and values (Maslow, 1943, 1954, 1970; Reiss, 2004). The researcher hoped to capture some basic beliefs and values that tend to be present within the general aviation community, but at best these attempts were heavily based on theory and are not necessarily indicative of reality. Identifying and depicting a motivation which might appeal to and garner a reaction from every participant is difficult with no real way to measure success in the current experimental design.

The findings for meteorological condition are limited due to the artificial and relatively low fidelity way the conditions were presented to the participant. In this study, the meteorological conditions were presented in a written format which was taken directly from Federal Aviation Administration guidance and regulations for flying in varying weather conditions. All pilots are required to know them. Recognizing these conditions for what they were, based on the way they were presented, could have inadvertently biased the participant's response.

Studies have shown that deteriorating weather identification is not as simple as recognizing the FAA standard, appreciating the danger, and reacting to it. Goh and Wiegmann (2001a) postulate that a pilot likely persists into flight because he or she is unaware that they are doing so at the time. Further research into weather dissemination tactics from the FAA's William J. Hughes Technical Center confirms that a pilot's actual ability to correctly diagnose the weather can be quite limited (Ahlstrom & Jaggard, 2010; Ahlstrom & Suss, 2015); therefore, it would take reproducing this uncertainty in order to gather data similar to what would occur in an actual inadvertent VFR into IMC scenario. These limitations would be the same for the effect of the interaction between motivational category and meteorological condition on the dependent variable.

All of the findings are limited in generalizability because of the nature of the sample and the sampling source. While the two social media print and online mediums used are well suited for a diverse readership of aviators, the data collected are only applicable to those who subscribe to these forums. Lastly, the researcher has also considered the fact that the study is cross-sectional, and the information collected was at the specific time the participant accessed the questionnaire. This limitation means the data are fixed and do not capture changes in behaviors over time.

Recommendations for Future Research

The idea that some motivation, versus no motivation, particularly in the MVFR category does have an effect on pilots, this gives future researchers a specific focus point to conduct additional experiments or phenomenological studies. The current research presented a broad swath of motivation and meteorological conditions, but future studies could just focus in on MVFR conditions.

A recommendation for future research is that the core components of the current research be repeated in a direct observation experimental design in either a full or partial motion simulator. Observing the participants' reaction to encountering the different meteorological conditions would mitigate the risk that recognizing the written accounting of weather condition might bring. An experiment of this type does come with the added risk of participant bias with the one being observed either consciously or unconsciously acting in a manner he or she believes is desired by the researcher. However due to the limitations in being able to accurately determine deteriorating conditions discussed earlier, the data collected is still likely to be higher fidelity. Instead of indicated willingness to persist annotated as a percentage on a slider scale, the time the participant continued in simulated flight would be recorded on a ratio scale.

Another recommendation would be to access additional general aviation pilot participants through other means such as at popular airshow events, industry trade-shows, and aviation forums. Increasing the sample in this manner might increase the likelihood that the results can be generalized across the entire population.

Summary

The purpose of this study was to gather data to support the idea that motivation may have an effect on a general aviation pilot's willingness to persist in VFR flight into IMC. The ultimate goal is to decrease aviation accidents related to that cause. The interaction between meteorological condition and motivation resulted in a significant effect on the dependent variable, particularly in the MVFR category, although with a low effect size. Further research is warranted in order to isolate these variables to determine more about how the fundamental components of motivation affect aeronautical decision making when encountering different meteorological conditions.

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APPENDIX A

PILOT QUESTIONNAIRE

Copy of Pilot Questionnaire

RESEARCH PARTICIPANT CONSENT FORM

Sabrina Woods

Embry-Riddle Aeronautical University

Ph.D. in Aviation Program

Purpose of Research

The purpose of this research will be to assess how you approach cross-country flying.

Specific Procedures

You will be presented with some scenarios and you will then be asked some questions about those scenarios. In addition, you will be asked some demographics questions. The data collection process is anonymous and your responses will remain confidential. If you no longer wish to participate in the research you may withdraw at any time and your data will be deleted from the dataset.

Duration of Participation

The duration of this is anticipated to take no longer than 10 minutes.

Risks

It is anticipated that this study will pose no greater risk than you would experience through normal daily activities.

Benefits

There are no known benefits to your participation other than knowing you have contributed to the advancement of scientific knowledge.

Compensation

There is no additional compensation awarded for participation in this research.

Confidentiality

The data collected during this study will be anonymous and confidential. We have no way of learning your true identity.

