Improving Performance in Pilot Training by Using the Chair Flying Technique

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ABSTRACT

"Chair flying" is a technique pilots often use to prepare themselves for a mission. Pilots sit on a chair, mentally rehearse the information which they need later, and go through every sequence of their flight. This also includes simulating the movements during the mission such as the work pilots have to do with their arms, hands, and feet as they interact with various controls. Two groups of subjects were given the chance to prepare themselves actively for a simple simulator mission. One group got the opportunity to prepare the mission by using the actual simulator. The other group was asked to use the chair flying technique. Both groups exhibited better performance on the simulator mission compared to a control group who only memorized the instructions. The Chair Flying Group showed less time to accomplish the mission, a more precise take off speed and a better situational awareness than the control group. The results suggest that Chair Flying can be beneficial as a special technique to prepare student pilots for a simple mission.

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INTRODUCTION

Flight training is expensive! This insight is more common sense than the result of thorough research. Thus, it makes a lot of sense to search for ways to improve, reduce, or substitute flight training without reducing its quality and safety. Several studies have shown that using a simulator before starting the actual pilot training was beneficial in several ways. Dennis and Harris (1998) demonstrated that the use of a computer based flight simulator package as an adjunct to ab initio flight training, irrespective of the nature of the control interface to the PC, resulted in superior performance compared to a group receiving no such prior simulation training. Since 1997 even the FAA gives credit to pilots who use certain simulators in pilot training when it is supervised by an instructor (Homan & Williams, 1998). Also in a non-scientific environment and just by experiencing the advantages of PC-based simulators, Heines (2004) described how the US Navy used workstations based on a Microsoft simulator to enhance training for student pilots. Though these are definitely big advantages and mean a lot of cost savings, it is still not possible to make a PC, including Flight Simulator software, available to all student pilots. Additionally, when student pilots have time to practice, they may not have their PC with them to prepare a mission or special maneuvers for the next flight. For that reason, wouldn't it be perfect to have a tool available which offers the same advantages as a PC-based simulator training but without being dependant on a PC or special software? The answer is definitely 'Yes' and the tool which could provide these advantages might be the "Chair Flying Technique".

"Chair flying" is a technique pilots often use to prepare themselves for a mission. They sit on a chair, mentally rehearse the information which they need later, and go through every sequence of their flight. This also includes simulating the movements during the mission using their arms, hands, and feet. Pilots have to move a throttle with the left hand, push rudder pedals with their feet, and move a stick with the right hand. Furthermore, they also must move switches and toggles to regulate engine or weapon systems. Pilots vary considerably in the way they simulate these movements. Some pilots do it without any kind of equipment by imagining the location of controls and then physically moving what they remember to be the correct position. Other pilots use equipment like a broomstick as a stick and a bottle as a throttle.

The obvious advantage of chair flying in contrast to simple mental rehearsal (without physical movements) is the pilot's transfer of knowledge into action. Doing so, the pilot not only memorizes the information but also the corresponding movements in the right sequence. As experienced aviators say, this helps the pilot during real flight to perform better by repeating some things they learned while chair flying.

It is important to distinguish mental practice from chair flying. Terms often used to describe mental practice are: "imaginary practice", "covert rehearsal", "symbolic rehearsal", and "conceptualization" (Lee, 1990; Linden et al., 1989). However, referring to a review from Driskell, Copper, and Moran (1994) mental practice is defined as "a training technique in which the procedures required to perform a task are mentally rehearsed '*in the absence of actual physical movement*'. Studies referring to mental practice were mostly conducted in an athletic environment (Howe, 1991; Lee, 1990). They often showed positive effects in terms of increased task performance, improved concentration, greater self confidence, or better skill acquisition. McDonald (2000) states, that mental practice has the same positive effect on performance as actual physical practice. Only a few studies like the one Shanks & Annabel (2000) conducted showed no effects. None of these studies were done in an aviation related environment. Furthermore none of these studies dealt with "Chair Flying", which has the aspect of physical movements.

This study is meant to be an initial project in the field of Chair Flying. Despite the fact that it is very common among pilots, there is no evidence, guideline, and scientific knowledge on how to apply this technique correctly. There are also open questions as to when Chair Flying is best, whether it would be efficient only for simple mission or for complex scenarios as well as for how long to practice it.

