USAFA TR 2000-06

Women in Military Aviation

C1C Katrine M. Waterman
Department of Behavioral Sciences and Leadership

Dr. James C. Miller
Human-Environmental Research Center

United States Air Force Academy
Colorado Springs, Colorado 80840

May 2000

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DEAN OF THE FACULTY
UNITED STATES AIR FORCE ACADEMY
COLORADO 80840

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
31 May 2000

2. REPORT TYPE

3. DATES COVERED *(From - To)*
August 1999 - May 2000

4. TITLE AND SUBTITLE
Women in Military Aviation

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
C1C Katrine M. Waterman, Dr. James C. Miller

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Human-Environmental Research Center and Department of Behavioral Sciences and Leadership
Dean of the Faculty
USAF Academy, Colorado 80840

8. PERFORMING ORGANIZATION REPORT NUMBER
USAFA TR 2000-06

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution A: Approved for public release. Distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
As women become increasingly involved in the world of aviation and combat flying roles, questions concerning gender issues in the cockpit are becoming extremely relevant. Some of the most significant areas of concern dealing with women in the cockpit are behavior, body composition, anthropometry, biomechanics, physiology, health, and learning. This project addresses these seven areas of concern for women in military aviation. We conducted this review through a literature search, and through interviews with both women and men in the operational Air Force and the civilian world. In addition, a computer-based simulator was used to compare the learning characteristics between men and women for basic flying skills. All the research cited reached the same general conclusions. There is no difference in the abilities of men and women to perform successfully and safely in an aviation career. The statistical analysis of the data collected for this experiment produced similar results; there was no significant difference between men and women in any of the four measures used to test basic flying performance. Overall, both men and women are physically and mentally equally qualified to pursue aviation careers.

15. SUBJECT TERMS
Aviation, women, simulation, learning, health, psychology, physiology, gender, research, military academy, USAFA, HERC

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Dr. James C. Miller
					19b. TELEPHONE NUMBER *(Include area code)*
Unclassified	Unclassified	Unclassified	Unl	27	(719) 333-2804

THIS PAGE INTENTIONALLY LEFT BLANK

This report entitled *Women in Military Aviation* is presented as a competent treatment of the subject, worthy of publication. The United States Air Force Academy vouches for the quality of the research, without necessarily endorsing the opinions and conclusions of the authors. Therefore, the views expressed in this article are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the US Government.

This report has been cleared for open publication and public release by the appropriate Office of Information in accordance with AFI 61-202 and USAFA FOI 190-1. This report may have unlimited distribution.

Alice J. Chen

ALICE J. CHEN, Lt Col, USAF
Director of Faculty Research

7 Sept 2000
Date

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Women have been involved in aviation for much longer than most people think. Almost 100 years before the first airplane was invented, women were risking their lives in hot air balloons (Jablonski, 1968). The first time women were involved in military aviation was during the Second World War, starting in 1942. Now, as women become increasingly involved in the world of aviation and combat flying roles, questions concerning gender issues in the cockpit are becoming extremely relevant. Some of the most significant areas of concern dealing with women in the cockpit are behavior, body composition, anthropometry, biomechanics, physiology, health, and learning.

This project addresses these seven areas of concern for women in military aviation. We conducted this review through a literature search, and through interviews with both women and men in the operational Air Force and the civilian world. In addition, a computer-based simulator was used to compare the learning characteristics between men and women for basic flying skills.

All the research cited reached the same general conclusions. There is no difference in the abilities of men and women to perform successfully and safely in an aviation career. Furthermore, Carretta (1997) states that there is no need for sex-separated training either. The statistical analysis of the data collected for this experiment produced similar results; there was no significant difference between men and women in any of the four measures used to test basic flying performance. Overall, both men and women are physically and mentally equally qualified to pursue aviation careers.

REVIEW

Almost 100 years before the first airplane was invented, women were risking their lives in hot air balloons (Jablonski, 1968). Women have played and continue to play a significant role in the aviation community, in both the military and the civilian world. Now, as women become increasingly involved in the world of aviation and combat flying roles, questions concerning gender issues in the cockpit are becoming extremely relevant. Some of the most significant areas of concern dealing with women in the cockpit are behavior, body composition, anthropometry, biomechanics, physiology, health, and learning.

This project addresses these seven areas of concern for women in military aviation. We conducted this review through a literature search, and through interviews with both women and men in the operational Air Force and the civilian world. In addition, a computer-based simulator was used to compare the learning characteristics between men and women for basic flying skills.

The first U.S. military training of female pilots started in 1942 to supply pilots for the non-combat roles of ferrying aircraft and flying instruction. The training stopped between the years of 1944 and 1970 (Lyons, 1992). At present, women are still a minority in the military as a whole, and even more so in flying occupations. Statistics from the USAF Military Center Personnel at Randolph AFB show that 18% of the total AF is composed of women; this is a 5.4% increase since 1975. Also, 3% of the total number of pilots are women and 3% of navigators are female. However, the numbers are rising as females are becoming integral parts of flying squadrons throughout the military. Women are now flying fighter aircraft and are not restricted from combat missions, with the exception of Special Operations with MC-130s, AC-130s, and special operations helicopters (Dyson, 1999). Although some research has been conducted concerning females in the military aviation world, more is needed. Current studies suggest that there is no significant reason why females should not be involved; however, not all aspects of complete integration have been examined in full. Thus, for the purposes of this project, we have examined differences between the two sexes in these areas: behavior, body composition, anthropometry, biomechanics, physiology, health, and learning.

