5-1-2010

Handedness as a Predictor of Success in FAR Part 141 Flight Training

Danielle Dracy

HANDEDNESS AS A PREDICTOR OF SUCCESS IN FAR PART 141 FLIGHT TRAINING

by

Danielle L. Dracy
Bachelor of Science, North Dakota State University, 2007

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota
May
2010

This thesis, submitted by Danielle L. Dracy in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Chairperson

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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Dean of the Graduate School

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Department	Aviation
Degree	Master of Science

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ACKNOWLEDGEMENTS

The author wishes to acknowledge her Thesis Committee in their support of this research project. Further, the author expresses endless gratitude to the Thesis Committee for their guidance and patience in the process which lead to the creation of this thesis.

ABSTRACT

The current study assesses the prevalence of left-, right-, and mixed-handedness and handedness as a predictor of success in flight training. The convenience sample is comprised of students enrolled in or who have previously completed the private pilot course at the University of North Dakota's Part 141 flight training program. The Edinburgh Handedness Inventory and self-report methods are used to determine subject's handedness. Success in flight training is assessed using student computerized academic and flight records. Statistical analysis of the data does not show a significant difference between left-, right-, and mixed-handed students with any of the measures used. This document explores research findings, potential implications, and ideas for future research resultant of the current study.

CHAPTER I

INTRODUCTION

Left-handers make up approximately 10% of the general population (Bragdon & Gamon, 2000; Coren, 1993; Hardyck & Petrinovich, 1977). Although this group is not one of the first you might think of as a neglected minority, left-handers have historically faced discrimination in a predominately right-handed world (Coren, 1993). Recent research has discredited many of the beliefs that have led to the prejudice against left-handed individuals. However, nearly all research recognizes that while left-handedness should not be viewed as a burden, individuals who are non-right-handed are in many ways different from the majority (Coren, 1993).

As a group, left-handers have distinctive strengths and weaknesses which may play a role in flight training. Contradicting studies of left-handedness as a predictor of success in academia elicits an inquiry of left-handedness as a predictor of success of student pilots, yet another unique group (Coren, 1993; Williams, 2001). Furthermore, a complete lack of previous research regarding handedness as a predictor of success in flight training educes an inquiry of left-handedness as a predictor of success in the unique learning environment of a collegiate flight training program.

Purpose Statement

This study is resultant of previous research. The intriguing findings in other professions and the lack of research in aviation encouraged the study of handedness as a predictor of success in flight training.

Significance of the Study

This study is the first in a line of research which could have far reaching effects in the fields of commercial aviation, aviation safety, and aviation education. Upon commencement of this study it was hoped the issues of pilot shortages, pilot safety, and high costs of flight training would be lessened by this study.

First, if it were found that any of the three groups (right-handers, mixed-handers, and left-handers) had a lower representation in flight training programs than in the general public, we could determine what biases cause this anomaly. Alleviating any unnecessary biases could increase the number of students in flight training programs. Thus, the current study would play a role in lessening any future pilot shortages.

Secondly, this study could help determine which groups are at a higher risk for errors, leading to safety concerns. For that reason, information could be applied in pilot selection and training.

Finally, it is widely known that flight training is expensive. If it were determined that any of the groups studied required significantly fewer dual flight hours to attain a private pilot certificate, individuals in this group may be selected to enter flight training programs in attempts to limit the cost incurred from flight training.

Research Questions

A review of literature, found in the next section of this document, leads to the development of five research questions. Statistical analysis of data collected answer each of these questions. The primary research question is:

1. Is the incidence of left-handers in flight training the same as in the general population?

The four remaining research questions are secondary and their significance is dependent on survey and flight training record results. These secondary research questions are as follows:

1. Do any of the groups studied show a difference in academic performance in Part 141 ground training?

2. Do any of the groups studied show a difference in the number of dual flight hours required to complete the first solo flight in Part 141 flight training?

3. Do any of the groups studied show a difference in the number of dual flight hours required to attain a private pilot license in Part 141 flight training?

4. Do any of the groups studied show a difference in stage check pass rates in Part 141 ground training?

Review of Literature

The question, “are you right or left-handed?” is more complex that it initially seems. To begin to understand how handedness may affect flight training, what it means to be left-handed or right-handed must be understood from the perspective of psychological researchers. According to Hardyck and Petrinovich (1977), handedness can be regarded as a continuum ranging from strong right-handedness across mixed-handedness to strong left-handedness. To be categorized as strongly right-handed one must have a strong preference to perform most activities using their right hand; to be categorized as strongly left-handed one must have a strong preference to perform most activities using their left hand. Mixed-handers may be entirely indifferent in regard to hand preference or have only a slight preference for using one hand or the other. Some texts use the terms mixed-handers and ambidextrous interchangeably; for the sake of continuity this text uses the term mixed-handers in reference to the third group.

Prevalence of left-, right- and mixed-handedness

It is generally accepted that right-handed individuals make up the vast majority of the general public; approximately 90% of the population falls into this category (Coren, 1993). Many studies report that left-handedness, from moderate left-handedness through strongly left-handed, is reported by approximately 10% of the population (Bragdon & Gamon, 2000; Coren, 1993; Hardyck & Petrinovich, 1977).

Past studies show variation in reported prevalence left and right-handedness dependant of the methods of reporting (Oldfield, 1971). When relying on self-reporting of hand preference, over 25% of males and 16% of females report some tendencies toward left-handedness (Oldfield, 1971). While it is widely accepted that 10% of the population is left-handed, some studies report incidence of left-handedness being at rare as 5% to as common at 25% of the general population (Williams, 1991).

The variation in prevalence of reported left-handedness can be attributed to several criteria. Two such criteria are the diversity of subjects surveyed and the tool used to measure handedness. The tools used to measure handedness are discussed later in this study. It is important to be cognizant of the sample used because the subjects studied have a huge impact on prevalence of handedness. For example, one study showed that left-handedness in more common among men than women with 10% of women being left-handed and 14% of men, thus studies with large representations of men will report higher prevalence of left-handedness (Coren, 1993). Also, prevalence of left-handedness decreases with age as 15% of 10 year-olds are left-handed and only 5% of 50 year olds are left-handed (Coren, 1993). Again, studies with large representations of children will report high prevalence of left-handedness since there is currently less tendency to encourage naturally left-handed children to write with their right hand than in previous generations. A largely overlooked group in studies of handedness is the mixed-hander. The most widely used tools that measure handedness show that 6% to 13% of the general population is mixed-handed, as defined by the tool used (Williams, 1991). As earlier stated, an important issue to consider is the tool used to measure handedness, as this tool may have an impact on reports of the prevalence of handedness among populations.

Handedness: theories of cause

Left-handedness has a long and rich history. Various theories of the causation of handedness exist, but many have been disproven in previous studies. Some of the earliest works argued that handedness was entirely a matter of habit and that all children should be taught to use either hand interchangeably (Jackson, 1905). Since that time research has allowed greater understanding on neurology and biology, and theories of handedness have evolved to accept that individuals are naturally inclined toward left, right, or mixed-handedness.

