The Aviatrix in Military Aviation

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A Brief History of the Female Military Pilot

The history of the aviatrix is brief and even shorter when speaking of military aviation, however, it is quite a distinguished history. In 1911, Harriet Quimby became the first female licensed American pilot and since that date, women's involvement in both civilian and military aviation has significantly increased. Amelia Earhart attempted her infamous around-the-world flight in 1926 and by 1935 over 700 women in the United States held civilian pilot licenses. With the onset of World War II, female contributions to aviation became more paramount. The "Women's Auxiliary Ferry Squadron" (WAFS) and the "Women's Flying Training Detachment" (WFTD) combined to form the "Women's Air force Service Pilots" (WASP) in the mid-forties (Grant, 2001). These brave women were not considered military members, yet still provided a valuable service to the Air Force.

The immense involvement of women in aviation during the second World War served as a stepping stone for future aviatrixes. Jacqueline Cochran became the first female to break the sound barrier in 1953 and by 1960 approximately 3.6% of all licensed pilots in the United States were women. But, it was not until 1973 that females first broke into military aviation when six women earned their Naval Aviator Wings. Next, the Army allowed women into their flying ranks as helicopter pilots in 1974. Two years later, the Air Force finally admitted the first ten female students to undergraduate pilot training. Although women were flying in all branches of the service by 1977, regulations specifically denied women the chance to fly combat aircraft in combat (Wilson, 2001). Now women are not restricted from combat missions with the exception of Special Operations with MC-130s, AC-130s and helicopters (Dyson, 1999). Presently, 3.5% of all AF pilots are female and 1% are fighter pilots. Female navigators in the AF make up 3.3% of all navigators and 12.4% of Air Force battle management AFSCs are held by women (AFPC, 2001). The numbers are rising as females are becoming integral parts of flying squadrons throughout the military.

Review

With the increasing involvement of women in military aviation, questions concerning gender issues in the cockpit are extremely relevant. Through a literature review, interviews with both men and women in the operational Air Force, and a computer-based simulator, the abilities of men and women in the cockpit were evaluated and compared in seven areas: behavior, body composition, anthropometry, biomechanics, physiology, health, and learning.

The overarching objective of this project was fairly simple: to understand whether or not there may be significant differences between men and women that would affect a woman's ability to have a military aviation career. Imbedded in the main objective are smaller objectives of determining the effects of different anthropometry and biomechanics between men and women, the psychology of women taking part in a "male" occupation, the effects of aviation on women's health, and operational issues concerning women in the military flying world. Last, I have attempted to determine if there may be significant differences between males and females in a computer simulation that allows assessments of the learning of basic flying skills.

Behavior

As women become a vital part of military flying missions, questions of gender differences in behavior arise. Some research has already been accomplished in this area. A study at the USAF Academy examined whether or not "there is a sex difference in predicting flight training performance of simple maneuvers in a simulator" (Berry and Koonce, 1986). Fifty male cadets and fifty female cadets participated in three, 50-minute simulator sessions where data was collected. The results showed that the female cadets were faster on the perceptual tasks. The male cadets were somewhat quicker on the visual memory, spatial orientation, and spatial scanning tasks. Men performed better on the psychomotor tasks than women. However, this study showed no overall average difference between men and women in basic flying abilities.

In another study performed at Brooks AFB, Dr. Thomas R. Carretta examined the gender differences on US Air Force pilot selection tests (Carretta, 1997). Carretta's results were similar to Berry and Koonce's; however, Carretta also provided some reasons why there might be differences between the sexes. He suggested that "well qualified women are less inclined to view the Air Force as an attractive career choice". Also, women might be less likely to take educated courses or get involved in extracurricular activities which would help them score better on pilot selection tests. Still, concluding his report, Carretta said:

> Despite sex differences in mean test performance, causal models of ability and prior flying knowledge on the acquisition of additional flying knowledge and flying skills showed similar results for men and women.

Caretta's study showed no reliable evidence of skill differences between the two genders.

Annette G. Baisden (1997) conducted a study concerning gender and pilot performance in Naval aviation training. She observed training data from 13,755 males and 42 female naval pilot training students. Her analysis indicated that women had significantly better scores on aviation selection tests than men ($p<.01$). However, men's performance grades during pre-flight academic training were significantly higher than the women's grades ($p < .01$). Attrition rates did not differ between the two genders and neither did the reasons for attrition. Baisden suggested that the students' college major, "disposition toward peer support, and systematic differences in both acceptance and equality" might be possible reasons for the differences between males and females. These are also areas she suggested for future research.