The overarching objective of this project is 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. Finally, we attempted to determine if there might be significant differences between males and females in a computer simulation that allows assessments of the learning of basic flying skills.

Behavior

With women becoming a vital part of the military flying missions, questions of gender differences in behavior arise. Some research has already been done in these areas. 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 were 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. (Carretta, 1997).

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). Even though the US is still somewhat biased against women, 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, spoke of a time when she was speaking over the radio while approaching a military base in

Saudi. She asked the control tower for a clearance three times with no answer. Finally, the male pilot got on the radio and immediately was 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. In addition, 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 typically has been dominated by males. Female aviators will face the same trials as women in high corporate positions. However, Hyde states that these obstacles are nothing that cannot be overcome with hard work and persistence on both the males and the females.

All of the studies above seem to suggest that there is no reason to disregard women as potential aviators in the military. 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

We must consider the different compositions of female and male bodies 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. Because females are more petite with less body muscle and more adipose tissue than males, there is some concern that physically they are not built to fly aircraft. No research to date shows that the difference in body composition between males and females 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, narrower shoulders, and more adipose tissue (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).

Finally, 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. All of these designs must be re-considered for the female aviator population.

Biomechanics

The biomechanics of the human body includes flexibility, which might prove to be an important aviation issue. Flexibility can reduce the risk of musculoskeletal injuries during ejection. Women usually posses a much greater range of flexibility than men (Greenhorn and Stevenson, 1997).

These differences in anthropometry and biomechanics between the two genders suggest that "each gender must adapt their own methods for maximum productivity, while keeping injuries at a minimum" (Greenhorn and Stevenson, 1997). Although differences in the genders do exist, no research has thoroughly proven that women are less capable than men of pursuing flying careers in the military due to biomechanics. In fact, the biomechanics of a woman's body might be better suited for a flying career than a man's. More research is needed to support either view.

Another biomechanical issue is acceleration tolerance. A common incorrect theory is that women are more tolerant to G-forces than men. However, the male and female subject groups used in the study that reported these initial results were not similar. The women used in the study were shorter than the men were; thus, there might have been bias from the start. We cannot be sure that the results produced from this study were not because 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). One hundred two 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, some factors did effect 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. The most important finding was that acceleration tolerance was found to be inversely proportional to height. Gillingham explained 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" (986). More recent studies have shown that there is no reason why women should be excluded from aircrew duties for reasons of G-tolerance (Kolka, 1997). 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 flying for the reason of less G tolerance.

The 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 from the Medeval Profiles 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 statically significant. Motion sickness occurred in 35% of the female subjects and in 45% of the male profiles.

The study also looked at the possibility of high G stress affecting female health. None of the women reported any pelvic or breast discomfort. In addition, there were no reported problems with the menstrual cycle due to the high G stress. 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 because 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). No woman has failed to complete centrifuge training at Holloman. 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.

Physiology

Endurance, or the total resistance to fatigue, is also important. As stated above, women have more adipose, or fat, tissue than men do. 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 insignificant when oxygen utilization (Vo_{2max}) 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 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 do, 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).

Women do sweat less than men do. However, they may be more efficient, thus 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° F before any 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 occur due to pregnancy that would obviously affect a female's ability to fly during pregnancy. 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. In addition, 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 flying interrupts the cycle, or that flying causes irregularity. 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 normally 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 that can be irreversible. Both females and males are equally subject to the symptoms above.

Radiation may not affect women only during pregnancy. Women have 50% higher chance of cancer incidence due to radiation exposure than men do (Lyons, 1992). Part of this increased risk may stem from the relatively high risk women face for breast cancer. More research is needed to determine the exact consequences of radiation exposure from flying.

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 either for cultural reasons or by virtue of the interactive effects of other sex-associated variables. (285)

In early life, girls may be rewarded for certain behavior 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 that important 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. In school, 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. However, 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, it had an indirect effect on actual flying skills. The influence of g was stronger for the female sample than for the male sample. In addition, 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. Males will usually have more experience in these fields than females, for whatever reason. However, women are completely capable of learning these skills. 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 or the standard in order to understand the concepts presented in flying, but this is true for any discipline. To 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

This extensive literature review revealed that there are some differences between males and females that might have an effect on flying skills and performance. Females do have a different body composition than males and there are some behavioral issues associated with women being in the cockpit that need to be looked at more carefully. However, research to date has shown that there is no reason to exclude women from the cockpit. In addition, 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.

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

METHODS

A computer-based simulator was used to compare the learning characteristics between men and women for basic flying skills.