Several social explanations developed in the early studies of handedness. The most common social explanation in historic literature is the "sword and shield" theory (Hardyck & Petrinovich, 1977). This theory proposes that soldiers who held his shield in his left hand offered his heart better protection and thus had a better chance of survival. By the same process, the right hand became more dextral and eventually came to be used for all activities that required skilled dexterity. Also by this process, and a belief that handedness is a genetic predisposition, the left-handers, unable to protect themselves, were killed and unable pass on their genetic material. According to this theory, the burden that left-handedness was to soldiers led to fewer future generations of left-handers thus right-handers became the majority.

As research methods become more advanced, theories of handedness become more complex. One marker of this theological advancement is the recognition that the two sides of the brain differ and are related to handedness. During the first century A.D., researchers first began to realize that one side of the brain had a relationship to the opposite side of the body (Gianntrapani, 1969).

Throughout the history of the studies of handedness many anatomical theories have come and gone regarding reasons for differences in cerebral function and handedness. One theory suggests that the left side of the brain is better vascularized; this theory suggested that the left side of the brain had a more rapid flow of blood, since the left carotid artery has a faster blood flow than the right carotid artery (Hardyck & Petrinovich, 1977). However, this position was discredited by advances in anatomical knowledge. It has since been determined that the vascularization of the brain provides for equal blood supply to both hemispheres.

The most recent theories of handedness recognize a genetic cause of handedness, but the explanation of how this genetic trait is passed-on is still unclear. The genetic theories of handedness are derived from studies which show children with two right-handed parents have a 10% chance of being left handed; left-handed fathers seem to have very little influence on the handedness of children; children of a left-handed mother have a 20% chance of being left handed; children with two left-handed parents have a 40% chance of being left handed (Coren, 1993; Bragdon & Gamon, 2000).

Another recent theory of the cause of handedness states that handedness is, in some cases, pathological. This theory argues that left-handedness is caused by abnormalities in fetal development (Bragdon & Gamon, 2000). Since cerebral hemisphere dominance and handedness is largely contralateral, an anomaly during development of the right hemisphere may shift dominant motor control to the left side (Bragdon & Gamon, 2000). Studies suggest that trauma to the fetus may hinder cerebral development; this theory is strengthened with the recognition that left-handers face many psychological hardships later in life, which are also associated with fetal and birth trauma.

Several of the psychological hardships and other medical implications of left-handedness may play a role in flight training. For example, Coren (1993) cites a higher incidence of depression and alcoholism among left-handers. These two diagnoses may restrict an individual from attaining an aviation medical certificate, thus restricting them from participating in flight training. Left-handers are also more common in groups of individuals with a history of autism, brain damage, criminality, drug abuse, epilepsy, and mental retardation (Coren, 1993). A history of any of these problems may also restrict individuals from attaining an airman medical certificate and engaging in flight training (FAA, 2008).

The need for handedness research in aviation is evident when reviewing handedness research among other professions. Research of the effects and incidence of handedness exists in various other groups including studies of architects, artists, physicians, surgeons, dentists, university students, and United States Presidents. Since previous studies of handedness in aviation and flight training are rare, a review of the studies in these other disciplines may give direction to the research of handedness in flight training.

Prevalence of left-, right-, and mixed-handedness in other fields

Coren (1993) found that university students with a declared major of architecture are more likely to be left-handed than the general population. From the same study, 29% of the faculty in the department of architecture were left handed (Coren, 1993).

A study of handedness among artists was initiated when it was observed that high number of famous artists were left-handed, including Leonardo da Vinci, Raphael, Hans Holbein, Paul Klee, and Pablo Picasso. The research found that 47% of the 103 art majors studied were left or mixed-handed while 22% of the general university population was non-right-handed (Coren, 1993).

Several studies have been done on the incidence of left-handedness in the medical field (Schott & Puttick, 1995; McManus & Jonvik, 1991). A survey of 67 physicians and 36 surgeons found 12% of physicians to be left-handed while there were zero reports of left-handedness among surgeons (Schott & Puttick, 1995). A similar study surveyed medical specialty choice among medical study. This study reported no statistically significant correlation between handedness and medical specialty choice among medical students (McManus & Jonvik, 1991).

Another study examined the prevalence of left-handedness among dental undergraduates and orthodontic specialists. This study found that 8.6% of the dental students and 17.2% of the orthodontists were left-handed compared to the 7.4% left-handedness among the greater university population. This study also found a higher incidence of mixed-handedness among the group of dentistry and orthodontics students (Henderson, Stephens, & Gale, 1996).

An additional study of university students grouped degree programs into language-based programs and science-based programs. This study found that right-handers were much more common in the language-based programs while left or mixed-handers were quite rare. Also, for every two left or mixed-handers in the language based programs, there were three left-handers in the science-based programs (Coren, 1993).

A final study reports findings in regard to the handedness of United States Presidents. Eight of the last 25 United States Presidents are reported to be left-handed including Presidents James Garfield, Herbert Hoover, Harry Truman, Gerald Ford, Ronald Reagan, George H. W. Bush, Bill Clinton, and Barack Obama (Holder, 2005; Arehart-Treichel, 2009). Simple arithmetic reveals that these eight presidents make up 32% of the United States Presidents since 1881. Assuming that no United States Presidents have had major cognitive deficits, one may expect less that 10% of this group to be left-handed with the knowledge that many neurological deficits plague left-handers as a group. This detail makes the 32% figure even more astonishing.

While handedness as a topic of research may have been completely ignored in regard to flight training, one study assessed the role of handedness in flying performance. The study was conducted in India and used a sample of 20 pilots from the Indian Armed Forces. The subjects completed the Edinburgh Handedness Inventory, a two-hand coordination test, Minnesota Rate of Manipulation Board Test, and Finger Dexterity Board Test. The results of this study reveal that left-handed aircrew is not at a disadvantage. The study also declared that there is no bias against the left-hander in the conventional cockpit. According to this study, the incidence of left-handers is the same in aviation as in the general population. This finding suggests that there is no bias against left-handers in pilot selection or training (Pipraiya & Chowdhary, 2006).

Handedness, Gender, and Cerebral Function

Handedness and cerebral function are closely tied; this fact allows for the study of learning and other cognitive tasks to be based on subjects hand preference (Zillmer, Spiers, & Culbertson, 2008; Coren, 1993). Early studies of handedness and cerebral function determined that the right cerebral hemisphere controls muscles on the left side of the body and the left cerebral hemisphere controls muscles on the right side of the body (Chudler, 2009). Also, in general, sensory information from the left side of the body crosses over to the right cerebral hemisphere and information from the right side of the body crosses over to the left cerebral hemisphere (Chudler, 2009). If this is the case, individuals with dominant left-side motor function (left-handedness) have right hemisphere cerebral dominance, and vice versa. This cross-over is often referred to as contralateral functioning (Bragdon & Gamon, 2000).

The theory of contralateral functioning is far too simplified according to some researchers. Levy and Reid (1978) argue that left-handers tend toward bilateralization of function, rather than strong right-hemisphere dominance. Since the language center is generally located in the left-hemisphere, bilateralization causes competition between language and perceptual function in the right-hemisphere. Under this theory it is believed that competition between cerebral hemispheres of the left-hander lead to reduced language and perceptual abilities.

