EFFECTS OF SELF-INSTRUCTIONAL METHODS AND ABOVE REAL TIME TRAINING (ARTT) FOR MANEUVERING TASKS ON A FLIGHT SIMULATOR

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3. ABSTRACT

Personal computer based flight simulators are expanding opportunities for providing low-cost pilot training. One advantage of these devices is the opportunity to incorporate instructional features into training scenarios that might not be cost effective with earlier systems. Research was conducted to evaluate the utility of different instructional features using a coordinated level turn as an aircraft maneuvering task.

In study I, a comparison was made between automated computer grades of performance with certified flight instructors' grades. Every one of the six student volunteers conducted a flight with level turns at two different bank angles. The automated computer grades were based on prescribed tolerances on bank angle, airspeed and altitude. Two certified flight instructors independently examined the video tapes of heads up and instrument displays of the flights and graded them. The comparison of automated grades with the instructors' grades was based on correlations between them.

In study II, a 2x2 between subjects factorial design was used to devise and conduct an experiment. Comparison was made between real time training and above real time training and between feedback and no feedback in training. The performance measure to monitor progress in training was based on deviations in bank angle and altitude. The performance measure was developed after completion of the experiment including the training and test flights. It was not envisaged before the experiment. The experiment did not include self-instructions as it was originally planned, although feedback by experimenter to the trainee was included in the study.

4. ACKNOWLEDGEMENTS

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8. INTRODUCTION

Advancements in computer technology have made the use of computer based simulators and trainers more feasible for research investigating factors related to pilot training effectiveness. Because the advantages of training on flight simulators includes savings in time and money, computer based training provides researchers with increased opportunity to investigate such factors that may affect flying and pilot training. Previous research by this team of researchers has investigated several techniques related to training pilots; they include: the use of different forms of automated feedback (see, for example, Ali, Guckenberger, Rossi and Williams, 2000) and the use of above real time training (ARTT) (see, for example, Rossi, Crane, Guckenberger, Ali, Archer and Williams, 1999)

These studies have found that some values of ARTT and some forms of feedback are beneficial for training some piloting tasks. However, many questions regarding the use of ARTT, feedback and other variables remain to be studied. For instance, some questions are to determine precisely which values of ARTT are most effective for different tasks and whether ARTT is beneficial for all tasks. With respect to feedback, questions remain regarding whether automated feedback, (and of what nature) can be adequately provided to improve training of pilots. In addition, in order to maximize the potential usefulness of a simulator for training, the development of performance measures that adequately capture the pilot's performance and assess training improvement is essential to the development of a simulator that can provide automated feedback to the trainee. This report, therefore, addresses these issues through two separate studies focusing on the teaching of a coordinated level turn.

The first study was an attempt to validate automated performance measures to adequately capture flying performance and training improvement for novice pilots. The second study addressed the use of ARTT vs. Real Time Training (RTT) and the use of post-flight feedback vs. no feedback for training of a coordinated level turn. Each study will be discussed separately. The Literature Review that follows addresses the three areas of Above Real Time Training, Self-Instructions, and Development of Performance Measures separately.

9. LITERATURE REVIEW

9.1: ABOVE REAL TIME TRAINING

Above Real Time Training is the training acquired on a real time simulator when it is modified to present events faster than normal. Crane and Guckenberger (2000) have provided a survey of the research work on ARTT, which covers its effects on training of novices and experienced individuals, and the types of algorithms needed to implement it on a simulator. Kolf (1973) noted that, "regardless of type or amount of pre-flight simulator training accomplished by the pilot, the actual flight appears to take place at much faster time frame than real time." Hoey (1976) reported that the mental state of test pilots operating remotely piloted vehicles can be approximately simulated without stressful conditions by increasing the simulated rate of time passage. Guckenberger et al

(1997) placed the objectives of NASA Dryden Flight Research Center and Air Force Human System Center's Technical Planning Integrated Product Team in perspective. For the training of pilots, they proposed several benefits from ARTT including increased rate of skill acquisition, decreased real time workload and decreased real time stress. Crane and Guckenberger (1997) have reported that pilots trained using ARTT performed emergency procedures and defeated bandit aircraft significantly faster than pilots trained in real time.

Rossi, Crane, Guckenberger, Ali, Archer and Williams (1999) trained university students on a gunnery task to compare RTT and ARTT at 1.5 times real time. The students trained in ARTT performed on test trials as well as students trained in RTT, although the ones trained in ARTT spent less clock time. During training the performance of students in ARTT was depressed compared to those trained in RT, however. The authors suggested that using ARTT as top-off training after RTT might result in more effective training. Williams (1999) also observed that ARTT as top- off training after RTT offers better training in comparison to ARTT alone or RTT alone in a similar gunnery task.

In an Air Force sponsored study, Ali, Guckenberger, Rossi, and Williams (2000) addressed the use of ARTT for training of pilots to perform basic flight maneuvers. They classified the flying maneuvers with reference to Fitts and Posner's (1967) model that recognizes different stages of skill acquisition as cognitive, associative and autonomous. Ali et al (2000) observed that flying straight and level is relatively less complex than performing climbs and descents and level turns. For the training of straight and level flying they suggested using ARTT at the cognitive stage or the use of ARTT alone as a beneficial mode of training. For the training of climb and descent and level turns, however, they propose that ARTT is beneficial at the autonomous stage or the use of ARTT is recommended as top-off training after RTT.

9.2: SELF-INSTRUCTIONS

Self-instruction through the use of feedback is increasingly becoming beneficial for Computer Based Learning. Proctor and Dutta (1995) provided a comprehensive discussion of the influence of feedback on motor skill acquisition. Ali et al (2000) used in-flight and post-flight automated feedback as a form of self-instruction. In-flight feedback consisted of audio cues that signaled trending out of the prescribed tolerances in altitude and heading. Post-flight feedback consisted of showing the student a set of strip charts upon completion of a flight. These strip charts provided a graphical comparison of prescribed tolerances with the values of altitude, heading, airspeed, and other parameters reached in a student's flight. A progressive investigation of the effects of different forms of self-instruction for training of flying skills on a simulator is likely to bring significant improvements in the training of pilots. In general, participants who received feedback performed better than their counterparts who did not receive feedback.

9.3: PERFORMANCE MEASURES

Straight and level flight, climb, descent and level turn are regarded as the four basic flight maneuvers in a Federal Aviation Administration (1995) publication on private pilot practical test standards. For evaluation of a trainee's flight, it prescribes certain tolerances in the basic flight parameters. Following FAA's guidelines, a certified flight instructor evaluates the performance of a trainee by directly observing his or her flight of an airplane.

For modern training simulators, however, Vreuls and Obermayer (1985) emphasize the need of automated performance measures as a substitute for the evaluation of performance by direct observations. They present several benefits of the automated performance measures. Measurements can be based on a larger number of factors than is possible through direct observation, and precision and reliability can be improved. Data can be collected, summarized and analyzed in a short period of time. Adapted feedback and automated training can be implemented and personnel requirements can be reduced. The authors, however, recognize the need of research for devising automated performance measures, validating them and obtaining the listed benefits from them. For validating automated measures, they have suggested several ways, including the need of experts to judge performance quality, then determine which measures correlate with experts' judgments. For automated grading, Vogel (2000) suggests awarding of grade points 4, 3, 2, 1, and 0 on flying performances within the given tolerances.

Ali, Guckenberger, Rossi and Williams (2000) used grade points for flying performances on the simulator. For example, positive and negative tolerance for air speed in knots was 3 for 4 points, 6 for 3 points, 9 for 2 points and 12 for 1 point. For automated scoring on the computer, the computer monitored flight parameters at every 3 seconds. To validate the automated scoring, several flights flown on a simulator were simultaneously evaluated by the computer and by a certified instructor. The comparison of the two kinds of evaluation revealed acceptable correlation for straight and level flights but very low correlation for climb, descent and turning maneuvers. In the referred report, the authors described the details of their method of automated scoring of a trainee's flight.