Experimental Design

Our null hypothesis was that there would be no difference in the basic flying skills of men and women (h_o: men = women). The alternate hypothesis was 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 <> women). We used two-tailed t-tests for independent samples 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 our experiment was 20 (14 males and 6 females).

Procedures

We introduced the subjects to the BFITS and gave them four months to complete the first fourteen lessons of the simulation. Lessons 1 through 9 taught and tested basic knowledge and flying procedures, while lessons 10 through 14 taught and tested actual flying skills. Each lesson required approximately 30 minutes of the subject's time.

Materials

The main tool used for this study was a computer simulation of an aircraft, the Basic Flight Instruction Tutoring System (BFITS) Research Station (Flynn 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 the Air Force Research Laboratory. The program taught the basic knowledge in a series of lessons requiring the participant to read and answer questions. Then it allowed the student to take that "book" knowledge and apply it to actual flying lessons. The data provided by BFITS supported studies of learning. For example, the program provided data on the number of words per minutes read by the student during the lessons and quizzes, the amount of time the student spent on the lessons and quizzes, and the number of correct responses the student gave for quizzes.

The BFITS hardware 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 required to initiate a roll (Flynn 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. We defined a novice as someone who had not yet soloed the glider aircraft in USAFA's Soaring Program. We did not pay the volunteers for their participation. However, C1C Waterman wrote a memorandum for record (MFR) for each participant that finished all fourteen lessons of the study. The MFR was given to the participant's Air Officer Commanding. All participants were required to read, understand, and fill out a consent form before starting the experiment. In addition, 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).

RESULTS

Due to the small number of female participants in lessons 3 and subsequent (Appendix 1, Appendix 2), we were able 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 male participants and 4 female participants 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 male 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 was shown ($t(17) = 4.17$, $p = 0.0006$). The mean WPM for the females was significantly lower than the male 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, the female data fell within one SD 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.

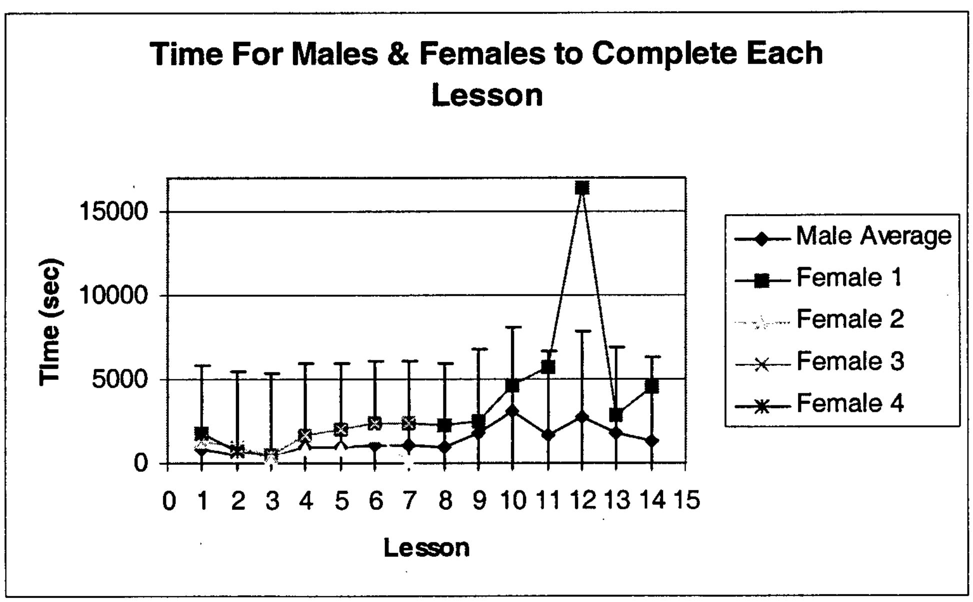

Figure 1. Time to read each lesson.

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

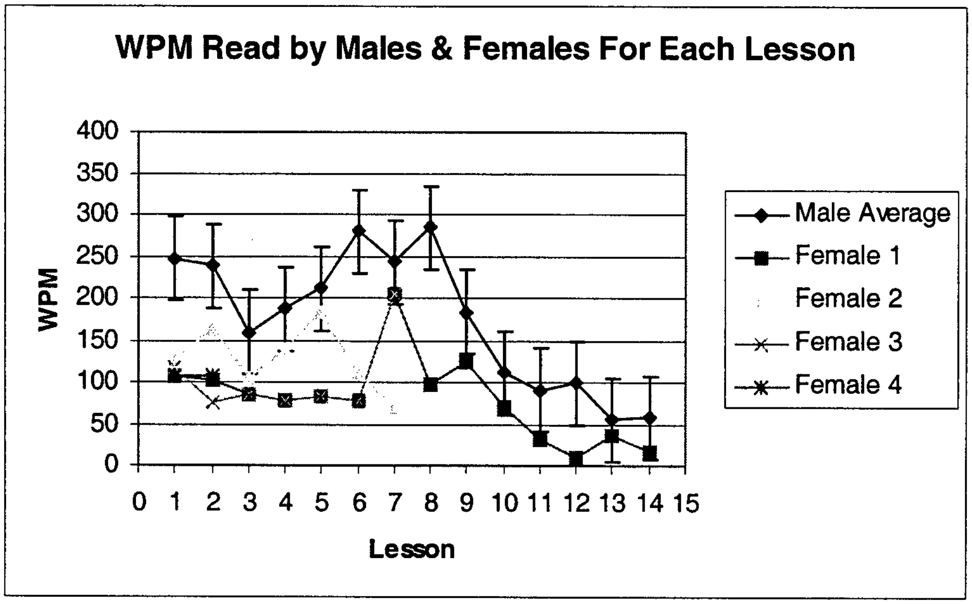

Figure 2. Words read per minute (WPM) for each lesson.