Regardless of which theory is closer to truth, nearly all literature acknowledges a link between handedness and cerebral function. Since cerebral dominance is so closely linked to handedness, cerebral hemispheric differences must be explored to further understand the cognitive differences between left-handers and right-handers. Each hemisphere of the brain is dominant for certain abilities. Chudler (2009) states that the right cerebral hemisphere is dominant for spatial abilities, face recognition, visual imagery and music. The left cerebral hemisphere is dominant for calculations, math and logical abilities (Chudler, 2009). This being the case, superior visual and spatial abilities and inferior mathematical, logical and language abilities can be expected among left-handers as compared to right-handers. However, these generalizations acknowledge that the two hemispheres are connected, and information is shared between the hemispheres.

Gender is yet another variable in studies of handedness. Differences in hemispheric specialization between genders must be addressed. Reports of gender differences in cerebral functioning are contradictory, but most propose that males are more likely to show strongly lateralized speech functions, usually in the left-hemisphere (Levy & Heller, 1992; Shaywitz, 1995). Females more commonly demonstrate bilateral and right-hemisphere specialization of speech functions. Also, males show strong right-hemisphere specialization in listening functions. Again, females demonstrate bilateralization in listening functions (Saucier & Elias, 2001).

Contradicting studies of hemispheric specialization do not overwhelm previous studies that show unique cognitive strengths between genders. Studies show the females exhibit superior language skills, mathematic computation, and fine-motor-dexterity; males show superior visiospatial skills including mental rotation (Zillmer, Spiers, &

Culbertson, 2008). However, it is important to recognize that such studies show great overlap and limited difference between genders in language and visiospatial skills. Also, researchers declare that these differences between genders may be due to cultural expectations and socialization rather than neurologic factors.

Handedness, Gender, and Academic Performance

Although no studies have been found to address left-handers performance in flight training, several have assessed differences in academic performance of left-handers. Results of these studies are contradicting. While most focus on the cognitive deficits of left-handers, some report superior academic performance among non-right-handed students.

Ground training, a major component of flight training, takes place in a traditional academic environment. While research specific to handedness as a predictor of success in ground training at Part 141 Flight Training is virtually non-existent, much research has been done regarding handedness and general academic success. For example, Williams (2001) found reduced verbal and spatial reasoning skills among left-handers. He asserts that these deficiencies lead to inferior academic performance among left-handers. Also, Coren (1993) cites higher incidence of learning disabilities, specifically dyslexia, among left-handers; dyslexia is often apparent through reading and writing difficulties, also resulting in impaired academic performance (Coren, 1993).

Numerous studies (Williams, 2001) support assertions of left-hander inferiority in the academic setting. A 2001 survey of the academic records of 190 13 to 18 year old males showed superior performance in the disciplines of geography, history, mathematics, science, French, English, and Latin among right-handers (Williams, 2001).

Another study attempted to assess the effect of gender and handedness on academic performance. Results of this study gave no evidence of a gender and handedness interaction as related to academic performance, yet this study again asserts right-handers superiority in academia overall, and specifically in mathematics (Williams, 2001).

Not all research cites the right-hander as the intellectual superior. Coren (1993) refers to laboratory tests that reveal superiority of the left-hander in activities that require visualization and mental manipulation of images. Another study of handedness and learning showed that 35.5% of non-right-handed subjects scored above class average while only 20.9% of right-handers scored above average; in this study 16.8% of right-handers scored below average, while only 3.2% of non-right-handers scored below the class average (Emore, Ebeye, Odion-Obomhense, & Igbigbi, 2008).

Evidence shows that left-handers tend to be more extreme in their overall abilities (Coren, 1993). While left-handedness tends to be more common in groups with various learning disabilities, it is also a trait among some extremely intelligent individuals. Since left-handers tend to be more extreme in this way, it is probable that those left-handers who are admitted to flight training programs and who are able to attain airmen medical certificates may be expected to perform better than their right-handed counterparts. Stringent flight school admission standards and requirements to attain an airman medical certificate eradicate those left-handers who suffer learning disabilities and mental illnesses; presumably, left-handers with learning disabilities and mental illnesses cause research results to indicate poorer academic performance among left-handers as a group. With these groups of left-handers excluded from flight training, the left-handers who are allowed in flight training may be expected to exhibit superior academic performance as compared to their right-handed classmates.

The mixed-hander is a third group that is largely overlooked in studies of handedness. However, Chase and Seidler (2008) evaluated degrees of handedness in relation to learning. The study reports that the degree of handedness does impact learning abilities. The study found that mixed-handers have superior learning abilities, in relation to strongly left-handed or strongly right-handed individuals.

Handedness, Gender, and Pilot Performance

Pilots are a specialized group of professionals who rely heavily on specific cognitive abilities; many such abilities depend greatly on visual cognition. Dror, Kosslyn, and Waag (1993) state that visual-spatial abilities are essential for both mission accomplishment and safety in the flying environment.

Earlier discussion disclosed that some laboratory tests reveal superiority of the left-hander in activities that require visualization and mental manipulation of images (Coren, 1993). Specifically, Porac and Coren (1981) cite left-handers superior performance on mental rotation tests. Also, Zillmer et al. (2008) states that males generally perform better on mental rotation tests than females. Interestingly, mental rotation tests are a commonly used screening criteria in various pilot selection processes. A 1993 study reveals the importance and presence of mental rotation abilities among pilots (Dror, Kosslyn, & Waag, 1993). The study exposed that pilots, as compared to non-pilots, required less response time in metal rotation and visual orientation tasks. This particular skill is essential in several phases of flight. Pilots are frequently required to manipulate visual imagery. For example, a pilot who is flying straight and level and then rolls the aircraft into a 30^o bank must mentally rotate his view to accurately assess their relative position. This single example is used to show how individuals who score higher on mental rotation tests may be at an advantage in the flight training environment. For this reason, left-handers and males are expected to show superior performance in the flight portion of pilot training.

The Dror et al. (1993) study details specific spatial relationships and how cognitive translations of these relationships are critical in several phases of flight. Pilots are required to determine objects relative positions to each other as well as judge distance between objects. Drors' (1993) study found that pilots judge distance between objects better than non-pilots, but non-pilots judge relative position as good as pilots. This finding indicates that judging distance may be more important in the flying environment than in other environments. Interestingly, the ability to judge distance is largely a function of the right-hemisphere (Dror, et al., 1993). This finding also elicits the expectation that left-handers would perform better than right-handers in the flying environment.