Ali, Khan, Rossi, Crane, Guckenberger and Bageon (2001) proposed that a performance measure which represents an increase or decrease of performance at different stages of training is a valid measure to assess progress in training even if the measure is not adopted for certifying a trained pilot. In their study, a trainee on the simulator was required to follow a prescribed ground track while maintaining required speed and altitude. At every prescribed instant of time in a flight, they used a single parameter for representing the performance; the parameter value was then averaged over the complete flight to obtain a consolidated performance measure. The single parameter was the magnitude of the displacement vector between the actual location and the prescribed location of the simulated flight at a given instant.

9.4: INFERENCE FROM LITERATURE REVIEW

The literature review reveals that many questions regarding the utility of ARTT for various flying maneuvers are unanswered. Also, the use of different values of ARTT has not been systematically studied for novice pilots. Both of these issues have yet to be resolved in the context of simulator training. Further, the development of performance measures that adequately capture the pilot's performance and assess training improvement is essential to the development of a simulator that can provide automated feedback to the trainee. Such automated performance measures provided in the form of feedback will maximize the potential usefulness of a simulator for training,

Therefore, this report addresses the issues mentioned above in the context of the training of a coordinated level turn. The first study addresses the evaluation of a performance measure to be used as automated feedback and the second study addresses the effects of feedback vs. no feedback in conjunction with different values of ARTT. Same equipment was used for both studies. Therefore the equipment is described prior to the description of the two studies.

10. EQUIPMENT

Mock setup of a partial cockpit housed in the Flight Vehicle Lab at Tuskegee University was used as the pilot training station. On this setup, a student gets a panoramic view on three monitors for the out-the-window (OTW) display and a fourth monitor for instrumentation panel located below the OTW monitors. Among the three OTW monitors, the center monitor has the heads up display (HUD). The four monitors are governed by a Heavy Metal Computer acquired from Quantum 3D, Lake Forest, California. The computer was configured by SDS International, Orlando, Florida. It has two Pentium II 400 MHz processors, 400 MB RAM, three extra display cards for Open GVS, based graphics and a Sound Blaster audio card. The flight simulation software is the Lite Flite version 3.3 (ref. Lite Flite, 1999) available from SDS International. Lite Flite offers flight simulation of several aircraft including a Predator unmanned air vehicle (UAV). The Predator (UAV) simulation was used in these studies. The joystick was a Saitek X36F. It had labels taped on each of the surrounding four corners indicating the function of the corresponding movement; they were "Left Wing Up", Right Wing Up", "Nose Up", "and "Nose Down". The throttle was a Saitek X35T and had the two labels in the appropriate positions, "Increase Power", "Decrease Power." The rudder pedals were CH pedals. More details on equipment and its fidelity are given in Williams (2000).

Study I – A Comparison of Automated Performance Measures and Instructor Grading of Level Turns

11.1 FLIGHT DATA FOR GRADING

An important element of the work under the grant was to conduct a comparative study of the automated grading of the performance generated by the computer and the grading by certified flight instructors. For this purpose six flights by novice pilots were conducted consisting of a 180 degree level coordinated turn with a bank angle of 30 degree followed by another 180 degree turn in the opposite direction with a 45 degree bank angle. The heads-up display (HUD) and heads-down display (HDD) of these flights were videotaped for post-flight analyses by the instructors.

11.2 AUTOMATED GRADING

The automated grading criteria were based on the requirements of 90 knots ±3knots in airspeed, 30 or 45 degrees ± 3degrees in bank angle and 10000 ft ± 50 feet in altitude. Flight parameters within these limits were graded as 'A'. Deviations of ± 6 knot in airspeed, ± 6 degrees in bank angle and ± 100 feet in altitude were graded as 'B'. Deviations of ±9 knots in airspeed, ±9 knots in bank angle and ±150 knot in altitude were graded as 'C'. Deviations of ±12 knots in airspeed, ±12 degrees in bank angle and ±200 feet in altitude were graded as 'D'. And, deviations of < - 12 knot and > +12knot in airspeed, < -12 degree and > +12 degree in bank angle and < -200 feet and > +200 feet in altitude were graded as 'F'. The flight parameters were graded every three seconds. An average grade was then calculated for each turn.

11.3 INSTRUCTORS' GRADING

The instructors were asked to review the videotapes of the turns and evaluate the performance of the novice pilots on flight simulator. They used the criteria based on their own respective experiences of grading pilots for Federal Aviation Administration (FAA) certification and their own perception of evaluating novice trainees. They were asked to grade the flight parameters of bank angle, airspeed and altitude. The instructors then provided an average performance grade for each of the turns based on these individual grades.

11.4 COMPARISON OF GRADES

The comparisons of the overall automated vs. the instructors' grades for each of the turns are shown as scatter charts in Figs. 1.1 and 1.2. As can be seen from the scatter charts, most of the scores are in the 2.0 or below range. This was expected, as the subjects were novice pilots. However, the two instructors' scores were somewhat inconsistent with one another. In general, instructor#1 graded higher in comparison with the automated grades, while the grading of instructor#2 was lower than the automated grades.

Table 1.1: Correlation Matrix for Average Turning Performance

	Automated	Instructor #1
Instructor #1	0.82316375	
Instructor #2	0.81366456	0.5849536

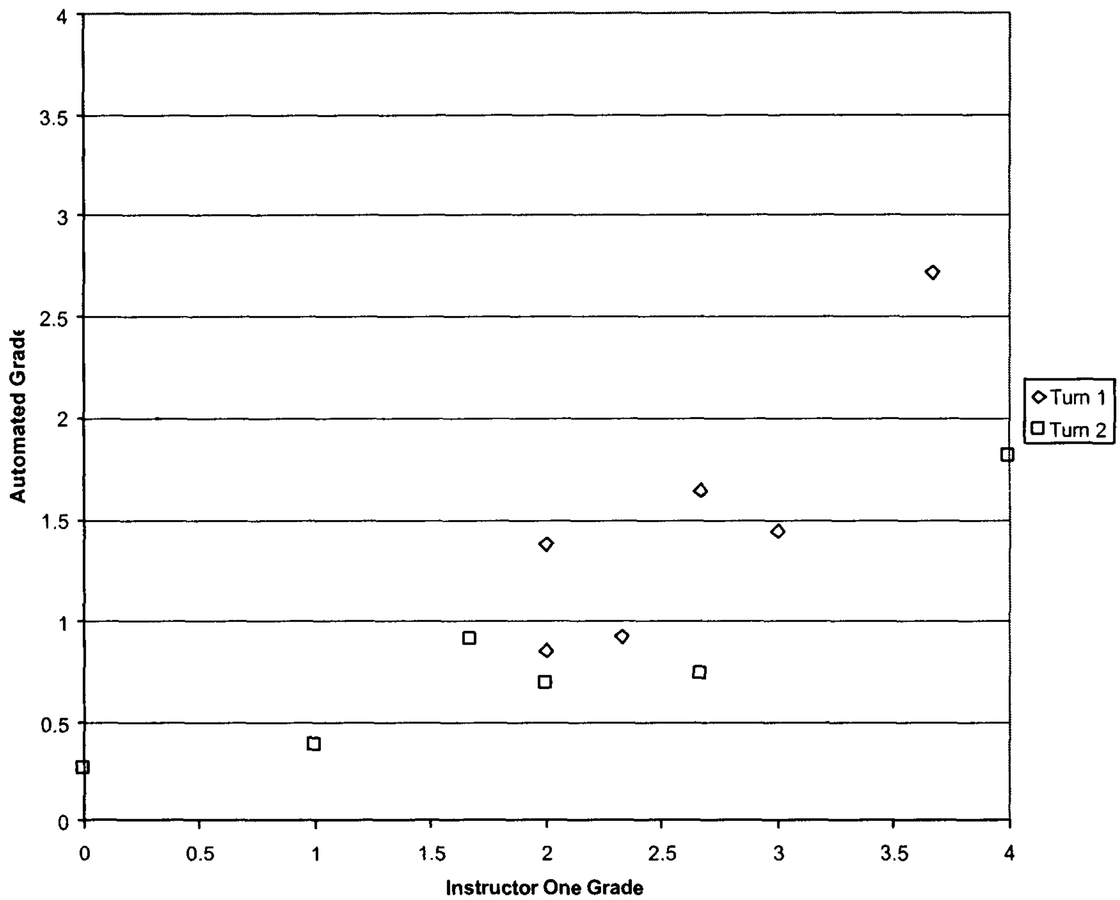

Figure 1.1: Scatter Plot of Instructor One Grade vs. Computer Automated Grade (Turn Task)