With women consistently being integrated into our military forces, more women will be involved with military operations overseas. For female pilots, this is a potential problem (Bartholomew, 1999). We are leaps and bounds above most countries in the world when it comes to equal opportunity. Few foreign countries allow women to be involved with military operations, much less aviation. Thus, when a female voice speaks over the radio or when a crew with a woman as a member flies in foreign countries, she is noticed. Capt Bartholomew, KC-135 co-pilot, told of a time when she was speaking over the radio while approaching a military base in Saudi Arabia. She asked the control tower for a clearance three times with no answer. Finally, the male pilot got on the radio and was immediately given the clearance. This is only one instance, and not a severe one, however, it suggests that women do face obstacles in the aviation world.

Perhaps one of the most important psychological issues associated with placing women in the cockpit is the extra responsibility of leadership that women have to assume in the aviation world. "Social psychology studies have documented that it is difficult for a woman to assume and be recognized in a leadership role" (Hyde 1996). Hyde explains that women in leadership positions are often seen as not having the right characteristics to lead. She points out three different hypotheses that may explain of why this belief might exist: 1) Women truly are lacking the personality traits and interpersonal skills needed for supervisory roles; 2) People are merely biased about women being in positions of leadership; and 3) Women supervisors have less inherent power than their male counterparts (this view can stem from behavior from both males and females).

Through her studies, Hyde looked at all three of these hypotheses. She concluded that women in leadership roles do face some barriers, of which a few are internalized, but most are external. The biggest problem may stem from the fact that women in these high ranking positions lack self-confidence in themselves to lead. Also, some people may be biased towards females who use more autocratic styles of leadership. Women who hold positions of power or leadership are subject to criticism and when they take a more coarse, autocratic leadership style, sometimes the criticism can be worse. Finally, women do have a smaller amount of inherent power in their working environments, which affects how co-workers and subordinates view their leadership style. All three of these considerations are important for females in the aviation world, which has typically been dominated by males. Female aviators will and do face the some of the same trials as women in any leadership roles whether that may be civilian or military. These obstacles, however, are nothing that cannot be overcome with hard work and persistence by both genders.

All of the studies referenced here suggest that there is no reason to disregard women as potential aviators in the military on a behavior basis. While there are still behavior factors that must be addressed and studied, none of the research to date in this area has proven that women are less capable than men of being military pilots.

Body Composition

The different compositions of female and male bodies must be considered in order to understand possible areas of concern for female pilots. Overall, total body fluid and skeletal weight are lower for adult females than males (Van De Graff, 1998). However, females have a much higher percentage of body fat (adipose tissue) than males. For the average 25 year-old female, the absolute body weight is approximately 55 kg. Only 42 kg (70.2%) of that is lean body weight, with 17.9 kg (29.8%) as body fat, and 4.4 kg (7.3%) skeletal weight. The average 25 year-old male has an absolute weight of 70 kg with 56.3 kg (80.4%) as lean body weight. 13.7 kg (19.6%) of the total male body weight is body fat and 5.8 kg (8.3%) is skeletal weight. Males and females have the same proportions of muscles and bone. Males, however, have stronger, larger muscles which weigh more. Males also have larger bones. Females are more petite with more relative body fat. And, because females are more petite with less body muscle and more adipose tissue than males, there is some concern that they are not physically built to fly aircraft. Although, no research to this date shows that the difference in body composition between males and females is significant and should disqualify women from the cockpit

Anthropometry

There are differences in the body structure between the two genders. In general, males are taller and have greater arm and leg length relative to body length than women. Women tend to have wider hips and narrower shoulders (Greenhorn and Stevenson, 1997). Smaller hands are also a general characteristic of women.

The smaller body frame and mass of women affects their body strength. Greenhorn and Stevenson define strength as "the maximum ability to apply or resist force." Normally, women have less strength than men due to their body structure. The differences in strength are more pronounced for the upper extremities than for the lower extremities. Women's strength measurements for their upper extremities ranged from 35% to 79% of men's upper body strength (Laubach, 1976). The strength in the lower extremities of women was 37% to 70% of men's. Despite the obvious differences in strength capabilities of the genders, male and female strengths do overlap in some common areas. Exactly how much overlap exists depends on what muscle groups are being studied and what tasks are being performed. However, "about one-third of women can be expected to possess muscular strength that is within the range of muscular strength for men" (Greenhorn and Stevenson, 1997).

Incorporating women into the military flying world brings up issues of proper equipment fit (Self, 1999). With chemical protective gear, the gloves are usually rather large for women. Flight suits and g-suits are just now being customized and tested for smaller humans. The aircrew oxygen mask was designed for the average male, not the average female. Thus, the face masks are usually too big for the average female pilot. In addition, ejection seats in fighter aircraft are designed for the average male, who is larger than the average female. New designs and technology are improving proper equipment fit, thus giving more females a chance in the cockpit.