As previously stated, no studies were found to have been completed in regard to handedness as a predictor of success in flight training. However, cerebral dominance has not been totally ignored in the flight training environment. In fact, the Aviation Instructors Handbook, distributed by the Federal Aviation Administration (FAA) devotes special attention to the issue. The following is an example of recognition given to the role of hemisphere dominance in flight training in the Aviation Instructors Handbook:

> According to research on the human brain, people have a preferred side of the brain to use for understanding and storing information. While both

> sides of the brain are involved in nearly every human activity, it has been shown that those with right-brain dominance are characterized as being spatially oriented, creative, intuitive, and emotional. Those with left-brain dominance are more verbal, analytical, and objective. Generally, the brain functions as a whole. For example, the right hemisphere may recognize a face, while the left associates a name to go with the face.
>
> While most people seem to have a dominant side, it is a preference, not an absolute. On the other hand, when learning is new, difficult, or stressful, the brain seems to go on autopilot to the preferred side. Recognizing a student's dominant brain hemisphere gives the instructor a guide for ways to teach and reinforce learning. There are also some people who use both sides of the brain equally well for understanding and storing information.
>
> (FAA, 2008, p. 2-18)

The preceding entry aligns with most of the literature of cerebral dominance and learning, but ignores that the flight training environment is unique as compared to the traditional learning environment. Also, this entry does not give enough attention to the role of cerebral dominance and handedness in aviation; especially since the incidences of left-handers in flight training is uncertain.

Measures of Handedness

A major goal of this study is to determine the prevalence of right, left, and mixed-handedness among students in flight training. One may assume that simply asking the subjects, "are you right or left-handed?" would be sufficient to determine the handedness of each subject. However, asking this question usually elicits little thought. Most people respond quickly, and their answers are usually reflective of the hand they write with (Crovitz & Zener, 1962). Historical studies of handedness have lead to the creation of several tools to measure degrees of handedness in individuals. Of the literature reviewed, the two most widely used handedness inventories are those created by Annett and Oldfield. Earlier inventories were created; some of the most recognizable are by Durost, Hull, and Humphrey. These earlier tools contributed to the study of handedness, but have been deemed unreliable and expensive to use.

The Annett handedness questionnaire is a 12-item tool (Annett, 1970). The questionnaire surveys hand preference when writing, throwing, striking a match, dealing cards, hammering, unscrewing a jar lid, and using a scissor, thread, broom, shovel, racket, and toothbrush.

The original Edinburgh Handedness Inventory by Oldfield is a 20-item questionnaire (Oldfield, 1971). A 10-item version of the Edinburgh Handedness Inventory was later created and is the more widely used version of the tool. Similar to the Annett handedness questionnaire, this 10-item tool includes questions about hand preference in writing, drawing, throwing, opening a box, striking a match, and in using a scissor, toothbrush, knife, spoon, and broom.

Williams (1991) compared the Edinburgh and Annett measures of handedness. The study revealed that the Edinburgh Handedness Inventory yielded more either-hand responses and fewer left-hand responses than does the Annett questionnaire. Both of these tools showed high internal consistency. Williams (1991) also found that no member of the sample showed difficulty in answering any part of either questionnaire. Also, both tools showed standard J-shaped distribution of handedness, with a marked tail of strong left-handers and few mixed-handers as expected.

Definition of Key Terms

To better understand this study, the key terms must be defined. While some of the terms used may be defined differently in different disciplines, the following list defines each of these key terms as they are used in the current study.

- Handedness: a continuum ranging from strong right-handedness across mixed-handedness to strong left-handedness (Hardyck & Petrinovich, 1977).
- Edinburgh Handedness Inventory: a quantitative tool used to measure handedness (Oldfield, 1971).
    - Laterality Quotient (LQ): units in which results of the Edinburgh Handedness Inventory are measured; LQ range from -100 to +100 (Oldfield, 1971). In this study, LQ of -100 to -40 are categorized as left-handed. LQ greater than -40 and less than +40 are categorized as mixed-handed. LQ of +40 to +100 are categorized as right-handed.
- FAR Part 141: the section of Federal Aviation Regulations which establishes an intensive set of standards for professional pilot training schools. FAR Part141 schools must follow a standardized curriculum for all students. Two major components of FAR Part 141 curriculum include flight training and ground training.
    - Flight training: training which occurs in the aircraft.
    - Ground training: training which occurs in the typical classroom environment.

- Dual flight hours: flight training which occurs with both the student pilot and Certified Flight Instructor (CFI) onboard the aircraft. Records of dual flight training are kept in student flight records and were available for the current study.
- First solo flight: first flight completed with only the student onboard the aircraft. During this flight, the student is required to complete take-offs and landings as sole manipulator of the aircraft. The first solo flight is considered a major milestone during flight training. In the United States, there is no minimum number of required dual flight hours prior to the first solo flight.
- Stage checks: assessments of both flight training and ground training progress. At UND, three stage checks are required for completion of the private pilot course. These three stage checks occur at specified points during flight training with the final stage check marking completion of the flight training course.

Assumptions

1. This study makes the assumption that the quality of instruction that each student received was similar, both in the cockpit and in the classroom.
2. This study makes the assumption that all students in the sample honestly and accurately answered the handedness questionnaire.

Limitations

1. The potential of confounding variables is a limit of the current study. While the study focuses on cognitive difference between left-, right, and mixed-handers, hardware issues may have an effect on the study as all student pilots in the study manipulated aircraft controls from the left-seat of the cockpit.

2. The study was limited to a small sample of students who were pursuing private pilot certificates in a single-engine fixed-wing aircraft from a Part 141 flight school; therefore, the findings may not be applicable to all flight training programs, all types of aircraft, or in all locations.
3. With the small population of students in UND's private pilot course and the unequal distribution of handedness, the sample size of the mixed- and left-handed groups are limited to very small numbers.

CHAPTER II

METHODS

To evaluate handedness as a predictor of success in Part 141 flight training, a measure of handedness is compared with existing records of performance in flight training. Specifically, the handedness measure, test scores, stage check pass rates, and the number of dual flight training hours required complete the first solo flight and to achieve a private pilot's license were collected as part of this study.

Sample

The population for this study consists of student pilots who are enrolled in or have completed the University of North Dakota's (UND) Part 141 flight training program. Specifically, the subjects of this study are student pilots who are enrolled in or have completed UND's private pilot course (Avit 102) with no previous flight experience.

Several sections of the private pilot ground school course at UND were included in the sample. Also, students in aviation safety, human factors, air transportation, and aerospace law courses at UND were surveyed. Avit 102 is a prerequisite for these courses, so all students enrolled in these courses have previously completed UND's private pilot training. Data was collected at UND during the summer and fall semesters of 2009.

Study Design and Data Collection

A quantitative descriptive design is used to answer the five research questions of this study. Three sources are used to collect data during this study. Information was collected from a survey, academic grades, and flight records of private pilot training.

The first set of data collected was via a handedness survey tool. This survey included the following: name, student identification number, gender, date of birth, declared major, the Edinburgh Handedness Inventory, flight course taken at UND, and academic course currently enrolled in. The majority of this information was collected so the results of this survey can be matched to the subjects academic and flight performance records. The Edinburgh Handedness Inventory was used to assign subjects to one of the three following groups: left-handed, right-handed, mixed-handed. During the data collection process, students were also verbally asked, “When someone asks if you are right or left-handed, how do you respond?” Students wrote their answer to this question on the survey, and the data was used as a qualitative self-reported assignment of handedness.

In addition to the survey tool previously described, academic grades, the number of dual hour received prior to first solo-flight, stage-check pass rates, and the total number of dual flight hours logged were collected for each subject. This information was retrieved from the software program that UND uses to track student performance in flight courses, the Aviation Information Management System (AIMS).