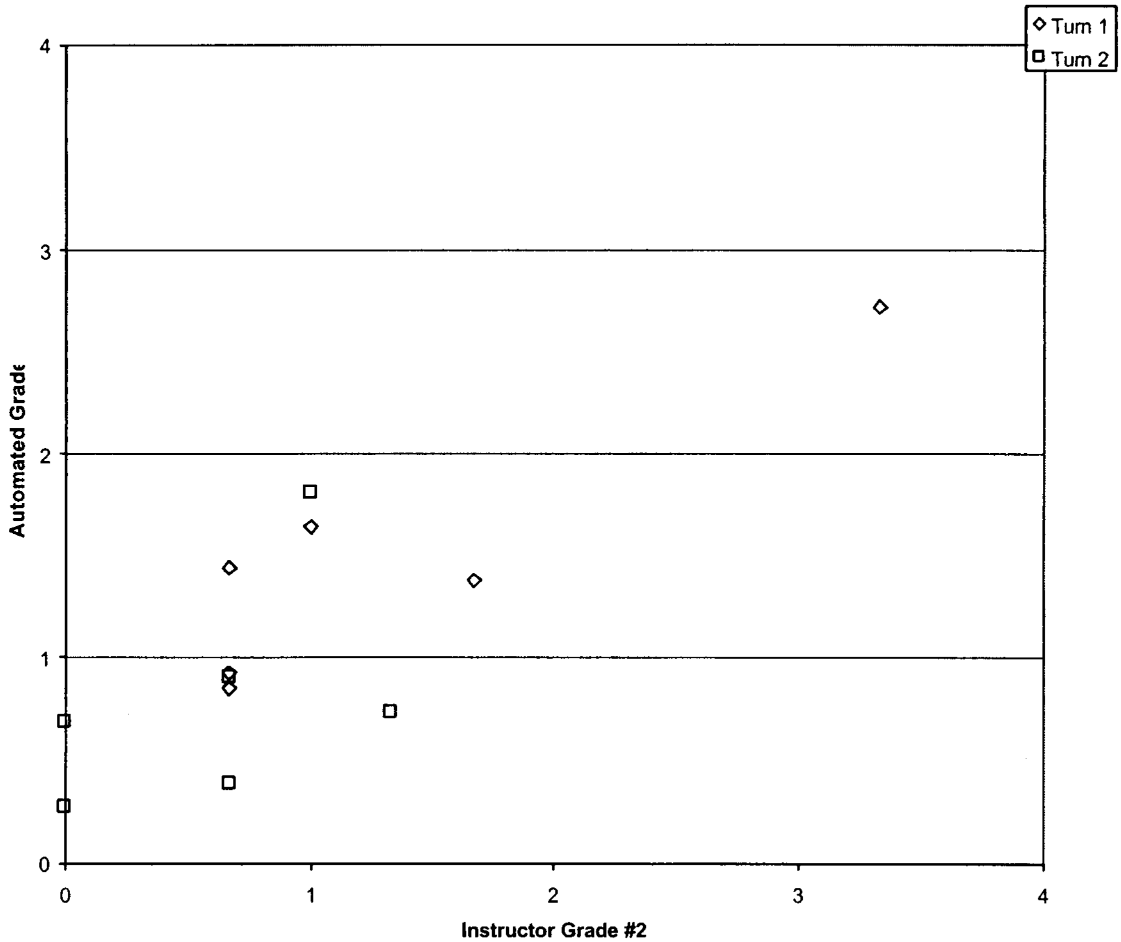

Figure 1.2. Scatter Plot of Flight Instructor Two Grade vs. Computer Automated Grade (Turn Task)

The automated and instructor grades for the individual flight parameters (i.e. airspeed, altitude and bank angle) were also compared. The correlations of the automated vs. the Instructors' grades were high, but the correlation between the instructors is moderate except for the altitude parameter as the pilots were consistently losing altitude. A higher correlation of instructor#1 grading with the automated grade of bank angle is observed, whereas for the other two parameters instructor# 2 had a higher correlation with the automated grade.

Table 1.2: Correlation Matrix for Grades on Airspeed:

	Automated	**Instructor#1**
Instructor#1	0.76693135	
Instructor#2	0.8843401	0.5335072

Table 1.3: Correlation Matrix for Grades on Altitude:

	Automated	Instructor #1
Instructor #1	0.7546494	
Instructor #2	0.8968185	0.71280634

Table 1.4: Correlation Matrix for Grades on Bank Angle:

	Automated	Instructor #1
Instructor #1	0.8005032	
Instructor #2	0.72207886	0.56360185

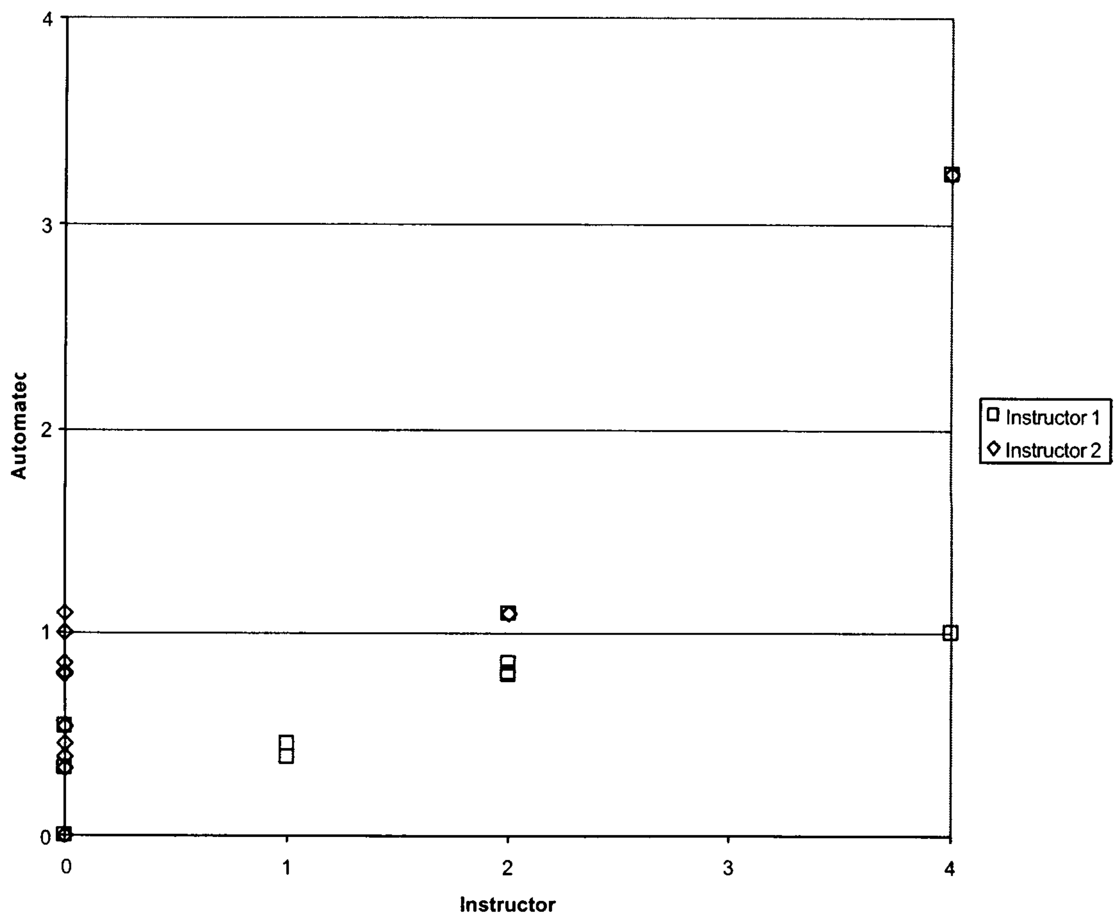

Figure 1.3: Instructor vs. Automated Grading (Airspeed)