Our main focus with this study was to show that Chair Flying as a preparation technique for a simple aviation related mission could be as efficient as practicing the same mission with a simulator. We hypothesized that subjects with no significant flight experience would perform worse on a simple flight task if they were only able to prepare that mission by reading a written instruction (Memorization Group) compared to a group which had the chance to prepare the mission with the simulator (Simulator Group) and a group which prepared the mission by using the Chair Flying technique (Chair Flying Group). We also hypothesized that the Simulator Group and the Chair Flying Group would show no significant differences in their performance.

METHOD

Participants

Sixty-four participants (53 males/11 females), all volunteers, between the ages of 18 and 23 years old (Mean age = 19.55 years old; SD = 1.17) took part in the experiment. One participant was excluded because of significant previous flight experience, three participants due to non-compliance (one did not read the Operating Handbook, two did not apply the Chair Flying technique). None of the remaining 60 participants had previous significant flight experience, thus, allowing the effectiveness of the three training conditions to be evaluated. Participants were randomly allocated to one of the three groups.

Equipment

The Desktop Simulator System used was a Tower-PC with 700 MHz, Intel III processor and 128 MB RAM. The image was presented on a full-color 17" monitor. This simulator system included a fully functional yoke, a flight simulator control console (Basic v.1.2) and rudder pedals (Figure 1). To keep the flying task as simple as possible we disabled the rudder pedals so that only the yoke and the Control Console could be used. The sound system was also disabled. The system software was Windows XP Professional Version 2002. The flight simulator software used was Flite Pro North America, 1999, V6.2.0. The experiment was conducted in the Air Warfare Laboratory of the United States Air Force Academy.

Experimental Design

The design was an independent groups design, with Memorization Group, Simulator Group, or Chair Flying Group as the independent variable.

Figure 1. Simulator Workstation

Procedure

Prior to the start of the experiment every subject received the Operating Handbook. This Operating Handbook contained information on how to handle and fly the simulator. It did not include information about the mission which was to be flown later. Subjects had been told to study the information and that there would be a short review on the Operating Handbook on the day of the actual experiment.

On the day of the experiment each subject reviewed the Operating Handbook and had the opportunity to ask questions. This took between 3 and 5 minutes. After that review, each subject had the opportunity for 5 minutes to become familiar with the controls by flying the simulator. Figure 2 shows the instrument panel with the instruments the participants used in the experiment. The investigator then gave every subject a handout of the mission and explained it. Then the investigator demonstrated, one time, how to fly the mission on the simulator. This phase took 5 to 10 minutes. The actual experiment began after the demonstration. Every subject had the same information but received different instructions to prepare for the mission depending on the group they were assigned to for the experiment:

a. Memorization group: Subjects got 15 minutes to study the information without having the opportunity to practice it. Each subject was seated away from the simulator so they would not accidentally practice with the controls.

b. Simulator group: Subjects got 15 minutes to practice their mission with the simulator. The subject could remain in front of the PC.

c. Chair flying group: Subjects got 15 minutes to prepare the mission. They studied the instructions and the investigator explained the method of chair flying and how to apply it. Each subject was seated away from the simulator so they would not accidentally practice with the controls while chair flying.

Figure 2. Instrument Panel

Each subject then accomplished the same mission, which was flying the mission they practiced before. They were required to start the mission by moving the throttle to full open. Immediately after this, they had to push the timer button to start the stop watch. At a speed of 72 knots they were instructed to pull the yoke back and lift the airplane off the ground. As soon as they established a climb attitude they had to retract the gear by moving the gear handle on the Control Console in the "up" position. They were then required to establish a specific climb attitude which allowed them to ascent at a speed of 95 knots. Having reached 7000 feet they needed to level off and accelerate to 120 knots. At this point they had to move the throttle back to 2000 revolutions per minute (RPM). By watching the stop watch they now had to hold 7000 feet and 120 knots for 30 seconds. Subsequently, they were required to push the "p" button on the computer keyboard to pause the mission. The data were then saved on a hard disk drive.