Instrument Reliability and Validity

The Edinburgh Handedness Inventory has been used extensively in the study of handedness over the past three decades. Ransil and Schachter (1994) assessed the reliability of the Edinburgh Handedness Inventory. This study demonstrated that the inventory is a reliable substitute for observing handedness in the performance of everyday tasks. In another assessment of the Edinburgh Handedness inventory, the test-retest reliability of the tool has been found to be about .80 (McMeekan & Lishman, 1975).

Data Analysis

The comparison of the number of hours logged to complete the first solo flight, the number of hours logged to obtain a private pilot certificate, stage-check pass rate, academic grade in the ground training portion of Aviation 102, and results of the Edinburgh Handedness Inventory was completed.

Comparisons and One-way Analyses of Variance (ANOVAs) were used to address the pre-established research questions. An assessment of the prevalence of left-, right-, and mixed-handers in flight training as compared to the prevalence of left-, right-, and mixed-handers in the general population was done and is explained in the results portion of this text.

Further, statistical tests were conducted to address the other four research questions:

1. Do any of the groups studied show a difference in academic performance in Part 141 ground training?

2. Do any of the groups studied show a difference in the number of dual flight hours required to complete the first solo flight in Part 141 flight training?

3. Do any of the groups studied show a difference in the number of dual flight hours required to attain a private pilot license in Part 141 flight training?

4. Do any of the groups studied show a difference in stage check pass rates in Part 141 ground training?

Each of these research questions were addressed using a One-way ANOVAs. Use of the One-way ANOVA was selected as an appropriate test because the researcher sought to assess variance of one independent variable at a time between the three groups of handedness (Crawley, 2005). For this reason, separate One-way ANOVAs were used to answer each of the final four research questions.

Protection of Human Subjects

Participation in the study was voluntary for all subjects. The study has been reviewed and approved by the University of North Dakota's Institutional Review Board (IRB). There are no foreseeable risks associated with participation in this study. After survey results, academic grades, and flight records were matched for each subject, all identifying information was removed and a random code was assigned to each subject. Results are only reported as group data. The academic records, flight records, and surveys are stored in a locked file. Only the researchers have access to these files. After three years, all academic records, flight records, and surveys used in this study will be shredded.

CHAPTER III

RESULTS

The purpose of this study is to determine the prevalence of left-, right-, and mixed-handedness in Part 141 Flight Training. Further, this study reveals handedness as a predictor of success in various facets of Part 141 Flight Training. As earlier explained, students at UND were surveyed; the results of these surveys are presented in this chapter.

Description of Subjects

Because of the unique variables examined in the study, different samples are used to determine the prevalence of left-, right-, and mixed-handedness in Part 141 Flight Training than are used to answer the remaining research questions.

The total sample of this study is used to determine the prevalence of left-, right-, and mixed-handedness in Part 141 Flight Training. This sample includes 193 students. All of these students were enrolled in at least one of the following courses at UND during the summer or fall semesters of 2009: introduction to aviation, aviation safety, human factors, air transportation, or aerospace law.

This sample (N=193) is very homogeneous. 92.75% (179 of 193) of the students in this sample are male; only 7.25% (14 of 193) of students in this sample are female. The students in this sample range in age from 18 years old to 32 years old, with a mean of 20.83 years.

The students surveyed have a variety of declared academic majors. The majority (66.84%) of the students surveyed have declared Commercial Aviation as their major. Table 1 shows the distribution of declared major of all students in this sample.

Table 1

Declared Major of All Students Surveyed

Declared Major	N	Percent of Students
Air Traffic Control	39	20.21
Airport Management	7	3.63
Aviation Management	9	4.66
Aviation Systems Management	2	1.04
Commercial Aviation	129	66.84
Engineering	3	1.55
Other	4	2.07
Total	193	100.00

Prevalence of Right-, Left- and Mixed-Handedness in Part 141 Flight Training

Two methods are used to determine handedness of students surveyed. The primary means used to determine handedness is via a quantitative tool, the Edinburgh Handedness Inventory. Of 193 students, 140 (72.54%) students scored ≤100 and >40; these students are classified as right-handed. Of 193 students, 38 (19.69%) students scored ≤40 and ≥-40; these students are classified as mixed-handed. Of 193 students, 15 (7.77%) students scored >-40 and ≤-100; these students are classified as left-handed. This information is displayed in Table 2 below.

Table 2

Prevalence of Handedness using the Edinburgh Inventory

Handedness	N	Percent of Students
Right-Handed	140	72.54
Mixed-Handed	38	19.69
Left-Handed	15	7.77
Total	193	100.00

The second tool used to determine handedness is a qualitative method; study participants were asked, "When someone asks if you are right- or left-handed, how do you respond?" Of 193 students, 141 (73.06%) students indicated that they are right-handed. Of 193 students, 9 (4.66%) indicated some tendency towards mixed-handedness. Of 193 students, 24 (12.44%) students indicated that they are left-handed. Nineteen (9.84%) of students did not respond to this question. This information is displayed in Table 3 below.

Table 3

Prevalence of Handedness using qualitative methods

Handedness	N	Percent of Students
Right-Handed	141	73.06
Mixed-Handed	9	4.66
Left-Handed	24	12.44
No Data	19	9.84
Total	193	100.00

The second set of research questions are addressed using a smaller portion of the students. Of the 193 students surveyed, only the portion of the data from the students who had completed the flight portion of UNDs private pilot course can be used. Further, only the data from students who entered UNDs private pilot course with fewer than 30 dual flight training hours can be used since students who enter UNDs flight training program with more than 30 dual flight hours complete a different flight training curriculum than the typical UND private pilot student. This leaves a sample of 81 (N=81) students used to address the following research questions:

1. Do any of the groups studied show a difference in academic performance in Part 141 ground training?

2. Do any of the groups studied show a difference in the number of dual flight hours required to complete the first solo flight in Part 141 flight training?

3. Do any of the groups studied show a difference in the number of dual flight hours required to attain a private pilot license in Part 141 flight training?

4. Do any of the groups studied show a difference in stage check pass rates in Part 141 ground training?

This group of 81 students is referred to as 'Group 2' in the remainder of this text.

Group 2 (N=81) is also very homogeneous. Over 96% (78 of 81) of the students in this sample were male; only 3.70% (3 of 81) of students in this sample were female. The students in Group 2 range in age from 18 years old to 28 years old, with a mean of 21.08 years. The students in Group 2 have a variety of declared academic majors. The majority (69.14%) of the students surveyed in Group 2 have declared Commercial Aviation as their major. Table 4 shows the distribution of declared major of all students in Group 2.

Table 4

Declared Major of Students in Group 2

Declared Major	N	Percent of Students
Air Traffic Control	16	19.75
Airport Management	3	3.70
Aviation Management	5	6.17
Commercial Aviation	56	69.14
Engineering	1	1.23
Total	81	100.00

The same two methods are used to determine handedness of students surveyed in Group 2 as in the original sample. Using The Edinburgh Handedness Inventory, 77.78% of students (63 of 81) in Group 2 scored ≤100 and >40; these students are classified as right-handed. 11.11% of students (9 of 81) in this group scored ≤40 and ≥-40; these students are classified as mixed-handed. 11.11% of students (9 of 81) in this group scored >-40 and ≤-100; these students are classified as left-handed. This information is displayed in Table 2 below.