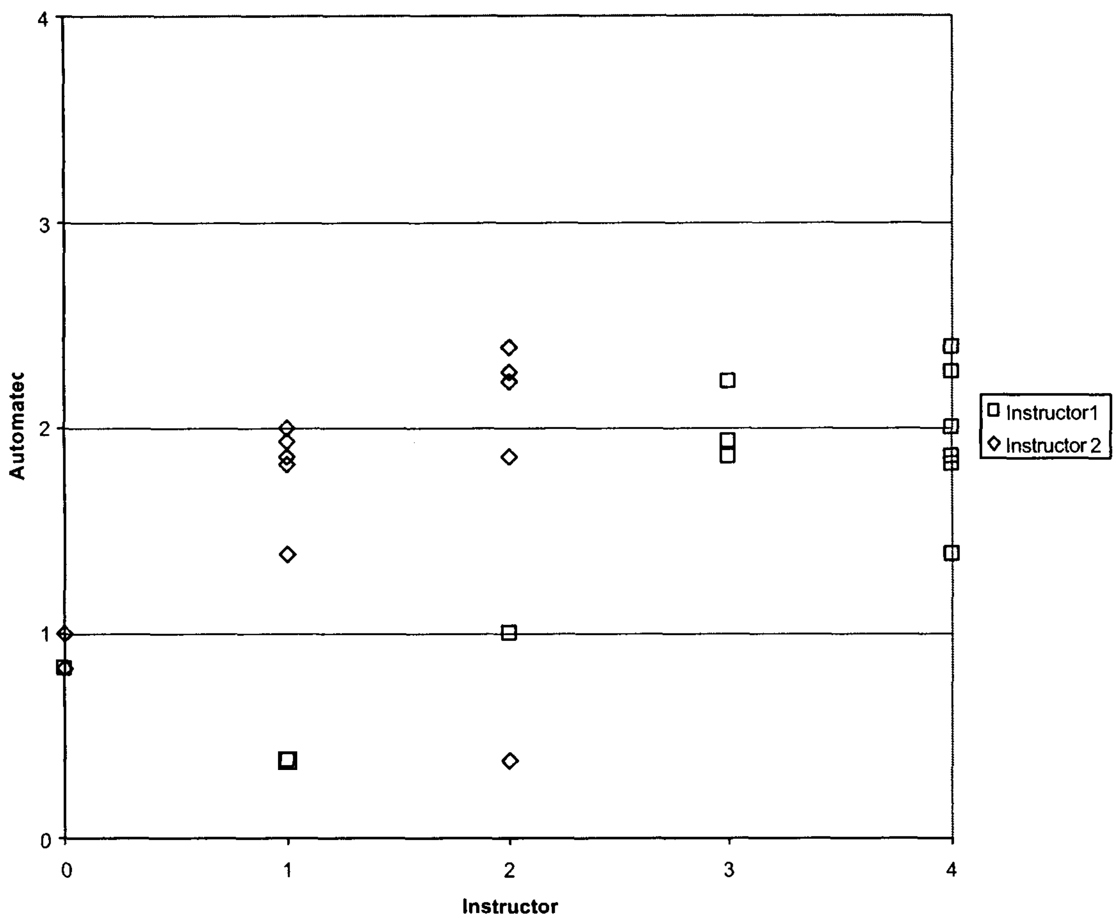

Figure 1.4: Instructor vs. Automated Grading (Bank Angle)

11.5 COMMENTS

This analysis points to the possibility that a comparison between automated and instructor grades may not be valid for novice pilots who have a wide variation in their performance. It also suggests that letter-grades may not be appropriate for tracking training progress as for novices the improvements are incremental. Thus they may exhibit improvements in controlling individual flight parameters but still the overall 'letter' grade may not show an improvement in overall skill. Although the correlations are moderate to high between instructors, the instructors both seem to have a systematic difference between their score and the computer score. Further, the differences in correlations on different parameters between instructors and the computer grade suggests that perhaps, the instructors are making evaluations based on different factors from each other. Thus the factors influencing the assessments of the instructors need to be understood. Future studies could systematically address these issues.

Study II – The Influence of Feedback and ARTT on the Training of a Coordinated Level Turn

12.1 METHOD

The purpose of this experiment was to investigate the effects of ARTT in comparison to Real Time Training (RTT), and the effects of one form of feedback vs. no feedback during the training of a standard two-minute turn with novice pilots.

12.1.1: PARTICIPANTS

Participants in the experiment were twenty undergraduate college students enrolled at Tuskegee University. The students were offered the incentive of extra course credit in either their psychology course or their engineering course in exchange for their participation in the experiment. Participants who had either no prior flying experience or few flying lessons were recruited. Actual pilots were not allowed to participate in the experiment. Those participants then were placed randomly in one of four groups selected by the experimenter, comprising five in each group. As described in the training section, four different groups were identified according to their respective training programs.

12.1.2: EXPERIMENTAL DESIGN

This experiment consisted of a 2 X 2 between-subjects factorial design. The first variable was the type of training, with the two levels being Real Time Training and Above Real Time Training. The second variable was Feedback vs. No Feedback. There were five participants in each group, with the exception of four in a 1.0/1.0 group (Groups are described in the training section). The data from the fifth participant in the 1.0/1.0 group was dropped as the score was an outlier. An examination of the student's data sheet revealed that he had complained of a headache and that the experimenter noted his lack of interest in the study.

12.1.3: PROCEDURE

Participants were asked to reserve approximately two hours of their time for the completion of the experiment. Each participant completed the experiment alone. Upon arrival at the laboratory, each participant was asked to complete a consent form (Appendix A) indicating a desire to participate in the experiment. The participant was then given a Background Survey (Appendix B) to be completed to give insight on any experience with previous flight training. All participants then experienced the following segments of training and testing to be described in detail below:

Orientation to Simulator Controls and Functions
Demonstration Flight
Familiarization Flights
Training Flights
Test Flights
Debriefing

Orientation to Simulator Controls and Functions

During the familiarization process, participants were informed of the basic parts of the aircraft, their functions, and the movements associated with each part. The participants then were given an overview of the locations and functions of the joystick, rudder pedals, and the throttle located in the mock cockpit. Then, participants were instructed in the location and functions of the following displays on the Heads Up Display (HUD): altimeter, radio altimeter, airspeed indicator, heading tape, artificial horizon, pitch ladder and clock. They were also instructed on the location and functions of the following instruments on the Heads Down Display (HDD): artificial horizon and the vertical velocity indicator. Because the turn and slip indicator on the HDD was not functioning properly, the use of HUD to determine if the aircraft was making a coordinated turn was explained.

Demonstration Flight

The experimenter then demonstrated a typical flight and the participants were allowed to control the plane with the help of the experimenter. During this demonstration the experimenter covered essential controls of the aircraft and explained how to maintain airspeed heading and a certain bank angle.