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 ($t(3) = -0.99$, $p = 0.396$). See Figure 3.

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 ($t(3) = 0.53$, $p = 0.632$). See Figure 4.

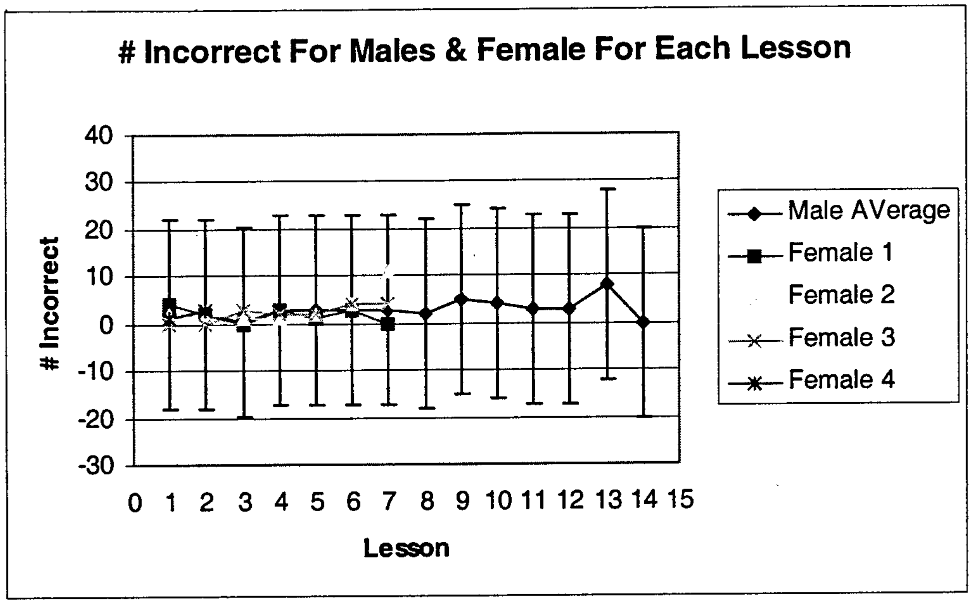

Figure 3. Number Incorrect vs. Lesson for Males and Females

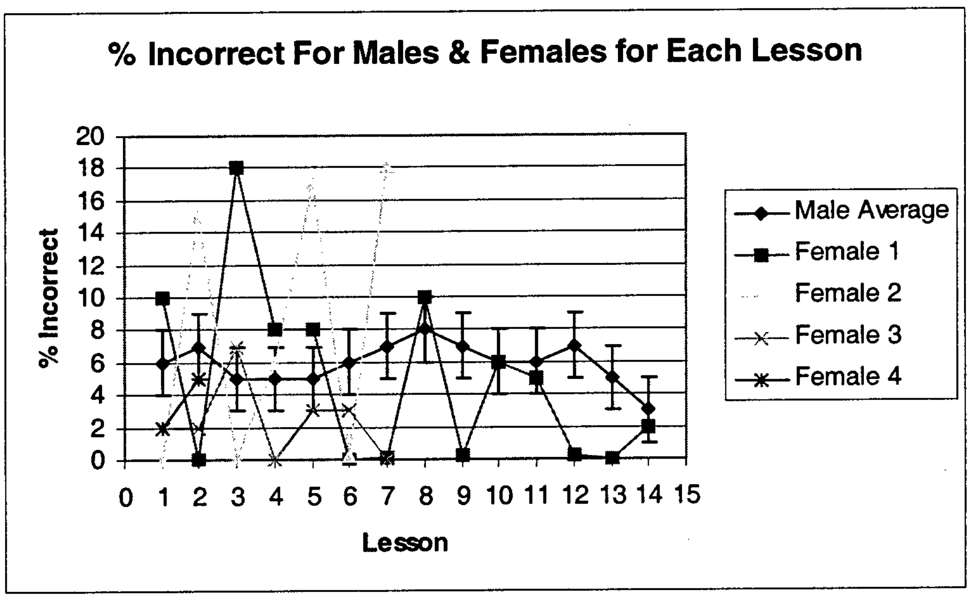

Figure 4. Percentage Incorrect Vs Lesson for Males and Females

DISCUSSION

The major difficulty in this experiment was finding volunteer participants. Of those who volunteered, not all completed the entire experiment. There were four reasonable explanations for the lack of participation. First, this experiment required the participant to complete a series of 14 different lessons that took between 20 and 50 minutes each depending upon the participant. This was a great deal of time to devote to work that was not required at USAFA.