Table 5

Prevalence of Handedness using the Edinburgh Inventory in Group 2

Handedness	N	Percent of Students
Right-Handed	63	77.78
Mixed-Handed	9	11.11
Left-Handed	9	11.11
Total	81	100.00

The second means used to determine handedness in Group 2 is a qualitative method; as in like the original sample, study participants were asked, "When someone asks if you are right or left-handed, how do you respond?" Of the 81 students in Group 2, 75.31% of students (61 of 81) indicated that they are right-handed. Of 83 students in this group, 2.47% indicated some tendency towards mixed-handedness. Of 83 students in Group 2, 14.81% students indicated that they are left-handed. 7.41% of students did not respond to this question. This information is displayed in Table 6 below.

Table 6

Prevalence of Handedness using qualitative methods in Group 2

Handedness	N	Percent of Students
Right-Handed	61	75.31
Mixed-Handed	2	2.47
Left-Handed	12	14.81
No Data	6	7.41
Total	81	100.00

The first research question posed in the second portion of this study is, "Do any of the groups studied show a difference in academic performance in Part 141 ground training?" This study uses Block Exam Scores from UND's Avit 102 course to evaluate academic performance.

Table 7

Mean Block Exam Scores by Handedness

Handedness	Exam Score
Right-Handed	87.61
Mixed-Handed	87.31
Left-Handed	86.79

A One-Way ANOVA is used to address the issue of differences in academic performance between the three groups. Based on the data from Group 2, a test statistic of 0.07 was calculated (F=0.07). The critical value for this data is 3.112 ($F_{2,79}$=3.112). In this case, it appears that there is no statistically significant difference between right-, mixed-, and left-handed students' academic performance.

Table 8

Exam Scores: One-way ANOVA Descriptive Table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5.62	2	2.81	.07	3.112
Within Groups	3021.84	79	38.25		
Total	3033.08	81			

The second research question posed in the second portion of this study is, "Do any of the groups studied show a difference in the number of dual flight hours required to complete the first solo flight in Part 141 flight training?" This study uses the number of total dual flight hours in the first block of flight training of UND's Avit 102 course to determine dual hours required to complete the first solo flight. In the UND flight training curriculum, 11 lessons are completed prior to the first solo flight; lesson 12 is the first solo flight. After the first solo, one additional lesson and a stage check are completed in Block One of flight training. Due to the nature of the flight training records available, the researcher has decided that the total number of dual hours in Block One of flight training is an appropriate way to measure dual hours required prior to the student's first solo flight.

Table 9

Mean Block One Dual Flight Hours by Handedness

Handedness	Block One Flight Hours
Right-Handed	20.30
Mixed-Handed	19.91
Left-Handed	23.32

A One-Way ANOVA is used to address the issue of differences in dual flight hours required prior to the first solo flight between the three groups. Based on the data from Group 2, a test statistic of 1.733 was calculated (F=1.733). The critical value for this data is 3.112 ($F_{2,79}$=3.112). In this case, it appears that there is no statistically significant difference between the number of dual flight hours required prior to the first solo flight of right-, mixed-, and left-handed students.

Table 10

Block One Dual Hours: One-way ANOVA Descriptive Table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	76.74	2	38.37	1.733	3.112
Within Groups	1748.85	79	22.14		
Total	1825.59	81			

The third research question posed in the second portion of this study is, “Do any of the groups studied show a difference in the number of dual flight hours required to attain private pilot license in Part 141 flight training?” This study uses the total number of dual hours completed during the three block training curriculum of UND’s Avit 102 course to evaluate the number of dual flight hours required to attain a private pilot license; in UND’s Part 141 curriculum, students who enroll in Avit 102 flight training attain a private pilots license upon completion of the three block curriculum and three associated stage checks.

Table 11

Mean Total Dual Flight Hours by Handedness

Handedness	Block One Flight Hours
Right-Handed	48.05
Mixed-Handed	46.24
Left-Handed	50.23

A One-Way ANOVA is used to address whether a difference in the number of dual flight training hours required to attain a private pilot license exists between the three groups studied. Based on the data from Group 2, a test statistic of 0.00019 was calculated (F=0.00019). The critical value for this data is 3.112 ($F_{2,79}$=3.112). Based on the current study, it appears there is no statistically significant difference in the number of dual flight hours required to attain a private pilot license between right-, mixed-, and left-handed students.

Table 12

Total Dual Flight Hours: One-way ANOVA Descriptive Table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	72.09	2	36.05	.00019	3.112
Within Groups	15173229.07	79	192066.19		
Total	15173301.16	81			

The final research question posed in the second portion of this study is, "do any of the groups studied show a difference in stage check pass rates in Part 141 ground training?" This question actually has two portions as UND's Part 141 flight training curriculum includes both a flight and a ground portion of the stage check. This study used the first attempt at both the flight portion and ground portion of the three stage checks in UND's Avit 102 course to calculate the stage check pass rate. Two One-Way ANOVA's were used to address the issue of differences in stage check pass rates between the three groups; one One-way ANOVA is used to test the differences in ground stage check pass rates, and a second One-way ANOVA is used to test the differences in flight stage check pass rates. Based on the data from Group 2, a test statistic of 0.32 was calculated (F=0.32) for the pass rate of the flight portion of the Avit 102 stage checks. Using data from the same sample, a test statistic of 1.12 was calculated (F=1.12) for the pass rate of the ground portion of the Avit 102 stage checks. The critical value for this data is 3.112 ($F_{2,79}$=3.112). In both cases, it appears that there is no statistically significant difference between either flight or ground stage check pass rates of right-, mixed-, and left-handed students.

Table 13

Flight Stage Check Pass Rates: One-way ANOVA Descriptive Table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.06	2	.03	.32	3.112
Within Groups	7.44	79	.094		
Total	7.56	81			

Table 14

Ground Stage Check Pass Rates: One-way ANOVA Descriptive Table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.11	2	.055	1.122	1.733
Within Groups	3.91	79	.049		
Total	4.03	81			

CHAPTER IV

DISCUSSION

This study explores the prevalence of left-, right- and mixed-handedness in flight training. Further, this study explores handedness as a predictor of success in Part 141 flight training. A discussion of the results and statistical analysis is presented in this chapter. Also, recommendations for future flight training and future research are presented.

Discussion of Results

One of the primary purposes of this study is to determine the prevalence of right-, left-, and mixed-handedness in flight training. In the results portion of this study, it was shown that approximately 75% of students surveyed reported right-handedness. In every way that the data was analyzed, the prevalence of right-handedness ranged from 72.54% to 77.78%. Initially these figures may be slightly lower than expected based on the review of literature in this report; however, there are several characteristics to keep in mind when comparing the current figures to the expected 90% right-handedness that is so widely accepted.

Past literature shows that researchers should expect a higher prevalence of left- and mixed-handedness in samples with a high number of males in the sample. In the current study, over 90% of the students surveyed were male; this is one reason that may explain the slightly lower prevalence of right-handedness in the current study.