Familiarization Flights

Participants then were told that they would engage in a series of familiarization flights. Participants flew four three-minute flights of three minute duration each in which they were told to maintain airspeed of 129 knot, a heading of 360 degrees, and an altitude of 5,000 ft. During all but the last flight, the experimenter coached the participant. For the first familiarization flight, the experimenter told the participant to focus primarily on maintaining altitude. Also, the experimenter assisted with the controls, if needed. During the second flight, the experimenter told the participant to focus primarily on maintaining altitude and heading, but the experimenter did not touch the controls. During the third flight the experimenter told the participant to focus on the altitude, heading and airspeed. Finally, on the fourth flight the participant was not coached, but told to maintain the airspeed, heading and altitude.

During familiarization flights, participants were graded as if on a 4.0 grade point average (GPA) scale. These scores were computed by a visual basic code that compared parameter values in the flight with the parameter values and tolerances in an input file. For the 4.0 grade, the tolerances in airspeed, altitude and heading respectively were ±6 knots, ±100 ft and ±2 degree. The grading procedure was same as described in section 11.2 on Automated Grading. Students who achieved a score of 2.0 on at least one familiarization flight continued into training. Students who did not achieve the minimum score of 2.0 were told that the experiment was concluded. They were debriefed and thanked for their participation. Twenty six participants completed familiarization flights. Twenty participants, who achieved the passing grade continued on to the training phase.

Training

Training consisted of ten sessions, in each session a participant was required to perform a coordinated level turn of 180 degree while maintaining 10 degree bank angle

and 129 knots airspeed at 5,000 ft altitude. A participant received training under one of the following four different training programs:
1.5/2.0 NoFB: A participant conducts the first five training flights at 1.5 ARTT (Simulation presents events 1.5 times faster than normal) and the next five training flights at 2.0 ARTT. No post flight feedback is provided.
1.5/2.0 FB: A participant conducts the first five training flights at 1.5 ARTT and the next five training flights at 2.0 ARTT. The participant also receives post flight feedback.
1.0/1.0 NoFB: A participant conducts all the ten training flights at RTT. No post flight feedback is provided.
1.0/1.0 FB: A participant conducts all the ten training flights at RTT. The participant also receives post flight feedback.

Participants in the 1.0/1.0 groups completed each session in three minutes. Participants in the 1.5/2.0 groups completed a 1.5 ARTT session in two minutes and a 2.0 ARTT session in one and a half minutes. Thus, all participants completed 10 sessions, but the participants in the ARTT groups completed training more quickly.

Participants were given the following scenario to provide a context for the training sessions.

Training Flights Briefing Scenario

You're a flight leader of a combat air patrol on a routine mission at 5000ft altitude, 129 knots and heading in a 360 direction. An unidentified low speed aircraft is being tracked by radar moving towards a no fly zone. Despite repeated requests, the aircraft fails to identify itself and continues towards the no fly zone. The Air Defense Radar Controller assigns the interception to your flight in order to make a visual identification. You are asked to initiate a right hand turn, maintain a bank angle of 10 degrees, an altitude of 5,000 ft and a speed of 129knot. Exactly after two minutes (as recorded on your heads up display) you should level out. Your heading should be 180 degree, putting you right behind the target close enough for visual contact. You will complete a number of these missions. Do your best, because once you have finished the practice missions, you will be required to complete a test mission with a slightly more difficult task.

Feedback in Training

Participants in the NoFB groups received no feedback during or after flights. If they asked questions about the task, they were reread the relevant instructions. Participants in the FB groups received verbal feedback after each flight. In verbal feedback, the experimenter told the participant the errors in manipulating the controls and in focusing on the wrong instruments. After the second, fourth, sixth, eighth, and tenth flights, participants in the FB groups were also shown a screen printout of the desired ground track and the pilot's actual ground track for comparison. Then, the instructor explained possible reasons for the deviations in performance.

Testing

Upon completion of training, participants were told that they would now complete two flights with a slightly different and more challenging task. These two flights were conducted in real time for all participants and each lasted for three minutes. No feedback or instruction was provided during testing. Participants were read the following scenario prior to each flight.

Testing Scenario

As part of a Combat Air Patrol, the Air Defense Radar Controller notifies you that a hostile aircraft is being tracked headings towards a vulnerable point (VP). Your instructions are to initiate a right hand turn in order to pursue the aircraft while maintaining a bank angle of 30 degrees, an altitude of 5,000ft., and a speed of 164 kts. You then are informed of a second target. Interception of the second target is also assigned to your flight as a priority two target. Exactly 48 sec. after instructions to initiate the turn you should level out. You will now be exactly behind the target on a heading of 180. You should fire your missile and immediately initiate a left turn with a 30-degree bank maintaining 5,000 ft. altitude and a speed of 164kts. In pursuit of the second target assigned. Exactly 48 sec after initiating the second turn you should level out. Your heading should be 360, putting you right behind the second target. Launch your missile. Mission accomplished.

Upon completion of the two flights, the participants were thanked and engaged in a debriefing session with the experimenter.

12.2 PERFORMANCE INDEX (PI)

In the present study, a trainee conducted several flights of the same kind. A flight required completion of a 180-degree level turn while maintaining the required bank angle, airspeed and altitude. It is understood that the required level turn follows a semi-circular flight path. At the outset, it was envisaged that the performance measure used by Ali et al (2001) was an appropriate measure for this study. Accordingly, the magnitude of the displacement vector between the actual location and the prescribed location of the simulated airplane at a given instant, in other words the deviation from the desired flight path, was expected to be an appropriate performance measure. But most of the flights conducted by the trainees showed little correspondence with the semi-circular flight path.

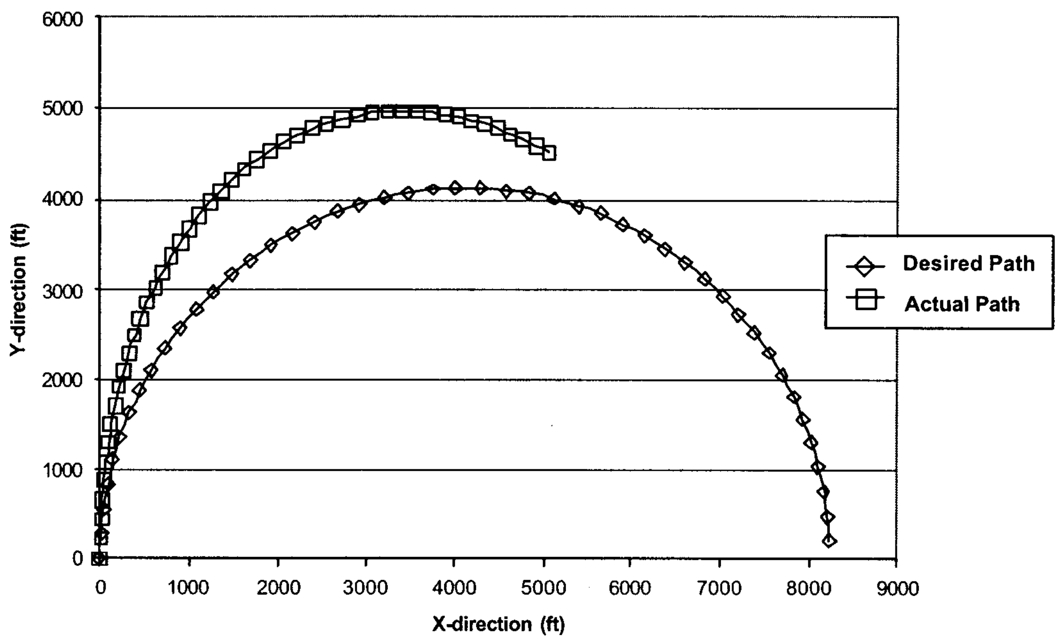

Figure 2.1. Turn Study. 180-degree-Turn paths (RT) in a training session, turns_00404.

Figure 2.1 shows the desired flight path in a 180-degree turn and the actual flight path of a typical flight performed by a participant in a training session. Fig 2.2 shows the desired flight path in an S turn and the flight path of a typical flight performed by a participant in a test session.