Biomechanics

Biomechanics is the study of human body motion. Flexibility is a component of biomechanics which might prove to be an important aviation issue. Flexibility can reduce the risk of musculosketal injuries during ejection. Women usually posses a much greater range of flexibility than men (Greenhorn and Stevenson, 1997), therefore, the biomechanics of a woman's body might be better suited for a flying career than a man's. But, more research is needed to support this opinion. The differences flexibility between the two genders do suggest that "each gender must adapt their own methods for maximum productivity, while keeping injuries at a minimum" (Greenhorn and Stevenson, 1997).

Another biomechanical issue is acceleration tolerance. A common incorrect theory is that women are more tolerant to G-forces than men. The male and female subject groups used in the study which reported these initial results were not similar. The women used in the study were shorter than the men, thus there might have been bias from the start. We cannot be sure that the results produced from this study were not due to the fact that the females were shorter than the males in the same study. Therefore, we must consider more research on the topic of G tolerance in the genders.

A study conducted at Brooks AFB in 1986 examined differences between males and females in +Gz tolerance (Gillingham, Cristy, Schade, Jackson, and Gilstrap). 102 USAF women, either students at USAFSAM or assigned personnel, underwent +Gz tolerance testing in the centrifuge at Brooks. Physically, the women used in this study were required to meet all USAF Flying Class III standards. The results obtained from this experiment were compared to 139 male subjects' results from a similar experiment. The research showed that the women's and the men's G tolerances were essentially the same, "as evidenced by the lack of any differences even approaching statistical significance (Gillingham, Cristy, Schade, Jackson, and Gilstrap, 1986). However, there were some factors that did affect G tolerance in both genders. Weight was directly proportional to G tolerance for males and females. Greater physical activity was associated with higher G tolerances for both genders. And, the most important finding was that acceleration tolerance was found to be inversely proportional to height. Gillingham explains his findings, "if the height difference between women and men as a group were eliminated, women's G tolerance would be lower then men's" (1986). Thus, a woman's G tolerance was found to be about ½ G less than a man's, but the difference in height between the genders can make their G tolerances equal. Even with these findings, Gillingham concluded that women's G tolerance is the same as men's and there is no reason to exclude them from military flying for the reason of less G tolerance.

Gillingham, Cristy, Schade, Jackson, and Gilstrap also collected research data from the centrifuge. Female subjects in this study had an 88% success rate in the centrifuge, that is 88% of the women completed all the centrifuge training. The men had a success rate of only 81%. However, the experimenters were unable to show that the difference in success rated between the two genders was statistically significant. Motion sickness occurred in 35% of the female subjects and in 45% of the male profiles. Thus, the study concluded, "The inherent G tolerances of men and women, as measured by centrifuge testing with standardized G profiles and tolerance endpoint, are essentially the same" (Gillingham, Cristy, Schade, Jackson, and Gilstrap, 1986). They reported that there is no G tolerance deficiency in women, thus women should not be excluded from the flying world on the basis of G tolerance.

In centrifuge training, necessary for all fighter pilots, at Holloman AFB, NM, women have performed just as well, if not better than men (Hover, 1999). However, experience has shown that women have more trouble than men with acceleration tolerance in the actual tactical arena – i.e., having to turn the head, fly, and pull G's at the same time. Thus, more tactical exercises have been added to centrifuge training and women's performance is now equal to men's performance. Although variation in the genders does exist, no research has thoroughly proven that women are less capable than men of pursuing flying careers in the military due to biomechanics. More research is needed to support either view.

Physiology

Endurance, or the total resistance to fatigue, is a component of human physiology which is important to our discussion. As stated above, women have more adipose, or fat, tissue than men. This excess tissue can be a hindrance when a person's body weight has to be moved either vertically or horizontally. Lyons states, "On average, men have higher absolute aerobic capacities than women" (1997). However, these differences become almost obsolete when oxygen utilization (Vo2max) measurements are adjusted for weight and when vigorous aerobic training is a part of a person's daily life. Lyons points out that performance on physical tasks where Vo2max was measured was no different for men and women when the performance was adjusted for Vo2max.

Thermoregulation (maintenance of a constant internal body temperature regardless of environmental influences) by women is a topic of great concern in the cockpit. Early studies showed that women were much less tolerant of stressful situations in hot environments than men. In response to equal heat loads, women tend to have higher core and skin temperatures, higher heart rates, and lower sweat rates than men. Conversely, although women tend to have a higher adipose tissue content than men, this insulation does not protect them in cold environments. In an environment characterized by the potential for high convective heat loss (cockpit), women cool faster than men because of their high surface area to mass ratio and their lower heat production (Kolka, 1997). Even though women do sweat less than men, their body functions may be more efficient, thus they do not need to perspire as much. Also, if women are physically fit, "there is no thermoregulatory bias to exclude women in military tasks, such as flying high performance aircraft" (Kolka, 1997). Aerobic fitness, acclimatization status, the time of day, hydration, and the menstrual cycle phase can all affect the thermoregulation of women (Kolka, 1997). These issues must be addressed when looking at the sex differences in thermoregulatory effects in aviation settings.