Voluntary Nature of Participation

You do not have to participate in this research project. If you agree to participate you can withdraw your participation at any time without penalty. Furthermore, if you withdraw from the study prior to its completion, your data will be removed from the dataset and destroyed.

Contact Information:

If you have any questions about this research project, you can contact Sabrina Woods at

woodss4@my.erau.edu. If you have concerns about the treatment of research participants, you can contact the IRB Administrator, Teri Gabriel at hollerat@erau.edu or call 386-226-7179.

* I have had the opportunity to read this consent form and have the research study explained. I do hereby give consent to have the data collected through this questionnaire to be used for its designed research purposes.

○ s ○ No

Copy of Pilot Questionnaire

* I affirm that I am 18 years of age or older.

Yes ◯

No ◯

Copy of Pilot Questionnaire

The following page is designed to gather some basic demographics from each participant. Afterwards, you will be presented with a scenario to which you will read and answer the following questions to the best of your ability. At any time you may discontinue the questionnaire and your information will be deleted from the dataset. If a resource is not specifically mentioned within the scenario as being available to you, please presume that it is not and answer the questions based on this presumption.

Copy of Pilot Questionnaire

We would like to collect a few demographics from you in order to better understand our audience.

Age: Please fill in your age.

Gender

◯ Female

◯ Male

◯ Other

◯ ...efer not to answer

* Are you primarily a general aviation pilot? (i.e., **NOT** Part 121/135).

- Yes
- No
- I am not a pilot

Please indicate the highest active certificate you currently hold.

- Private
- Sport
- Commercial
- Airline Transport Pilot
- Recreational
- I do not currently hold an active certificate

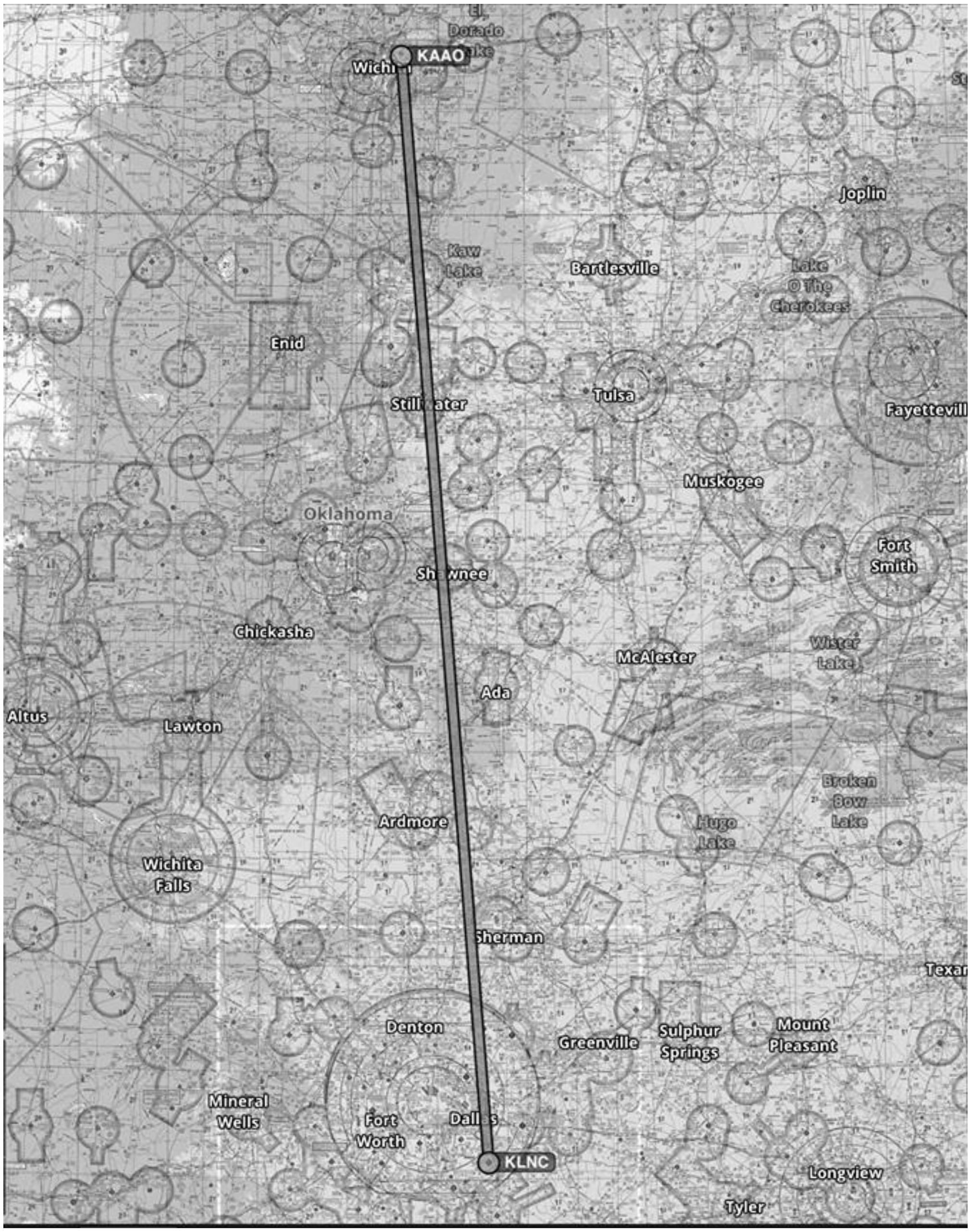
Experience: Please fill in approximately how flight hours you have.