Observations of the actual flights led the investigators to realize that the out of the window (OTW) display, HUD and HDD did not provide sufficient cues for the trainee to gain situation awareness, thereby making the execution of the 180-degree turn during training rather difficult and execution of the S turn during testing nearly impossible (Fig. 2.2). Therefore, the deviation from the desired flight path was not considered to be a valid performance measure.

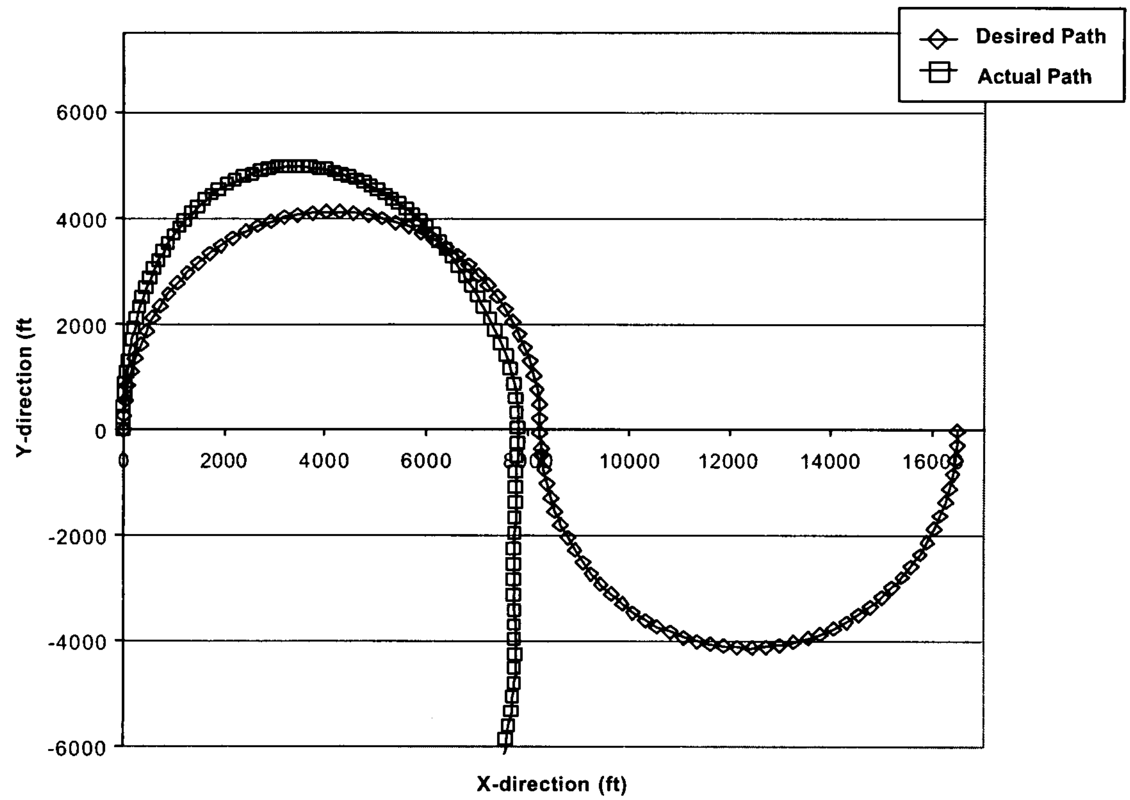

Figure 2.2.Turn Study. S-Turn paths in a test session (RT) turns_00404

However, irrespective of the flight path, the trainees attempted to maintain the required bank angle, speed and altitude. Therefore, a deviation based on the root mean square (rms) value of the dimensionless representations of the differences in the actual and desired values of bank angle, air speed and altitude was considered to be a more realistic measure of the performance of the subjects. At any given instant in a flight, this performance index is defined by:

$PI = \sqrt{[(\Delta\phi)^2 + (\Delta h/R)^2 + (\Delta V/R)^2]}$, where

$\Delta\phi$ = deviation in the bank angle from the desired bank angle over the turn duration
Δh = deviation in altitude from the desired altitude over the turn duration
ΔV = deviation in velocity from the desired speed over the turn duration
R = theoretical radius of turn for the desired speed and bank angle given by the relation $R= V^2/(g\tan\phi)$, where V= desired speed and g is the acceleration due to gravity.

In general, a deviation in speed must be included in the calculation of the PI. However for this specific study, it was observed that a deviation in velocity and altitude were directly correlated (Fig. 2.3 and 2.4). This primarily was due to the fact that the pilots were not manipulating the throttle during the turn. Hence, inclusion of only the deviation in altitude also captured the effect of poor speed control.

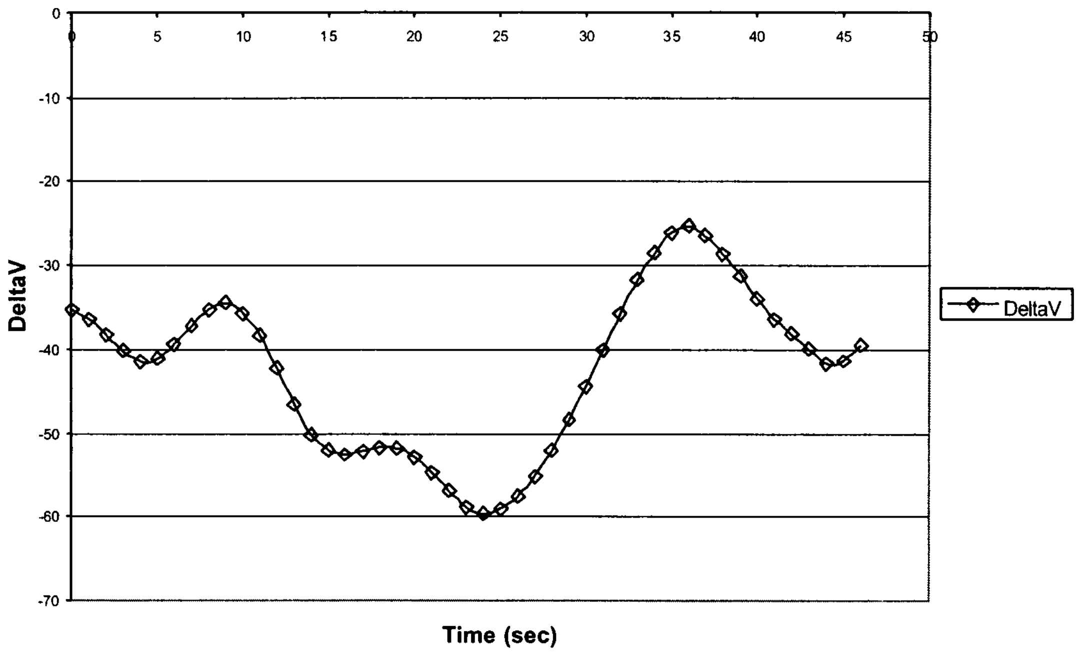

Figure 2.3.Turn Study. Velocity Deviation with Time (turns_00295)