Health

The biggest medical concern that female aviators face is pregnancy. Areas of concern deal with the effects on the fetus and the performance ability of the pregnant pilot. The possibility of damage to the fetus during flying operations is the largest concern in allowing females unrestricted access to all military flying missions (Lyons, 1992). Radiation exposure is always a risk when flying (for males and females alike), especially at high altitudes. Radiation can cause congenital malformation and mental retardation in the fetus at very early stages in pregnancy. Heat might also be a problem for pregnant aviators. However, body temperatures must reach 102^{o} F before damage will occur to the fetus.

Research has shown that pregnant women have a reduced G tolerance, due to the stresses placed on their bodies during pregnancy. Weight gain is also an effect of pregnancy which can hinder a pilot. Some females may also experience psychiatric problems that can occur during pregnancy which would obviously affect a female's ability to fly during this time. Thus, there have been some restrictions placed on women flying certain types of missions. First, female pilots must be on birth control when not specifically trying to have children. Also, women may not fly during the first 13 weeks of pregnancy or during the last 16 weeks. Women may fly, if they feel comfortable and safe, between the 13th and 24th week of pregnancy (Schwietz, 1999). Female pilots must follow certain restrictions if flying while pregnant, but pregnancy is not disabling to a flying career for the entire 9 month period.

Another health topic of concern is the menstrual cycle of females. It is questionable whether or not the cycle is interrupted by, or that irregularities are caused by flying. According to Schwietz (1999), there is no medical research that suggests the menstrual cycle is affected by jet lag or other flying related experiences. Conversely, females must be aware that they might experience effects from their menstrual cycle that could disrupt a flying schedule. For example, over- exhaustion (physical and mental), different eating habits, sore muscles, and headaches. However, these effects are not a problem all women face. Effects of the menstrual cycle depend upon the individual.

A concern for both males and females in the military flying world is the exposure to toxic jet fuel, JP4. The book, Chemical *Hazards of the Workplace*, outlines some of the problems associated with JP4, benzene. If Jp4 is either absorbed through the skin or inhaled, it can cause central nervous system depression and depression of the hematopoietic system. It also increases the likelihood of leukemia and multiple myeloma. The most significant toxic effect of benzene is injury to bone marrow which can be irreversible. Both females and males are equally subject to the symptoms above.

Learning

Up until this point, we have concentrated on the possibility of physical and behavioral differences important to flying between men and women. Perhaps one of the more important issues to examine is how men and women learn to fly. Is there a gender difference in the ability to learn to fly an aircraft and make the necessary decisions needed while flying? We are all familiar with the stereotype that boys are supposed to be more analytical, logical, and reflective in their thinking; while, girls are more emotional, impulsive and intuitive (Moursund, 1976). Moursund says that these stereotypes are essentially true:

> These differences are not noticed in children under the age of nine. Thus, it is possible that these cognitive gender differences are partially learned once the child is older. However, work done by Dawson (1972) also suggests that the levels of prenatal androgen in the brain cause males to have higher spatial and numerical cognitive abilities.

Another way to look at these gender differences in cognition is that the same cognitive style has different implications for men and women. Moursund explains this point:

> That is, a style preference or pattern that is useful or adaptive or facilitates learning among males might have the opposite effect among females for either cultural reasons or by virtue of the interactive effects of other sex-associated variables.

In early life, girls may be rewarded for certain behaviors for which boys would be punished. Alternatively, a certain cognitive style might be more useful for doing a more "masculine" task versus a more "feminine" task.

Moursund explains that there are differences in the way men and women think, but that these differences might not be significant in the cognitive realm. One gender might be more inclined to perform a certain task, but in no way does that exclude the other gender from performing that same task equally well or better. On average, girls tend to take more music, art, and literature classes, while boys prefer to take math and science courses. In elementary school, boys usually score higher on math tests, while girls score better on language comprehension tests. But, girls have overall better grades than boys (Goodwin and Klausmeier, 1966). Thus, for some reason or another each gender seems to be assigned cognitive tasks they are suppose to be better at, yet we cannot prove that either gender is exclusively and significantly better than the other at any cognitive task.