Please specify your ethnicity.

- White
- Hispanic or Latino
- Black or African American
- tive American or American Indian
- Asian/Pacific Islander
- Other
- Prefer not to answer

Copy of Pilot

Your Scenario



Imagine a scenario where you have rented a Cessna 172, equipped with a Garmin G1000 avionics suite, from Aircraft Flight School Inc. for a VFR cross country flight from Colonel James Jabara Airport (AAO) just outside Wichita, Kansas, to Lancaster Regional Airport (LNC), Lancaster, Texas. You have a full tank of fuel with just over 40 gallons on board. The aircraft has been certificated for VFR flight only. Flying with you is a close friend of your choosing. This person is not a pilot; however he/she has flown with you before. You have both paper and electronic navigation charts, an Electronic Flight Bag (EFB) of your choice, and the aircraft is equipped with ADS-B In. Current winds at your departure airport are light with occasional gusts up to 10 mph, and visibility is 8 nautical miles with a 7,000-foot ceiling.

A 33.34% **The two of you have bought nonrefundable VIP tickets to the "BIG" game and have a whole grand weekend planned out. In addition, you have won the "biggest fan" accommodations package that includes a stay at a 5-star luxury hotel. You will forfeit this if you do not show up on time.**

B 33.33% **The two of you have been given coupons to a famous aviation museum that has been getting good reviews online and by word of mouth. The coupons are good for free entry and they do not expire.**

You have nothing else going on so you decided to go check it out.

C 33.33% **The two of you are looking forward to surprising friends and family whom you haven't seen in years. They are unaware you are flying in just to come see them. You are excited about the big traditional holiday gathering and are eager to show off your piloting skills.**

Copy of Pilot Questionnaire

You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 10 nautical miles with a 6,000-foot ceiling. Please use the percentage scale below to indicate your willingness to persist:

0 Not Willing 100 Willing

You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 3 nautical miles with an overcast cloud layer at 2,500 feet AGL. Please use the percentage scale below to indicate your willingness to persist:

0 Not Willing 100 Willing

You are about 40 minutes out from your destination. A quick check of the conditions at your destination indicate visibility is 2 nautical miles with an 800-foot overcast cloud layer. Please use the percentage scale below to indicate your willingness to persist:

0 Not Willing 100 Willing

Copy of Pilot Questionnaire

Applying the same scenario, what do you think the willingness of **other pilots** would be to persist if the conditions indicate visibility is 10 nautical miles with a 6,000-foot ceiling?

Not Willing Willing

Applying the same scenario, what do you think the willingness of **other pilots** would be to persist if the conditions indicate visibility is 3 nautical miles with an overcast cloud layer at 2,500 feet AGL?

Not Willing Willing

Applying the same scenario, what do you think the willingness of **other pilots** would be to persist if the conditions indicate visibility is 2 nautical miles with an 800-foot overcast cloud layer?

Not Willing Willing

Copy of Pilot Questionnaire

Thank you for participating in this questionnaire. If you have any questions about this research project, you can contact Sabrina Woods at woodss4@my.erau.edu. If you have concerns about the treatment of research participants, please feel free to contact the Embry-Riddle Aeronautical University Institutional Review Board Director Teri Gabriel at teri.gabriel@erau.edu.

Copy of Pilot Questionnaire

Thank you for your interest however you do not meet the criteria necessary to participate in this questionnaire.