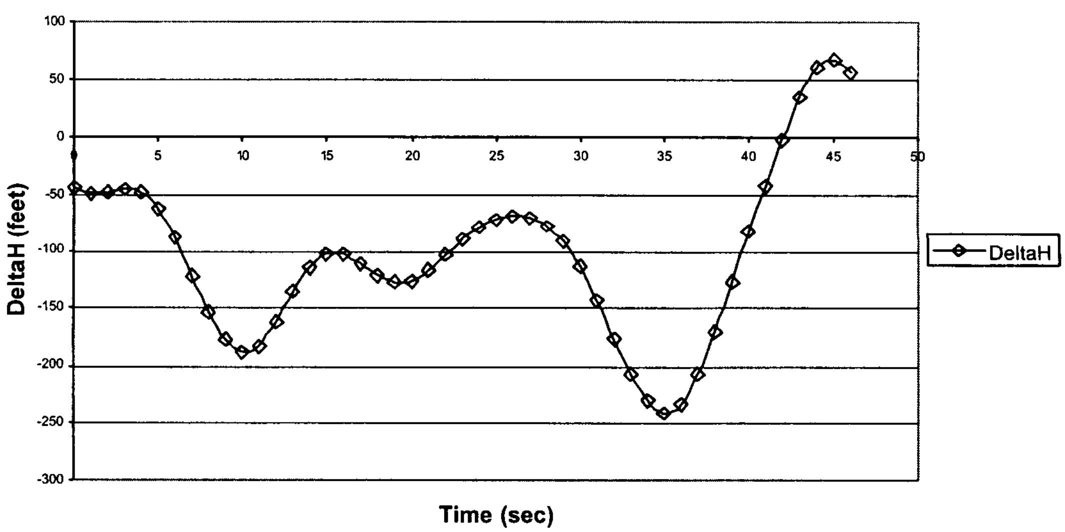

Figure 2.4.Turn Study. Altitude Deviation with Time (turns_00295)

We suggest that this performance index may be used as an automated performance measure for future studies. We did not use it as an automated measure in this study, however, because the index was developed after completion of the study during data analysis.

The PI developed for this study, as described above, is used in the analyses reported below. It is understood that a decrease in the deviation implies improvement in performance. For a flight, the PI is the time average of the deviations at different instants in the flight. For training flights of a participant, the averaging of PI was done for the complete flight. For testing flights of a participant, the averaging of PI was done for the first 180-degree turn of the flight instead of covering the full S turn. It implies that the requirement of the second half of the S turn was dropped from the evaluation due to lack of cues as pointed out earlier in this section.

12.3 RESULTS

As mentioned in the training and test sections, a participant completed ten training flights and two test flights. As explained in the Performance Index (PI) section, the PI for a participant's flight represents an average of a combined measure of bank angle and altitude deviations in the flight. Thus a decrease in the PI represents improvement in performance. Fig 2.5 provides PI values for training flights numbered 1 to 10 and for test flights numbered 1 and 2. Every point graphed in Fig 2.5 represents PI value for the respective flight averaged over all the participants in the respective group. For example, the average value of PI for the five participants in the 1.5/2.0 NoFB group in their third training flight is 0.2.

A three-way , split-plot Analysis of Variance (ANOVA) was conducted with one between-subjects factor, test trial 1 vs. test trial 2, and two within-subjects factors, training time and feedback condition. There was no significant difference in performance scores between the two test trials, $F(1, 15) < 1$, and interactions between test trials and training time, feedback condition, and test time by feedback condition interaction were all not significant (all F values < 1). For the between-subjects factors there was no significant interaction between training time and feedback condition, $F(1, 15) = 2.99$. However, there was a significant difference in performance scores between feedback and no feedback groups, $F(1, 15) = 6.418$, $p < .05$. Specifically, participants in the feedback groups performed better than those in the no feedback groups on test trials as shown in Fig. 2.6. In addition, there was a significant difference in performance scores for training time, i.e., participants in the RT/RT groups performed better than those in the ARTT groups on test trials, $F(1,15) = 7.009$, $p < .05$ as shown in Fig 2.7.

12.4 DISCUSSION

The various training interventions also were observed to influence performance across training flights (Fig. 2.5) in addition to the test trials discussed above. In general, participants in both of the feedback groups improved performance early in training, and performed better than their counterparts across training sessions. This finding is consistent with the ANOVA of test trial performance. The group who received ARTT without feedback (1.5/2.0 NoFB) did not exhibit improvement with time. It is possible that the improvement that may be experienced through practice alone was masked by the increasing difficulty of changing from 1.5 ARTT to 2.0 ARTT. Evidence of this possibility comes from examining the performance of participants in the RTT without feedback group (1.0/1.0 NoFB). The participants who experienced RTT without feedback may be viewed as a control group and it may be seen that their performance improved with practice in the absence of extrinsic feedback; however, this improvement did not appear substantially until the eighth training session. Similarly, one can observe an improvement after initial sessions for the participants in ARTT/FB, but no substantial improvement in later sessions during the 2.0 segment of training. Thus, it seems that during RTT, feedback is not as necessary as during ARTT, although the use of feedback can greatly enhance performance early in training. Also, the use of ARTT may not be suitable for novice pilots early in their training.

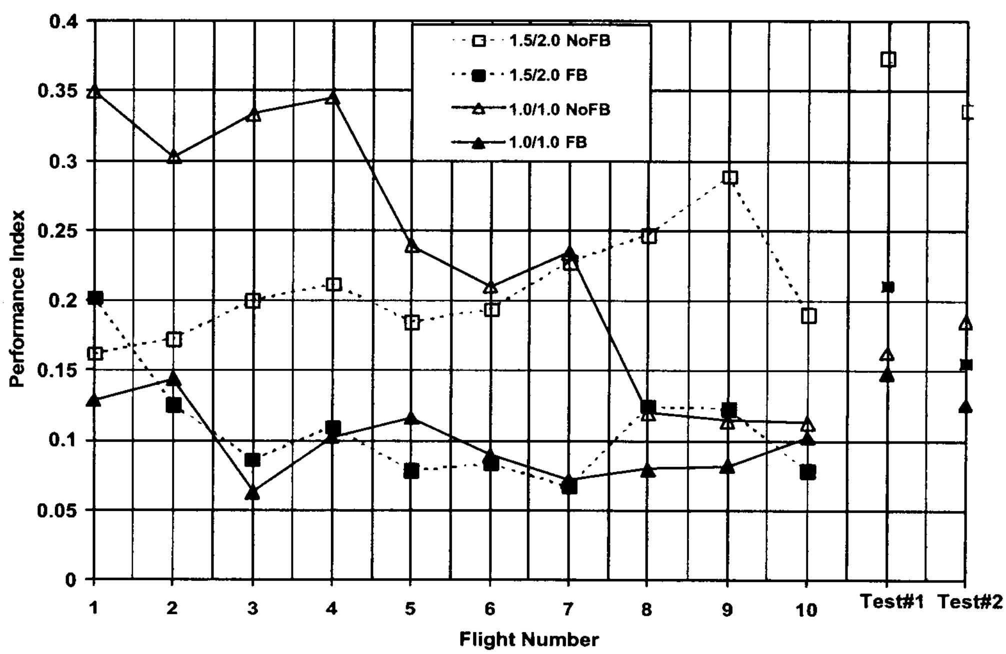

Figure 2.5 Average Performance Index for Each Group for Training and Test Flights. (Decrease in performance index implies improvement in performance).

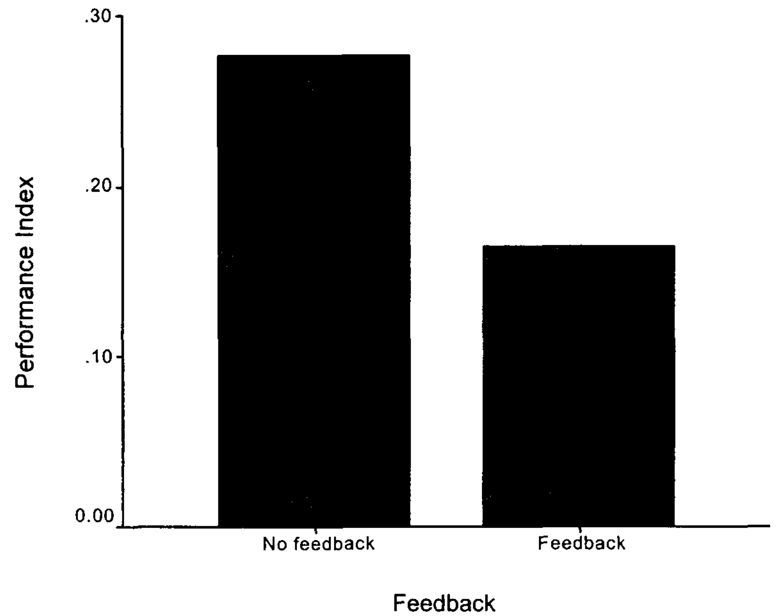

Figure 2.6 Average test performances of Feedback and No Feedback groups. (Decrease in performance index implies improvement in performance.)