Second, we were unable to offer any incentive, such as a monetary reward or class credit, for volunteering and completing the experiment. We did write an AF Memorandum for Record that we sent to the Air Officer Commanding for each participant that completed all 14 lessons. However, it was probably ineffective as an incentive. Third, our experiment required that only novice pilots participate. We defined a novice as a cadet who had not soloed in the glider program at USAFA. Cadets take the soaring program the summer after their freshmen year and then are involved with more flying programs throughout the rest of their cadet careers. Thus, we had to seek participants from the 4-degree (freshmen). BFITS taught most of the material taught in the introduction to USAF Undergraduate Pilot Training (UPT), giving a cadet a head start on the program. However, this fact was not widely known among cadets and they were apprehensive about volunteering their time. Finally, the 4-degree class is not too concerned with their flying careers yet – they still have three years of education at USAFA before they can even think about applying for UPT.

For these reasons, we found it difficult to find a sufficient number of female and male participants to complete all 14 lessons. It would be better to involve the 1-degree (senior) class in BFITS experiments. However, most are not novice pilots.

We were also concerned that we had so many more male participants than female participants. At USAFA, approximately 15% of the total number of cadets are females. In our study, about 10% were females. Thus, the proportion of females that participated in our study was slightly below the proportion of females at USAFA.

The small number of female participants in flying experiments compared to the amount of male participants is not common to our 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 smaller 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 fewer female participants in experiments that deal with flying and skills needed for flying careers? Three reasons seem to offer sound explanation. First, flying is just now becoming an accepted career for women. Women were not involved in military aviation until WWII, as WASPS. In addition, 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 to flying careers. Finally, there are fewer women in society that desire to pursue a flying career. Most women become involved with other types of careers.

Research by Carretta in the area of gender differences and flying performance did not produce any basis for sex-separated training syllabi. Our results showed that the female 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 stated that each gender brought different strengths to the cockpit. Of course, neither gender has been shown to perform significantly better or worse in skills related to flying tasks.

Our data showed that 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 our study to take longer to read each lesson to ensure that they comprehended the material. Moursund stated that there are some slight differences in the way men and women think, but that these differences are not likely to be relevant in cognitive issues.

We were unable to test this part of her hypothesis because of our small female sample size. The few females in our study might have been more motivated than the males to take their time and perform well on all the tasks we assigned because they were working in an environment that has not been open to female for a very long time. Females who have careers that go against the general stereotype for females tend to be more motivated and harder working than their male peers. 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

We reviewed many factors here, from the behaviors of males and females to their abilities to withstand G forces. Despite some basic cognitive and physical differences between the genders, all the research to date on the topic of whether females are as suited as men for the cockpit has concluded that sex-discrimination in the training or performing of flying careers is not scientifically supported. Carretta completed his study on gender acquisition of pilot skills by saying that there is "no argument for a sex-separated training syllabus" (1997). In 1986, Gillingham and colleagues looked at women's G tolerance and its relationship to flying. Their research led to the conclusion that "women should not categorically be excluded from aircrew duties for reasons of G tolerance." Newsom and colleges also studied female tolerance to $+G_z$ centrifugation. They discovered that female "tolerance to a selected level of $+G_z$ acceleration did not differ significantly from that observed in males" (1977). Baisden (1997) researched *Gender and Performance in Naval Aviation Training*. She resolved that the attrition rate for females in pilot training was not significantly different from that of the male's attrition rate. Another study by Carretta on differences in gender on pilot selection tests indicated that although there were sex differences in mean test performance, models of ability and flying skills "showed similar results for men and women" (1997). Lyons' research on aeromedical concerns for females in the cockpit looked at many health interests that might be a factor in the flying world. He concluded, "although men on are on the average, larger, stronger, and more aerobically fit than women, there are large variations within each sex and a large overlap between the sexes" (1992). Last, a study by Cannon (1986) showed that women were just as capable as men at using a peripheral display in the cockpit.

Women are still very scarce in the aviation world to date. Fewer than 2% of maintenance technicians and approximately 25% of NASA astronauts are women (AVweb News Wire, 2000). The basic lesson from the literature review in this project is that there is no sound emotional, mental or physical reason why women should be excluded from the military or civilian flying world. The more important lessons come from what can be done and accomplished having this basic knowledge.

The issue is not whether women are capable of being successful in flying careers. The issue is how to get more women into the cockpit. Motivation and societal norms are the main factors that we must overcome for more women to have the chance at an aviation career. The program, Women in Aviation International (WAI) has over 5,000 members and is working to provide support, education, and money to women pursuing all types of aviation careers, from maintenance technicians to airline pilots and aircraft designers and engineers. WAI is working with NASA "to encourage young women and girls to explore careers in engineering, aerospace and education" (AVweb News Wire, 2000).

Women have already contributed vast amounts of knowledge to the aviation world; from Amelia Earhart to 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 out there in the way of aviation careers is all most women need to succeed in the flying world.