APPENDIX B

SUBJECT MATTER EXPERTS

Jeff Guzzetti has served as the director of Federal Aviation Administration's Accident Investigation Division, which is responsible for ensuring the integrity of FAA's policies and practices for all FAA investigations of aircraft accidents and incidents. The division also serves as the FAA's primary liaison with all dealings with the National Transportation Safety Board (NTSB). His prior experience includes stints with the Department of Transportation's Office of Inspector General, the Naval Air Systems Command, the Cessna Aircraft Company, and 18 years at the NTSB as an accident investigator and manager. Mr. Guzzetti graduated from Embry-Riddle Aeronautical University with a B.S. degree in Aeronautical Engineering. He is a commercial-rated pilot with multiengine instrument ratings in airplanes, seaplanes, and gliders.

Susan Parson works for the General Aviation and Commercial Division of the Federal Aviation Administration's Flight Standards Service as a special technical assistant to the director of the FAA Flight Standards Service (AFS). In this capacity, she manages the AFS director's internal and external communications, continues as editor of FAA Safety Briefing magazine, and serves as the lead FAA representative for the Airman Certification Standards (ACS) project to improve airman testing and training. She has authored over 90 GA safety articles and several online training documents and courses. These include Conducting an Effective Flight Review, Instrument Proficiency Check

Guidance, and Best Practices for Mentoring in Flight Instruction. She has created a number of advanced avionics training courses and modules, and she is the primary author of the Civil Air Patrol's National Check Pilot Standardization Course.

Susan holds an ATP certificate, as well as ground and flight instructor certificates with instrument, single engine, and multi-engine land ratings. An active general aviation pilot, Susan instructs on weekends for her Leesburg-based flying club and the Civil Air Patrol, in which she holds the National Stan/Eval Advisor position.

Dr. Carolina Anderson was born in Bogota, Colombia, and was introduced to aviation at an early age by her Dad who flew for Avianca, the main Colombian airline; she started flying gliders at age 14 and soloed at 16, towed by her dad in a Super Cub. Later on, she earned her private pilot certificate while she was attending school pursuing a mechanical engineering degree so that she could understand better how airplanes work.

Today, Dr. Anderson is an Associate Professor of Aeronautical Science in the College of Aviation at ERAU. She holds a Ph.D. in Aviation from Embry-Riddle Aeronautical University (ERAU), graduated with the first group of Ph.D. graduates at ERAU in December of 2013, and became the first woman with a Ph.D. in Aviation. Dr. Anderson also holds a Master in Business Administration in Aviation from ERAU, and a B.S. in Mechanical Engineering from Los Andes University in Bogota, Colombia. In addition, Dr. Anderson holds an ATP and Commercial Pilot certificates in single engine, multi-engine, instrument airplanes, gliders and seaplanes; CFI in gliders, Instrument, single and multi-engine airplanes; Check Pilot and Training Center Evaluator. Dr.

Anderson has over 4,000 hours of flight time and over 3,500 hours of flight instruction. Dr. Anderson has over 20 years of experience in General Aviation in the U.S. and internationally as an aircraft owner, operator, flight instructor, and volunteer of many General Aviation Organizations.

APPENDIX C

INSTITUTIONAL REVIEW BOARD

Embry-Riddle Aeronautical University
Application for IRB Approval
Determination Form

Principal Investigator: Sabrina Woods

Other Investigators: Dr. Scott R. Winter

Role: Student **Campus:** Worldwide **College:** Aviation/Aeronautics

Project Title: Assessing How Motivation Affects General Aviation Pilots in Continued Visual Flight Rules Flight Instrument Meteorological Conditions

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 06/27/2018 **Approval #:** 18-152

Determination: Exempt

Dr. Michael Wiggins IRB Chair Signature: Michael E. Wiggins, Ed.D. Digitally signed by Michael E. Wiggins, Ed.D. DN: cn=Michael E. Wiggins, Ed.D., o=Embry-Riddle Aeronautical University, ou=Aeronautical Science Department, email=wigginsm@erau.edu, c=US Date: 2018.06.28 09:34:55 -04'00' **Date:** 06/28/2018

Brief Description:

The purpose of this research is to assess how pilot's approach cross-country flying. The proposed research bridges the gap between what is currently presumed about the decision to continue in visual flight rules flight into instrument meteorological conditions and marries those ideas with the extensive studies in how motivation theoretically affects the decision-making process. The study will conduct an experimental design via online questionnaire to determine how different motivation and different types of meteorological conditions might affect a pilot's willingness to persist.