Previous studies reveal that younger populations have a higher prevalence of left-handedness than do older populations. With the sample of the current study, a mean age of approximately 21 years old may be another reason for a slightly lower prevalence of right-handedness in flight training.

A final reason for the seemingly lower prevalence of right-handedness in the current group may be because of the manner in which the data is evaluated. Many prior research neglects mixed-handedness as a unique group in studies of handedness. The current study compared three groups (right-, left-, and mixed-handedness) rather than only left-handedness and right-handedness. Previous research lead the current study to include mixed-handedness as a unique group in this study; for comparison purposes the following table shows the data divided into the more traditional left- and right-handed groups:

Table 15

Prevalence of Left/Right-Handedness Only

	Total (N=193)	**Group 2 (N=81)**
Right-handed	86.53 %	87.65%
Left-handed	13.47%	12.35%

With the consideration of gender and age, the data in the current study are strikingly similar to past reports of the prevalence of handedness in the general population.

Contradicting historic studies created challenges in hypothesizing the effect of handedness on academic performance in flight training. Statistical analysis of the current data does not support the belief that left-, right- or mixed-handers are superior in the academic setting.

Analysis of dual flight hours required prior to the first solo flight and receiving a private pilot certificate is also completed in this study. Past research seemed to elicit the expectation that mixed- or left-handers would excel in the cockpit during flight training; statistical analysis does not support this belief. In fact, statistical analysis of the data in the current study do not show a significant difference in either the number of dual flight hours required prior to the first solo flight or the number of dual flight hours required prior to receiving a private pilot certificate among any of the three groups studied.

Further statistical analysis is completed to determine if a handedness is related to stage check pass rates in UND's flight training curriculum. Based on the data from this study, there is no support for the belief that handedness is related to stage check pass rates.

Recommendations and Practical Implications

The ideas which lead to the creation and completion of this study lead the researcher to believe that a correlation between handedness and success in flight training exists. Such a correlation may have had implications in pilot selection, flight training, and aviation safety. The results of this study reveal no significant findings which would support the belief that correlation exists between handedness and success in flight training. As a result of these findings, it is recommended that no changes be implemented to specially address the issue of handedness in flight training. The results of this study should only support the belief that left-, right-, or mixed-handed students are equally likely to be successful in current flight training curriculum.

The assertion that no changes be made to address the unique handedness groups in only applicable under the current study. This study leads to the development of several ideas for future research. Based on the literature reviewed in this study, the researcher believes that some of the ideas for future research may expose differences among left-, right-, and mixed-handers in flight training. The future research, explained in the next section of this text, may eventually lead to suggested changes in flight training with regard to left-, right- and mixed-handers.

Future Research

While none of the research questions yield statistically significant results, this study is not a dead-end of research. Historic research shows that there is a difference between left-, right- and mixed-handed individuals. The limited handedness research in aviation allows great opportunity for variations of this study to be applied in other facets.

Confounding Variables

The possibility of confounding variables is nearly always a concern in research. While this study focused primarily on the cognitive differences between left-, right- and mixed-handers, future research may focus on the hardware issues related to handedness in aviation.

It is unique that experience rather than handedness effect which side of the cockpit a pilot sits on. In flight training, a pilot operates the aircraft from the left-seat of the cockpit, but upon entering the professional world of aviation the pilot is transferred to the right-seat until experience and promotion allow the pilot back into the left-seat. Cockpit design has been extensively studied to ensure efficiency and safety in aviation, but the effect of handedness on the left-seat/right-seat equation seems to be ignored. The hardware issues related to handedness may be an interesting topic of future research.

Handedness of Pilots in Declared Emergencies

Another area for handedness research in aviation may have great safety implications. An assessment of handedness among pilots involved in emergencies or aviation disasters could lead to improvement in aviation safety. If it were to found that left-, right-, or mixed-handed pilots were involved in more than a proportionate number of emergencies and disasters a long line of research would be elicited to determine why such a relationship exits.

It is hereby proposed that future researchers evaluate the handedness of pilots involved in aviation disasters and near-disasters. Future research may study the handedness of pilots who have been involved in various types of emergencies or disasters. Further, the pilots' reaction and outcome of the situation could be assessed. Using this study, we may be able to determine whether there is a difference in reaction of left-, right-, or mixed-handed pilots in the high stress environment of an emergency.

Unique Learning Styles of Right-, Left-, and Mixed-handers

Handedness research in flight training could be assessed in further detail in yet another way. Aviation literature acknowledges that notion that left-handers may have unique learning styles in comparison to right-handers (FAA, 2008). This may lead future researchers to assess the teaching styles used in both flight and ground training.

An assessment of teaching styles in both flight and ground training could expose a teaching bias toward the styles most effective with left-, right- or mixed-handed students. If it is found that the teaching styles used are geared more toward the learning styles common in any of the groups of handedness, further research is elicited. Future research may explore right-, mixed-, and left- handedness student pilots' response to unique teaching styles and delivery methods. This type of research may help the industry to develop unique training regimes for left-, right- or mixed-handed student pilots if it is found that any other these three groups respond better or more poorly to any of the unique teaching methods studied.

Part 141 v. Part 61 Flight Training

There is currently more than one route to becoming a pilot. This study explored handedness in Part 141 flight training programs, typically collegiate aviation programs. However, many pilots receive training in from private companies who do not follow the strict curriculum of collegiate aviation programs; this type of training is commonly conducted under FAR Part 61.

Part 61 training facilities conduct pilot training much differently than collegiate aviation programs; these training programs typically have less stringent ground training requirements and focus more of the students' training time in the cockpit. The difference between Part 141 and Part 61 flight training may be another area of interest in future studies of handedness in aviation. Future research could explore potential differences in the prevalence of each handedness group between the two flight training environments. Further, researcher could explore if left-, right-, or mixed-handed perform better in one training environment than another. In summation, a study quite similar to the current study could be complete in the Part 61 training environment. A comparison of the two studies may expose interesting differences between pilots' participation and success in Part 141 and Part 61 flight training programs.

Larger Sample Size

A final consideration of future research is the sample size to be used in future studies. One of the limitations of this study is the small population of students in UND's Avit 102 course. This limitation is exacerbated by the unequal distribution of handedness in the sample of students surveyed. With such a small sample to begin with and with only 11% of the sample falling into the left- and mixed-handed group, the study has an exceedingly small number of left- and mixed-handed subjects in the study.

Future research in studies of handedness in the pilot population should take into about this unequal distribution when collecting data. By considering the unequal distribution, future research shall strive to attain a much larger sample to ensure a sizable number of left- and mixed-handers be included in the group.

Also because of the limited sample size, the researcher in the current study is unable to explore another interesting facet of handedness in flight training. Initially, the researcher hoped to explore the interaction of handedness and gender in flight training. Previous research explores unique relationships between handedness and gender in other disciplines, but such research was not found in the realm of flight training. Unfortunately, the small sample size compounded with the unequal distribution of handedness was further compounded by the male dominated population of aviators. Ideally, a larger sample size would allow comparison of six groups in flight training: left-handed males, right-handed males, mixed-handed males, left-handed females, right-handed females, and mixed-handed females. In the current study, data was collected from only one left-handed female, and zero mixed-handed females were in the sample. This did not allow the researcher to explore how gender, in conjunction with handedness, may be related to success in flight training. The previous ideas lead the researcher to recommend seeking a much larger sample size in future research of handedness in the flight training environment.