A study by Carretta and Malcolm Ree at Brooks AFB was concerned with the acquisition of pilot skills by male and females. 3,369 male USAF officers and 59 female USAF officers were observed while completing 53 weeks of undergraduate pilot training from 1981 to 1993. Due to the small female sample, results were tentative, but still useful. The results showed that general cognitive ability (g) had a direct influence on acquisition of the job knowledge; however, g had an indirect effect on actual flying skills. The influence of g was stronger for the female sample than for the male sample. Also, the relationship between prior job knowledge and flying performance was stronger for women than men. Early flying skills greatly influenced later flying skills for both genders. The study concluded that, "No argument for a sex-separated training syllabus is supported" (Carretta and Ree, 1997).

What does all this mean for the cockpit? Pilot training and flying itself require a solid understanding of math and strong spatial cognition. In general males will usually have more experience in these fields than females, for whatever reason, prior to pilot training. But women are completely capable of learning the skills needed for flying--their gender does not hinder their ability to learn the necessary concepts. The only difference might be that certain individuals (males or females) might have to work harder than their peers in order to understand the concepts presented in flying, but this is true for any discipline. To better understand the possibility of cognitive differences in areas important to flying, more research needs to be done on the differences between men and women in the exact cognitive issues involved in flying.

Summary of Literature Review

This extensive literature review reveals that some differences between males and females exist which could possibly effect flying skills and performance. Females do have a different body composition than males and some behavioral issues associated with women being in the cockpit need to be researched more thoroughly. It is widely believed that men and women think differently and that women are more inclined to choose career fields in the arts or social sciences, while men are more attracted to the engineering fields. However, research shows that these are merely generalizations (Carretta and Ree, 1997). There is no real intelligence difference between males and females. Either gender is capable of accomplishing any cognitive task. Research to date has shown that there is no reason to exclude women from the cockpit for any of the areas discussed previously.

To examine the conclusions experimentally, a flight simulation was used to test the hypothesis that there is no significant difference between males and females in the acquisition of basic flying skills.

Methods

Materials

The main tool used for this study was a computer simulation of an aircraft, the Basic Flight Instruction Tutoring System (BFITS) Research Station (Flyn et al., 2000). The BFITS was designed to observe and track the behavior of students as they learn and practice basic flying skills. The development work and field validation for BFITS were performed by contractors supported by AFRL/HE (Dr. James Miller, 1999). The program teaches the basic knowledge in a series of lessons requiring the participant to read and answer questions. Then it allows the student to take that "book" knowledge and apply it to actual flying lessons. The data provided by BFITS supports studies of learning. For example, the program provides data on the number of words per minutes for the student during the lessons and quizzes, the amount of time the student spends on the lessons and quizzes, and the number of correct responses the student gives. This program is not in use at any other Air Force laboratory, thus the results produced here can be very useful.

The BFITS software consisted of a personal computer, rudder pedals (model #300-110, CH Products, Poway, CA), and a control yoke (model #200602, CH Products, Poway, CA). There was a slight modification made to the software. The roll axis spring in the yoke was replaced to reduce the breakout force to initiate a roll (Flyn et al., 2000).

Participants

Twenty USAFA college students and USAFA staff members (6 women and 14 men) volunteered to participate in this study. All participants were novices in aviation experience. Novice was defined as someone who had not yet soloed the glider aircraft in USAFA’s Soaring Program. Volunteers were not paid for their participation. All participants were required to read, understand, and fill out a consent form prior to starting the experiment. Also, all participants were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 1992). The project was reviewed and approved by the USAFA Institutional Review Board (FAC 1999009).

Experimental Design

Our null hypothesis stated that there would be no difference in the basic flying skills of men and women (h_o: men = women). The alternate hypothesis stated that there would be a difference between the basic flying skills of men and women, but a significance direction was not decided upon (h_a: men < or > women). A two-tailed T-test was performed on the data to determine if there was a statistical difference between the two groups.

Koonce et al (1995) showed that, as a function of BFITS use prior to first solo, there was a reduction in the requisite number of flight hours by d = 1.2, where d (effect size) is in standard deviation units (by weighted, pooled variance; Cohen, 1988). This was a relatively large effect; about 88.5% of the BFITS group soloed more quickly than controls. We expected similar or greater effect sizes for the variables to be examined in this study. The coefficient of variability should be lower for the procedures and skills to be measured in this investigation than for flight hours, which are subject to many vagaries. With 12 subjects in each of the groups proposed by Koonce's study, the power of the test with d = 1.2 would have been about 89% (probability of rejection of the null hypothesis; Cohen, 1988). (Flyn et al., 2000). However, the actual sample size used in my experiment was 20 (14 males and 6 females).

Procedures

The subjects were introduced to the BFITS and given a time period of 4 months to complete the first fourteen lessons of the simulation. Lessons one through nine taught and tested basic knowledge and flying procedures, while lessons ten through fourteen taught and tested actual flying skills. Each lesson required approximately 30 minutes of the subject's time.