REFERENCES

American Psychological Association. *Publication Manual.* Washington, DC. Fourth Edition, 1997.

AVweb News Wire. *Women in Aviation International Holds 11th Annual Conference in Memphis.* 13 March 2000. http://www.avweb.com/newswire/news0011a.html

Baisden AG (1997) "Gender Performance in Naval Aviation Training." In Defence Research Group, North Atlantic Treaty Organization, *Optimizing the Performance of Women in the Armed Forces of NATO*, Workshop, London, October 1995 (Technical Proceedings AC/243(Panel8)TP/3; Draft UNCLAS; No public release)

Bartholomew, Cathy, Captain, USAF (1999). KC-135 Tanker pilot and Instructor, Department of Behavioral Sciences and Leadership, USAF Academy. Personal communication.

Bindon K (1997) "The Role and Performance of Women in the Fully Integrated Canadian Forces and Behavior and Attitude: which come first?" In Defence Research Group, North Atlantic Treaty Organization, *Optimizing the Performance of Women in the Armed Forces of NATO*, Workshop, London, October 1995 (Technical Proceedings AC/243(Panel8)TP/3; Draft UNCLAS; No public release)

Cannon RA, Schwank JCH "Effect of Alternate Instrument Displays on Novice Pilots." Department of Behavioral Sciences and Leadership, USAFA. 1986.

Carretta TR (1997). "Sex Differences on U.S. AF Pilot Selection Tests." Armstrong Laboratory Human Resources Directorate, Brooks AFB, TX.

Carretta TR, Ree MR (1997). "A Preliminary Evaluation of Causal Models of Male and Female Acquisition of Pilot Skills." Armstrong Laboratory Human Resources Directorate, Brooks AFB, TX.

Dyson, Kas, Captain, USAFR (1999). C-130 pilot, Special Operations. Personal communication.

Friedl KE (1997). "Current Research Priorities for Health and Performance Issues of US Servicewomen." In Defence Research Group, North Atlantic Treaty Organization, *Optimizing the Performance of Women in the Armed Forces of NATO*, Workshop, London, October 1995 (Technical Proceedings AC/243 (Panel 8) TP/3; Draft UNCLAS; No public release)

Gillingham KK, Schade CM, Jackson WG, Gilstrap LC (1986). Women's G Tolerance. *Aviation, Space, and Environmental Medicine.* Vol 58, No 8.

Greenhorn DR, Stevenson JM (1997). "Gender Based Biomechanical Differences that Impact on Task performance." In Defence Research Group, North Atlantic Treaty Organization, *Optimizing the Performance of Women in the Armed Forces of NATO*, Workshop, London, October 1995 (Technical Proceedings AC/243(Panel8)TP/3; Draft UNCLAS; No public release)

Hover, Glenn, Maj USAF (1999). Aerospace Physiologist and Assistant Professor, Department of Behavioral Sciences and Leadership, USAF Academy. Personal communication.

Hyde JS (1996). *The Psychology of Women: Half the Human Experience, 5th ed.* Heath and Company, pp. 195-198.

Jensen RS, Rakovan LA (1995). Eighth International Symposium on Aviation Psychology.

Kern, Tony, LTC USAF (1999). B-1 pilot and Associate Professor, Department of History at USAF Academy. Personal Communication.

Klausmeier H, Goodwin W (1966). *Learning and Human Abilities, 2nd ed.*. New York: Harper and Row.

Kolka MA (1997). "Gender Issues in Thermoregulation and Physical Performance in Hot and Cold Environments." In Defence Research Group, North Atlantic Treaty Organization, *Optimizing the Performance of Women in the Armed Forces of NATO*, Workshop, London, October 1995 (Technical Proceedings AC/243(Panel8)TP/3; Draft UNCLAS; No public release)

Koonce JM, Berry GA (1986). "Comparison of Males and Females in the Prediction of Basic Flight Performance." USAFA.

Lyons TJ (1992). "Women in the Fast Jet Cockpit – Aeromedical Considerations." *Aviation, Space, and Environmental Medicine,* September 1992, pp. 809-817.

McCloy TM, Koonce JM (1981). "Sex as a Moderator Variable in the Selection and Training of Persons for a Skilled Task." First Symposium on Aviation Psychology, USAFA.

Miller, James C., USAFA. (1999). Director, Human-Environmental Research Center, USAF Academy. Personal communication.

Miller JC, Kirk MT, Flynn JS, Hurt MP, Schlueter JC, Stewart, MW, Weeks III MW (2000). *Development of a Basic Flight Instruction Tutoring System (BFITS) Research Station.* USAF Academy, Dean of the Faculty, Human-Environmental Research Center, Technical Report 2000-03.

Moursund J (1976). *Learning and the Learner.* California: Brooks/Cole Publishing Company.

Newsom BD, Goldenrath W, Winter WR, Sandler H (1977). Tolerance of Females to +G Centrifugation Before and After Bedrest. *Aviation, Space, and Environmental Medicine*, 48, 4.

O'Donnell, Kathy (1999). Research Psychologist, Institutional Research and Policy, USAF Academy. Personal communication.