In summation, although no statistically significant findings were revealed in the current study, the study maintains value. This study could help to eliminate historic prejudice against right-, left- or mixed-handers. Also, the study addressed an issue of potential concern which had not before been studied. Further, the study evoked numerous ideas for future handedness research in aviation.

APPENDIX A

HANDEDNESS AS A PREDICTOR OF SUCCESS IN FAR PART 141 FLIGHT TRAINING: Survey

First Name: ________________________ Last Name: ________________________

Student ID: ________________________ Date of Birth: ___ / ___ /______

Gender: ☐ Male ☐ Female

Current Declared Major:

☐ Commercial Aviation ☐ Aviation Management
☐ Air Traffic Control ☐ Flight Education
☐ Airport Management ☐ Aviation Systems Management
Other: ________________________

Course(s) you are currently enrolled in (select all that apply):

☐ Avit 102: Introduction to Aviation ☐ Avit 302: Air Transportation
☐ Avit 208: Aviation Safety ☐ Avit 403: Aerospace Law

Flight Course Taken in Conjunction with UNDs Avit 102 Private Pilot Ground Course:

☐ Avit 102
☐ Avit 105 (entered 102 with >30 dual flight hours, but no Pilot Certificate)
☐ Avit 112 (entered 102 with Private Pilot Certificate)

Please indicate your preferences in the use of hands in the following activities by putting a ☒ in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ☒☒.If in any case you are really indifferent put ☒ in both columns.

Some activities require both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		Left	Right
1	Writing	☐☐	☐☐
2	Drawing	☐☐	☐☐
3	Throwing	☐☐	☐☐
4	Scissors	☐☐	☐☐
5	Toothbrush	☐☐	☐☐
6	Knife (with fork)	☐☐	☐☐
7	Spoon	☐☐	☐☐
8	Broom (upper hand)	☐☐	☐☐
9	Striking Match (match)	☐☐	☐☐
10	Opening box (lid)	☐☐	☐☐

REFERENCES

Annett, M. (1970). A classification of hand preference by association analysis, *British Journal of Psychology, 61,* 303-321.

Arehart-Treichel, J . (2009). What does left hand know that right hand doesn't? *Psychiatric News,* 44 (6), 22.

Bragdon, A., & Gamon, D. (2000). *Brains the work a little differently: Recent discoveries about common brain diversities*. Cleveland, OH: Allan D. Bragdon Publishers.

Chase, C., & Seidler, R. (2008). Degree of handedness affects intermanual transfer of skill learning. *Experimental Brain Research*. *190*, 317-328.

Chudler, E.H. (2009). One Brain.... or two?. Retrieved April 30, 2009, from Neuroscience for Kids Web site: http://faculty.washington.edu/chudler/split.html

Coren, S. (1993). *The left-hander syndrome: The causes and consequences of left-handedness*. New York, NY: Random House.

Coren, S. (1993).Measurement of handedness via self report: The relationship between brief and extended inventories. *Perceptual and Motor Skills*. *76*, 1035-1042.

Crawley, M.J. (2005). *Statistics: an introduction using R*. West Sussex, England: John Wiley and Sons Ltd.

Crovitz, F., & Zener, K. (1962). A group-test for assessing hand and eye dominances. *American Journal of Psychology*. *75*, 271-276.

Dror, I.E., Kosslyn, S.M., & Waag, W.L. (1993). Visual-spatial abilities of pilots. *Journal of Applied Psychology*. *78 (5)*, 763-773.

Emore, E., Ebeye, O.A., Odion-Obomhense, H.K., & Igbigbi, P.S. (2008). A look at the effect of handedness on learning. *Journal of Applied Sciences*, *8 (1)*, 172-176.

Federal Aviation Administration. (2008). *Aviation Instructors Handbook: FAA-H-8083-9A*. Flight Standards Service.

Federal Aviation Administration. (2008). *Federal Aviation Regulations/Aeronautical Information Manual*. Englewood, CO: Jeppesen.

Gianntrapani, D. (1969) Developing concepts of lateralization of cerebral functions. *Cortex. 5,* 353-370.

Hardyck, C., & Petrinovich, L.F. (1977). Left-handedness. *Psychological Bulletin*. *84 (3)*, 385-404

Henderson, N.J, Stephens, C.D, & Gale, D. (1996) Left-Handedness in Dental Undergraduates and Orthodontic Specialists. *British Dental Journal*. 181 (8), 285-288.

Holder, M.K. (2005). Famous left-handers. Retrieved April 30, 2009, from Indiana University Web site: http://www.indiana.edu/~primate/left.html

Jackson, J. (1905). *Ambidexterity*. London: Kegan Paul.

Levy, J., & Reid, M. (1978). Variations in cerebral organization as a function of handedness, had posture in writing, and sex. *Journal of Experimental Psychology*. *107*, 119-144.

Levy, J., & Heller, W. (1992). Gender differences in human neuropsychological function. *Handbook of behavioral neurobiology: Sexual differentiation.* New York, NY: Plenum

McManus, I.C., & Jonvik, H. (2009). Right and left-handedness and medical speciality choice. *Unpublished Manuscript*.

McMeekan, E.R.L., & Lishman, W.A. (1975). Retest reliabilities and inter-relationship of the Annett hand preference questionnaire and the Edinburgh handedness inventory. *British Journal of Psychology*. *66*, 53-59.

Oldfield, R.C. (1971).The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*. *9*, 97-113.

Pipraiya, M.R., & Chowdhary, G.C.S. (2006). Role of handedness in flying performance. *Indian Journal of Aerospace Medicine*. *50 (2)*, 20-31.

Porac, C, & Coren, S (1981). *Lateral preferences and human behavior*. New York, NY: Springer-Verlag.

Ransil, B.J., & Schachter, S.C. (1994). Test-retest reliability of the Edinburgh handedness inventory and global handedness preference measures , and their correlation. *Perceptual and Motor Skills*. *79*, 1355-1372.

Saucier, D.M., & Elias, L.J. (2001). Lateral and sex differences in manual gesture during conversation. *Laterality: Asymmetries of Body, Brain, and Cognition*. *6*, 239-245.

Schott, J., & Puttick, M. (1995). Handedness among surgeons. *British Medical Journal*. *310*, 739.

Shaywitz, B.A. et al. (1995). Sex differences in the functional organization of the brain for language. *Nature*. *373 (6515)*, 607-609.

Williams, S.W. (1991).Handedness inventories: Edinburgh versus Annett. *Neuropsycholgia*. *5 (1)*, 43-48.

Williams, S.M. (2001).Differences in academic performance at school depending on handedness: Matter for neuropathology? *Journal of Genetic Psychology*. *148(4)*, 496-478.

Zillmer, E.A., Spiers, M.V., & Culbertson, W.C. (2008). *Principles of neuropsychology*. Belmont, CA: Thompson Wadsworth.