Results

Due to the small number of female participants in lessons 3 and subsequent, we were unable to perform statistical analyses to compare the performances of males and females for only the first two simulator lessons. The two lessons were solely academic (no flying). We collected data for 44 male participants and 4 female participants in lesson 1, and 37 males and 4 females in lesson 2. After lesson 2, there were only three female participants that continued through the remaining lessons. We simply plotted their data as individual points along with the males means and standard deviations.

There was a significant difference between males and females for time that they took to read lesson 1 ($t(5) = -4.27$, $P = 0.008$). The female mean was significantly greater than the male mean. There was also a significant difference between males and females in the words per minute (WPM) read on lesson 1, ($t(46) = 5.95$, $p = 3.4 \times 10^{-7}$). Females had a much lower mean WPM than the males.

The results for lesson 2 were very similar to the lesson 1 results. There was a significant difference between males and females for the time they took to read lesson 2, ($t(4) = -3.01$, $p = 0.040$). Again, the female mean was much greater than the male mean. There was also a significant difference between males and females in WPM on lesson 2, ($t(17) = 4.17$, $p = 0.0006$). The mean for WPM for the females was significantly lower than the males mean for WPM.

The results of these statistical analyses suggested that males were significantly faster in the average amount of time that it took them to read each lesson than the females. However, female data fell within on SD (standard deviation) of the male data (Figure 1). Since there was no practical difference between males and females, the null hypothesis could not be rejected in practice.

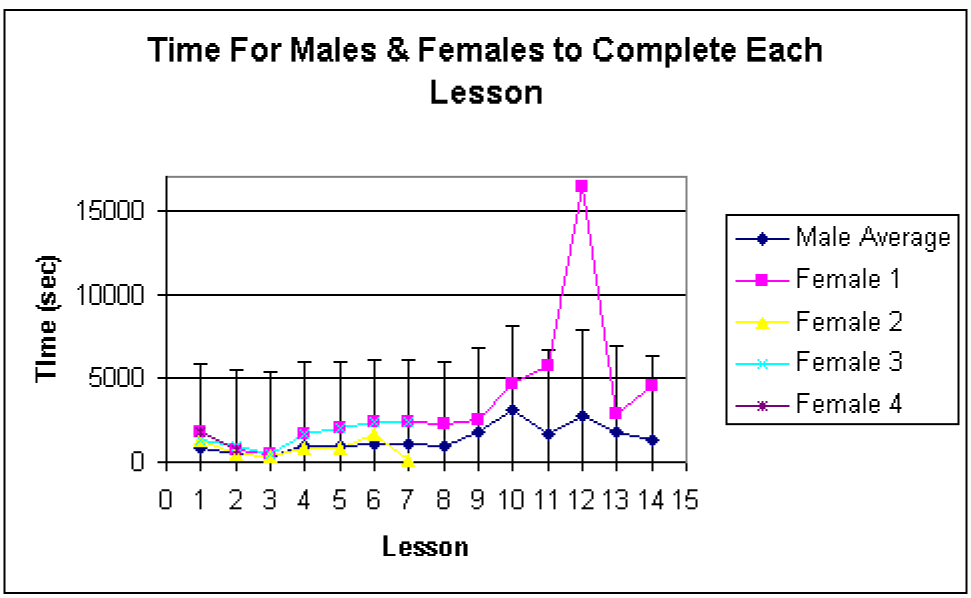

Figure 1. Time to read each lesson.

Although the results fir reading time illustrated no real difference between genders, the data for WPM differed. The statistical analysis revealed significant differences between male and female WPM for lessons 1 and 2, and the female data points fell more than one SD from the mean of the male average (Figure 2).