Robinette, Kathy (1999). "Crew Systems Briefing on Female Accommodations." AFRL/HE, Wright-Patterson AFB, OH.

Schwietz, Leigh Anne, Col, USAF (1999). Physician, USAFA Hospital. Personal communication.

Self, Brian (1999). Assistant Professor, Department of Engineering Mechanics, USAF Academy. Personal communication.

Stroud M.A. (Workshop Chairman) (1995). "Optimising the Performance of Women in the Armed Forces of NATO." NATO DRG Panel 8 Workshop. October 16-19.

Van De Graff KM (1998). *Human Anatomy*, 5th ed.. Weber State University.

Vance, Kristin, Major, USAF (1999). Assistant Professor, Department of Behavioral Sciences and Leadership, USAF Academy. Personal communication.

Appendix 1A

Time for Males and Females to Finish Each Lesson

TIME			
MALE DATA	N	MEAN	SD
Lesson 1**	44	880.008	514.2
Lesson 2*	37	443.38	200.05
Lesson 3	37	302.95	214.98
Lesson 4	37	980.11	1886.46
Lesson 5	36	985.03	476.23
Lesson 6	33	1091.53	728.52
Lesson 7	28	1049.97	496.97
Lesson 8	24	990.6	612.99
Lesson 9	24	1727.68	878.53
Lesson 10	21	3136.05	1529.32
Lesson 11	10	1692.09	623.99
Lesson 12	9	2787.8	2187.39
Lesson 13	5	1842.6	522.86
Lesson 14	5	1257.2	58.11
FEMALE DATA	N	MEAN	SD
Lesson 1	4	1531.5	263.4
Lesson 2	4	743	188.5
Lesson 3	3	412.7	29.6
Lesson 4	3	1414.3	489.6
Lesson 5	3	1590.7	643.2
Lesson 6	3	2134.7	449.2
Lesson 7	3	1937.3	716.5
Lesson 8	1	2204	
Lesson 9	1	2454	
Lesson 10	1	4665	
Lesson 11	1	5660	
Lesson 12	1	16358	
Lesson 13	1	2818	
Lesson 14	1	4489	

* male-female difference, $p < .05$

** male-female difference, $p < .01$

Appendix 1B

WPM Read by Males and Females for Each Lesson

WPM			
MALE DATA	N	MEAN	SD
Lesson 1**	44	246.76	146.21
Lesson 2**	37	237.86	148.35
Lesson 3	37	158.75	65.64
Lesson 4	37	186.57	102.89
Lesson 5	36	211.98	95.95
Lesson 6	33	280.00	232.86
Lesson 7	28	242.68	193.98
Lesson 8	24	284.76	174.98
Lesson 9	24	182.58	96.06
Lesson 10	21	112.44	66.36
Lesson 11	10	90.97	42.61
Lesson 12	9	99.82	83.59
Lesson 13	5	54.94	18.28
Lesson 14	5	58.2	3.98
FEMALE DATA	N	MEAN	SD
Lesson 1	4	114.67	8.32
Lesson 2	4	11.65	37.40
Lesson 3	3	91.60	11.78
Lesson 4	3	98.37	38.12
Lesson 5	3	118.43	58.60
Lesson 6	3	89.23	18.76
Lesson 7	3	115.63	79.76
Lesson 8	1	97.20	
Lesson 9	1	125.40	
Lesson 10	1	69.50	
Lesson 11	1	31.10	
Lesson 12	1	9.40	
Lesson 13	1	35.80	
Lesson 14	1	16.80	

* male-female difference, $p < .05$

** male-female difference, $p < .01$

Appendix 1C

Number of Incorrect Answers for Males and Females for Each Lesson

# INCORRECT			
MALE DATA	N	MEAN	SD
Lesson 1	44	1.91	1.67
Lesson 2	37	1.62	1.27
Lesson 3	37	.263	.55
Lesson 4	37	3.11	3.21
Lesson 5	36	3.81	2.48
Lesson 6	33	3.23	2.17
Lesson 7	28	3.28	2.96
Lesson 8	24	2.12	1.66
Lesson 9	24	5.08	4.13
Lesson 10	21	4.18	2.75
Lesson 11	10	3	2.32
Lesson 12	9	2.6	2.22
Lesson 13	5	8	1.095
Lesson 14	5	0	0
FEMALE DATA	N	MEAN	SD
Lesson 1	4	1.75	1.71
Lesson 2	4	1.75	1.26
Lesson 3	3	1.33	1.53
Lesson 4	3	2	1
Lesson 5	3	1.667	.58
Lesson 6	3	3.667	.58
Lesson 7	3	5	5.60
Lesson 8	1	0	0
Lesson 9	1	0	0
Lesson 10	1	0	0
Lesson 11	1	0	0
Lesson 12	1	0	0
Lesson 13	1	0	0
Lesson 14	1	0	0