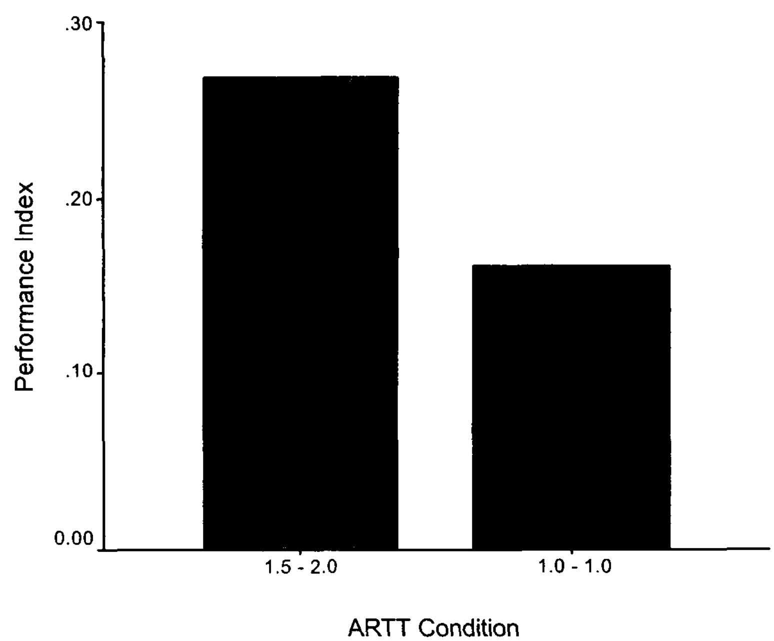

Figure 2.7 Average test performances of ARTT and RTT groups. (Decrease in performance index implies improvement in performance.)

13. CONCLUSION

Two studies were conducted in the context of training of a coordinated level turn on a flight simulator.

In study I, a comparison was made between automated grades of performance with certified flight instructors' grades. The study pointed to the possibility that a comparison between automated and instructor grades may not be valid for novice pilots who have a wide variation in their performance. The study also suggested that novices may exhibit improvements in controlling individual parameters; therefore an overall grade may not capture the incremental improvements.

In study II, the experiment consisted of a 2x2 between subjects factorial design. The first variable was the type of training with two levels being real time training (RTT) and above real time training (ARTT). The second variable was feedback versus no feedback. For training of the level turn, a performance index based on deviations in the bank angle and altitude offered a valid measure to monitor improvement in performance. On the test trials, the participants in the feedback groups performed better than those in the no feedback groups; and participants in the RTT groups performed better than those in the ARTT groups, but the training was accomplished in less clock time for the ARTT groups. If ARTT is to be used for training novices to perform level turns on a simulator, then it should be used in conjunction with appropriate feedback and it should be used after the trainee has attained adequate improvement in performance to have reached a plateau.

14. RECOMMENDATIONS FOR FUTURE WORK

The present two studies addressed the training and measurement of a coordinated level turn using a PC-based flight simulator. Several issues from each study have been raised and may be addressed through future studies.

First, the development of an adequate performance measure to capture flying performance and the improvement of flying performance remains a challenge. In Study I, the automated performance measures involving deviations from prescribed tolerances resulting in GPAs were correlated fairly well with the instructor's grading of such turns. However, the differences between the instructor's grades and the computer grade may be minimized in future studies. In addition, the fact that the two instructors' grades were systematically different from one another and from the computer grade suggests that the measure may not adequately capture the pilot's performance. Also, future studies could determine what factors are being used by the instructors when grading. For example, our analysis suggests that instructors may be focusing on different parameters of the flight.

In study II, the researchers developed a new index to evaluate flying performance that appears to track training progress well. Future work using this new performance index could include:

(i) Evaluation of this index in comparison to certified flight instructors and other performance measures, (ii) using this performance index as an automated feedback measure in the training of various piloting tasks, and (iii) using this performance index and comparing novice pilots to experienced pilots when performing turns and other maneuvers.

The study II also left unanswered several questions. Since participants in the ARTT groups did not perform better than those in the RTT groups there are several possible explanations:

First, the use of ARTT for this maneuver is not effective.Second, the change from 1.5 ARTT to 2.0 ARTT masked improvement in performance.

One might suggest, therefore, that if ARTT is to be used, it should be used as top-off training, i.e., after the pilot has experienced sufficient improvement in performance to have reached a plateau. If ARTT is to be used, that it be used in conjunction with appropriate feedback.

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16.1 INFORMED CONSENT FORM

DEVELOPMENT AND ASSESSMENT OF A NOVEL TRAINING PACKAGE USING SELF INSTRUCTION METHODS AND ABOVE REAL TIME TRAINING (ARTT) FOR BASIC MANEUVERING TASKS ON A FLIGHT SIMULATOR

As an undergraduate student of Tuskegee University, you are invited to participate as a trainee in an experimental research study. The study will develop and evaluate a new program of training on a flight simulator.

Your participation will require approximately two hours of flying on a simulator one day. You will take a seat as a pilot in a mockup cockpit located in the flight vehicle design laboratory on Tuskegee's campus. You will control the flight movements of the joystick, throttle and rudder pedals while watching the flight parameter changes on the simulated instruments panel Heads Up Display (HUD) and the moving icon of the airplane on the computer screens. The available instructor will give you a set of instructions, allow you some time for familiarization and for asking questions, and provide feedback on your performance whenever necessary.

No physical or medical testing risks are involved in the experiment. The experiment, however, is not official pilot training. As a possible risk, some of the simulator flight techniques that you will learn may not be applicable in real flying. Moreover, as it happens in any learning exercise, you may need to overcome temporary disappointments on possible lack of progress in performance, especially when your flight will face a simulated crash.

In general, the training will be an enjoyment and a learning experience. The data provided by you on a survey form and the data on your performance in the training will be coded to protect your confidentiality. Your participation is voluntary and you may withdraw from the experiment at any time. Your participation is voluntary and you may withdraw from the experiment at any time. Your participation, according to your agreed upon schedule, however will be greatly appreciated by investigators.

The successful completion of this research program will be a valuable contribution by Tuskegee University in improving the methods of training pilots on a simulator.

Fro any questions or concerns, please feel free to contact the investigators on campus: Dr. Syed Ali at 727-8853, Dr. Marcia Rossi at 727-8830, or Dr. Muhammad Khan at 727-8637. In the event of an unresolved grievance, you may also contact Dr. Stephen Sodeke, the Chairperson of the Human Subjects Review Committee (HSRC) at 727-8363.

The available investigator will give you a copy of this form to keep. By signing below, you are agreeing to participate in the study.

______________________________	______________________________
Signature of Participant/ Date	Signature of Investigator/ Date

16.2 Background Survey - Turn Study

Code ______

Major ______

Sex: ______ Male

______ Female

Age: ______

Are you: ______ Left Handed

______ Right Handed

Do you have any flight experience?

______ Yes

______ No

If so, how many hours (estimate)?_______

How long ago was your most recent flight training, if any? ______

How many hours a week do you engage in video/ computer games?

______ Light: 0-5 hours

______ Medium: 6-13 hours

______ Heavy: 13 or more hours

What type of video / computer games do you play?

______ Sports

______ Fighting

______ War

______ Cards

______ Flight

______ Mystery

______ Other

What type of controllers do you use?

______ Joystick

______ Control Pad

______ Keyboard

______ Arcade