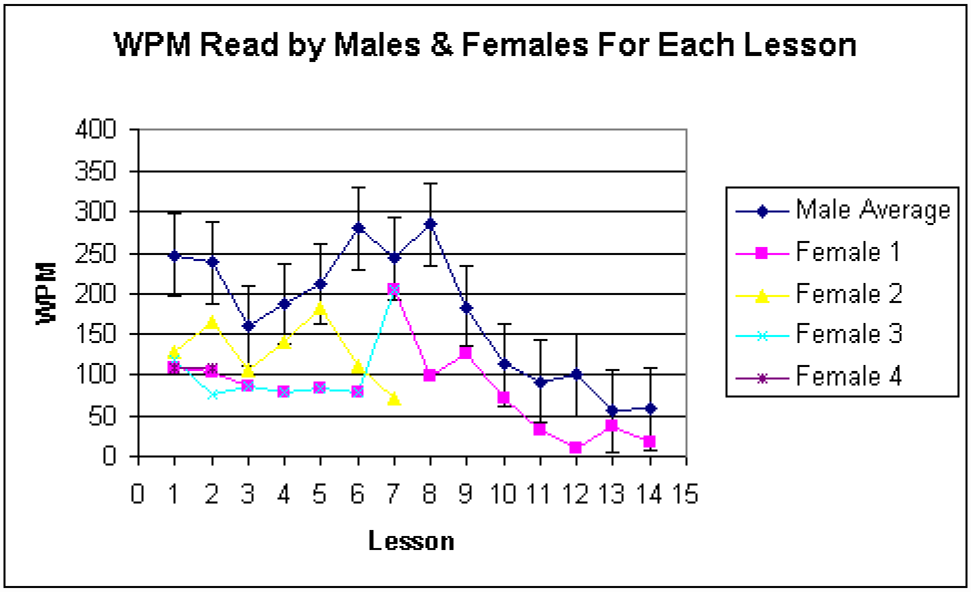

Figure 2. Words read per minute (WPM) for each lesson.

There was not a significant difference between males and females in the number of incorrect answers they gave on lesson 1, ($t(3) = -1.00$, $p = 0.390$). There was also no significant difference between males and females in the number of incorrect answers they gave on lesson 2, ($t(3) = -.99$, $p = 0.396$). See Figure 3.

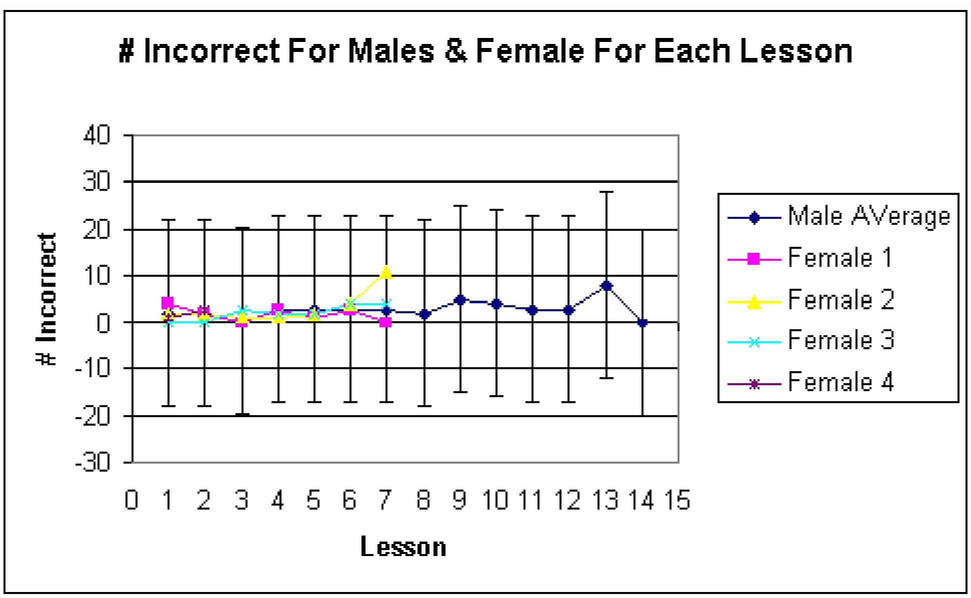

Figure 3. Number incorrect vs. lesson for males and females.

There was no significant difference between males and females in the percentage incorrect in lesson 1, ($t(4) = 1.34$, $p = 0.252$). There was also no significant difference between males and females in the percentage incorrect in lesson 2, ($t(3) = .53$, $p = 0.632$. See Figure 4.

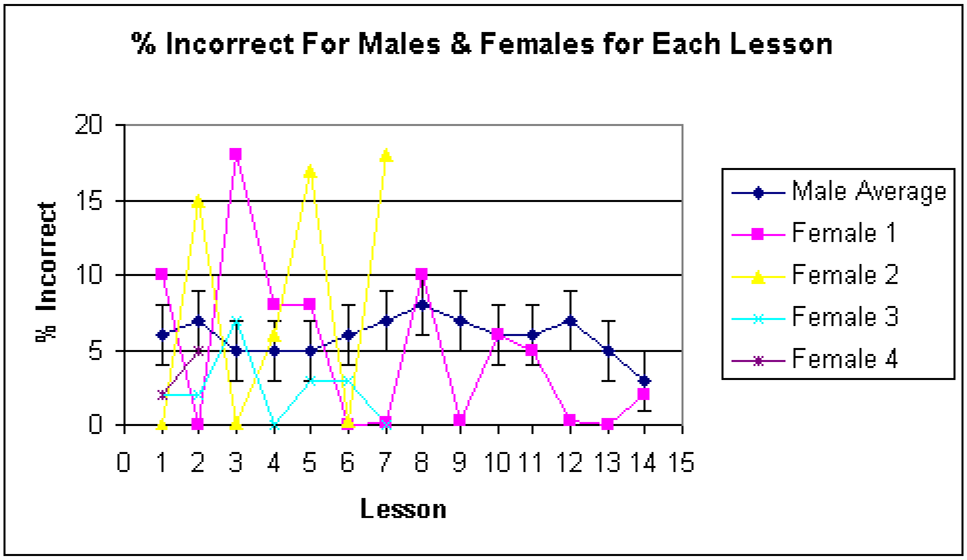

Figure 4. Percentage incorrect vs. lesson for males and females.