Appendix 1D

Percent Incorrect Answers for Males and Females for Each Lesson

% INCORRECT			
MALE DATA	N	MEAN	SD
Lesson 1	44	6.42	6.12
Lesson 2	37	7.17	5.82
Lesson 3	37	5.20	5.03
Lesson 4	37	5.26	4.05
Lesson 5	36	5.4	5.08
Lesson 6	33	6.19	6.03
Lesson 7	28	7.11	6.02
Lesson 8	24	8.48	7.03
Lesson 9	24	6.55	5.46
Lesson 10	21	5.85	5.82
Lesson 11	10	5.77	5.87
Lesson 12	9	7.01	6.69
Lesson 13	5	4.83	3.39
Lesson 14	5	3.33	3.42
FEMALE DATA	N	MEAN	SD
Lesson 1	4	3.36	4.20
Lesson 2	4	5.31	6.72
Lesson 3	3	2.45	3.94
Lesson 4	3	4.78	4.22
Lesson 5	3	9.12	7.32
Lesson 6	3	1.03	1.57
Lesson 7	3	6.05	10.35
Lesson 8	1	9.5	
Lesson 9	1	.2205	
Lesson 10	1	6.33	
Lesson 11	1	4.75	
Lesson 12	1	.24	
Lesson 13	1	0	
Lesson 14	1	2	

Appendix 2

Sample Size, Mean, and SD for Each Lesson and Gender

Lesson by Sex	Time	WPM	# Incorrect	% Incorrect
Lesson 1 (male)	880 ± 514 (44)**	247 ± 146 (44)**	2 ± 2 (44)	6 ± 6 (44)
Lesson 1 (female)	1531 ±263 (4)**	114 ± 8 (4)**	1.75 ± 1.71 (4)	3 ± 4 (4)
Lesson 2 (male)	443 ± 200 (37)*	238 ± 148 (37)**	2 ± 1 (37)	7 ± 6 (37)
Lesson 2 (female)	743 ± 188 (4)*	12 ± 37 (4)**	1.75 ± 1.26 (4)	5 ± 7 (4)
Lesson 3 (male)	303 ± 215 (37)	159 ± 66 (37)	.26 ± .55 (37)	5 ± 5 (37)
Lesson 3 (female)	412 ± 30 (3)	92 ± 12 (4)	1.33 ± 1.53 (3)	2 ± 4 (3)
Lesson 4 (male)	980 ± 1886 (37)	187 ± 103 (37)	3 ± 3 (37)	5 ± 4 (37)
Lesson 4 (female)	1414 ± 490 (3)	98 ± 38 (3)	2 ± 1 (3)	5 ± 4 (3)
Lesson 5 (male)	985 ± 476 (36)	212 ± 96 (36)	4 ± 2 (36)	5 ± 5 (36)
Lesson 5 (female)	1590 ± 643 (3)	118 ± 59 (3)	1.67 ± .58 (3)	9 ± 7 (3)
Lesson 6 (male)	1091 ± 729 (33)	280 ± 233 (33)	3 ± 2 (33)	6 ± 6 (33)
Lesson 6 (female)	2134 ± 449 (3)	89 ± 19 (3)	3.67 ± .58 (3)	1 ± 1 (3)
Lesson 7 (male)	1049 ± 497 (28)	243 ± 194 (28)	3 ± 3 (28)	7 ± 6 (28)
Lesson 7 (female)	1937 ± 716 (3)	116 ± 80 (3)	5 ± 5.60 (3)	6 ± 10 (3)
Lesson 8 (male)	991 ± 613 (24)	285 ± 175 (24)	2 ± 2 (24)	8 ± 7 (24)
Lesson 8 (female)	2204, NA (1)	97, NA (1)	0, NA (1)	10, NA (1)
Lesson 9 (male)	1728 ± 879 (24)	183 ± 96 (24)	5 ± 4 (24)	7 ± 5 (24)
Lesson 9 (female)	2454, NA (1)	125, NA (1)	0, NA (1)	.22, NA (1)
Lesson 10 (male)	3136 ± 1529 (21)	112 ± 66 (21)	4 ± 3 (21)	6 ± 6 (21)
Lesson 10 (female)	4665, NA (1)	70, NA (1)	0, NA (1)	6, NA (1)
Lesson 11 (male)	1692 ± 624 (10)	91 ± 42 (10)	3 ± 2 (10)	6 ± 6 (10)
Lesson 11 (female)	5660, NA (1)	31, NA (1)	0, NA (1)	5, NA (1)
Lesson 12 (male)	2788 ± 2187 (9)	100 ± 84 (9)	3 ± 2 (9)	6 ± 7 (9)
Lesson 12 (female)	16358, NA (1)	10, NA (1)	0, NA (1)	.24 NA (1)
Lesson 13 (male)	1842 ± 523 (5)	55 ± 18 (5)	8 ± 1 (5)	5 ± 3 (5)
Lesson 13 (female)	2818, NA (1)	36, NA (1)	0, NA (1)	0, NA (1)
Lesson 14 (male)	1257 ± 58 (5)	58 ± 4 (5)	0 ± 0 (5)	3 ± 3 (5)
Lesson 14 (female)	4489, NA (1)	17, NA (1)	0, NA (1)	2, NA (1)

* male-female difference, $p < .05$

** male-female difference, $p < .01$