RESEARCH PARTICIPANT CONSENT FORM

Purpose of Research
The purpose of this research will be to assess how you approach cross-country flying.

Specific Procedures
You will be presented with some scenarios, and you will then be asked some questions about those scenarios. In addition, you will be asked some demographics questions. The data collection process is anonymous, and your responses will remain confidential. If you no longer wish to participate in the research you may withdraw at any time and your data will be deleted from the dataset.

Duration of Participation
The duration of this is anticipated to take no longer than 10 minutes.

Risks
It is anticipated that this study will pose no greater risk than you would experience through normal daily activities.

Benefits
There are no known benefits to your participation other than knowing you have contributed to the advancement of scientific knowledge.

Compensation
There is no additional compensation awarded for participation in this research.

Confidentiality
The data collected during this study will be anonymous and confidential. We have no way of learning your true identity.

Voluntary Nature of Participation
You do not have to participate in this research project. If you agree to participate, you can withdraw your participation at any time without penalty. Furthermore, if you withdraw from the study prior to its completion, your data will be removed from the dataset and destroyed.

Contact Information:
If you have any questions about this research project, you can contact Sabrina Woods at woodss4@my.erau.edu. If you have concerns about the treatment of research participants, you can contact the IRB Administrator, Teri Gabriel at teri.gabriel@erau.edu or call 386-226-7179.

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I am prepared to participate in the research project described above.

APPENDIX D

RESULTS OF MANUAL BOOTSTRAP METHOD

A manual single bootstrap was attempted on two different samples that were randomly split from the main dataset. A two-way mixed ANOVA and tests for normality were run on the two split samples.

For the two-way ANOVA, meteorological condition (weather) remained significant with a large effect size across both the two new samples. This mirrored the results of the original test. Likewise, the independent variable motivation did not have an effect on one's willingness to persist in either the two new datasets or the original one.

There is a minor difference between the two new samples in the significance of the interactions of the independent variables on the dependent variable; however, the effect size was still very small for both. The small effect size was also found in the significant result of the interaction in the main sample.

Test of Within Subject Effects for Sample 1

Source		Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Weather	Sphericity Assumed	834375.123	2	417187.562	883.711	.001	.781
	Greenhouse-Geisser	834375.123	1.878	444388.158	883.711	.001	.781
	Huynh-Feldt	834375.123	1.907	437609.680	883.711	.001	.781
	Lower-bound	834375.123	1.000	834375.123	883.711	.001	.781
Weather * Motivations	Sphericity Assumed	717.365	4	179.341	.380	.823	.003
	Greenhouse-Geisser	717.365	3.755	191.034	.380	.811	.003
	Huynh-Feldt	717.365	3.813	188.120	.380	.814	.003
	Lower-bound	717.365	2.000	358.683	.380	.684	.003
Error(Weather)	Sphericity Assumed	234154.701	496	472.086			
	Greenhouse-Geisser	234154.701	465.640	502.866			
	Huynh-Feldt	234154.701	472.853	495.196			
	Lower-bound	234154.701	248.000	944.172			

Test of Between Subject Effects for Sample 1

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Intercept	2375628.805	1	2375628.805	2292.968	.001	.902
Motivations	1832.869	2	916.434	.885	.414	.007
Error	256940.316	248	1036.050			

Test of Within Subject Effects for Sample 2

Source		Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Weather	Sphericity Assumed	727845.619	2	363922.809	828.751	.001	.806
	Greenhouse-Geisser	727845.619	1.871	388950.826	828.751	.001	.806
	Huynh-Feldt	727845.619	1.907	381626.560	828.751	.001	.806
	Lower-bound	727845.619	1.000	727845.619	828.751	.001	.806
Weather * Motivations	Sphericity Assumed	6425.125	4	1606.281	3.658	.006	.035
	Greenhouse-Geisser	6425.125	3.743	1716.750	3.658	.007	.035
	Huynh-Feldt	6425.125	3.814	1684.422	3.658	.007	.035
	Lower-bound	6425.125	2.000	3212.563	3.658	.028	.035
Error(Weather)	Sphericity Assumed	175648.842	400	439.122			
	Greenhouse-Geisser	175648.842	374.261	469.322			
	Huynh-Feldt	175648.842	381.444	460.484			
	Lower-bound	175648.842	200.000	878.244			

Test of Between Subject Effects for Sample 2

Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Intercept	1795883.200	1	1795883.200	1928.609	.001	.906
Motivations	5285.496	2	2642.748	2.838	.061	.028
Error	186236.083	200	931.180			