Discussion

The major dilemma of this experiment was finding volunteer participants. Only 20 volunteers participated and not all of them completed the entire experiment. Thus, statistical analyses on the data was difficult and may not be very accurate. Only academic data was available for analysis, not enough females completed the flying portion of the experiment for proper analysis.

Another concern was the number of male participants versus the number of female participants. There were 14 male participants and 6 female participants in my experiment. At the United States Air Force Academy (USAFA), approximately 15% of the total number of cadets are females. In my study, 70% of the total number of participants were males and 30% were females. Thus, the proportion of females that participated in my study was well above the proportion of females at USAFA. The small amount of female participants in flying experiments compared to the amount of male participants is not common to my study alone. Baisden's study on *Gender and Performance in Naval Aviation Training* (1997) had 13, 755 male participants and only 421 female participants – thus, only 3% of the total participants were female. In another study, A *Preliminary Evaluation of Causal Models of Male and Female Acquisition of Pilot Skills*, performed by Carretta and Ree (1997), the number of female participants was far less than that of the male participants. There were 3,369 male USAF officers and 59 female USAF officers in the study--only 2% of the total participants were females.

Why are there less female participants in experiments that deal with flying and skills needed for flying careers? There could be many unrelated variables that are involved, but three reasons seem to offer sound explanation. First, military aviation is just now becoming an accepted career for women. Women were not involved in military aviation until WWII. Also, women have just recently been authorized to fly fighter aircraft. Men, on the other hand, have been involved in flying careers since the Wright Bothers built their first aircraft. Second, females tend to excel and participate in academics (literature and art) that are not necessarily conducive for aviation careers. Finally, there are fewer women in our society that desire to pursue a flying career, most women become involved with non aviation related careers.

Research conducted by Carretta in the area of gender differences and flying performance did not produce any basis for sex-separated training syllabi. Results showed that the females participants read lessons one and two more slowly than the male participants. However, Carretta found that the AFOQT Pilot Selection Test was a good indicator for both genders, thus "the common variance accounted for by each factor were similar" (1997). In another study, A Preliminary Evaluation of Casual Models of Male and Female Acquisition of Pilot Skills, Carretta also found that "group mean differences on the verbal and quantitative tests, measures of g, favored women. The opposite was true for the tests of job knowledge" (1997). Thus, Carretta states that each gender brings different strengths to the cockpit, however, neither gender has been proven to perform significantly better or worse in skills related to flying tasks.

The data suggested a significant difference for WPM between the two genders. Research by Moursund showed that young girls tend to be more intuitive than young boys. Thus, the more careful and cautious nature of females might have caused the females in my study to take longer to read each lesson to ensure comprehension of the material. The few females in my study might have been more motivated that the males to take their time and perform well on all the tasks I assigned because they were working in an environment that has not been open to females until recently. Women who have careers contrary to the general stereotype for females tend to be more motivated and harder working than their male peers. Although I showed a significant difference between the genders on WPM, there was no significant difference on the time. Of course, differences in academic skills may provide an alternative interpretation of the results. The small sample of women may simply have been slower readers.

Conclusions

Overall, no sound emotional, mental or physical reasons exist for why women should be excluded from military flying careers. Currently, women compose just over 23% of the entire military population in the United States Air Force--66,376 are enlisted members and 11,848 hold an officer rank (cite AFPC website). The total number of females is still scare, but gradually increasing as more and more women choose careers directly related to the Air Force's primary mission, flying. Approximately, 3% of all Air Force personnel with pilot, navigator and air battle manager AFSCs are female. And, many more women are working in other operational and logistical AFSCs such as aircraft and munitions maintenance and air controlling.

The issue is not whether women are capable of being successful in military flying careers. The issue is how to get more women into the cockpit. In the mere 25 years that women have been flying in the United States Air Force, they have contributed vast amounts of knowledge to the aviation world; from the early beginnings of Amelia Earhart and Jacqueline Cochran to the influential ideas of Patty Wagstaff who helped engineer the first military trainer (T-6A) designed to accommodate female flyers. Motivation, dedication and a little knowledge of what is available in the way of aviation careers is all most women need to succeed in the military flying world.

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