Measures

Eight measures of performance were taken out of the data that could be recorded by the simulator software. These measures included the total time which was the time until each subject hit the "p" button and stopped the mission after completing it; take off time, which was the time when the gear left the ground; take off speed which was the speed at the time of take off; gear up time which was the time when the subject retracted the gear; the number of subjects who overshot 120 knots (+10 knots) after reaching 7000 feet (The difference of 10 knots was according to the margin which is used during Pilot training at the Air Force Academy and it is also the limit during the FAA PPL Check ride); the number of subjects who overshot 7000 feet (+50 feet) after the initial climb (The difference of 50 feet was according to the experience in Pilot Training at the Air Force Academy), and the average diversion from 7000 feet and 120 knots during the last 30 seconds of the mission. Overshooting the desired speed of 120 knots after reaching 7000 feet seemed to us a good indicator for the lack of properly distributed attention. Only those who were constantly aware of the situation, who crosschecked their instruments regularly, and not only focused on the altitude but also on the speed, did not overshoot 120 knots. Overshooting 7000 feet seems to be same kind of indicator for situational awareness and distribution of attention as overshooting 120 knots. Due to the fact that the altitude was put in the focus of attention of each subject overshooting 7000 feet played a minor role regarding these criteria. The deviation from 7000 feet and 120 knots during the last 30 seconds of their flight is an indicator for each subject's mission quality.

RESULTS

Treatment of Data

Descriptive statistics as well as a one-way analysis of variance (ANOVA) for independent groups was utilized to analyze the data. Post hoc analyses using Least Significant Difference (LSD) were also conducted. A summary of these analyses is presented in Tables 1 and 2.

Total Time

The mean time for participants to accomplish the mission in the Memorization Group, Simulator Group, and Chair Flying Group as shown in Table 1 were 343.5 seconds (SD = 100.8), 250.8 seconds (SD = 119.5), and 276.5 seconds (SD = 72.0), respectively. Differences among the three groups were statistically significant ($F = 4.64$; $p = .014$). The post hoc analysis (Table 2) showed that there was no significant difference between the Simulator and the Chair Flying Group but the Memorization Group needed significantly more time than the Simulator and the Chair Flying Group ($p < .05$).

Table 1. Means and Standard Deviations for all Dependant Variables

	Memorization Group n = 20		**Simulator Group n = 20**		**Chair Flying Group n = 20**	
Total Time (sec)	343.5	(100.8)	250.8	(119.5)	276.5	(72.0)
Take off time (sec)	18.9	(2.2)	17.0	(3.6)	17.4	(2.3)
Take off speed (knots)	90.5	(5.0)	88.4	(4.0)	87.3	(3.5)
Time Gear up (sec)	75.0	(119.2)	34.1	(44.9)	29.8	(19.0)
Overshooting 120 knots	0.70	(0.47)	0.25	(0.44)	0.35	(0.49)
Overshooting 7000 feet	0.50	(0.51)	0.30	(0.47)	0.50	(0.51)
Deviation 120 knots	4.8	(8.9)	3.4	(4.1)	2.6	(2.1)
Deviation 7000 feet	35.3	(43.8)	22.4	(28.4)	26.2	(29.9)

Note: Standard deviations appear in parentheses.

Table 2. Mean Differences for the Impact of Group Affiliation on the Dependant Variables

	Memorization Group vs. Simulator Group	**Memorization Group vs. Chair Flying Group**	**Simulator Group vs. Chair Flying Group**
Total Time (sec)	92.70*	67.00*	-25.70
Take off time (sec)	1.90*	1.50♦	-0.40
Take off speed (knots)	2.10	3.20*	1.10
Overshooting 120 knots	0.45*	0.35*	-0.10

Note: * Significant at an alpha level < .05; ♦ Significant at an alpha level < .10.

Take Off Time

The mean take off time for the three groups were 18.9 seconds (SD = 2.2) for the Memorization Group, 17.0 seconds (SD = 3.6) for the Simulator Group, and 17.4 seconds (SD = 2.3) for the Chair Flying Group (Table 1). Our analysis showed a marginal significant difference for the main effect in take off time ($F = 2.60$, $p = 0.083$). The post hoc analysis (Table 2) showed that there was a significant difference between the Memorization Group and the Simulator Group ($p < .05$). The difference between the Memorization Group and the Chair Flying Group showed marginal significance ($p < .10$). Simulator Group and Chair Flying Group again showed no significant difference.

Take Off Speed

The mean take off speed (Table 1) for the Memorization Group was 90.5 knots (SD = 5.0), for the Simulator Group it was 88.4 knots (SD = 4.0), and for the Chair Flying Group it was 87.3 knots (SD = 3.5). Our analysis showed a marginal significant difference for the main effect in take off speed ($F = 2.98$, $p = 0.059$). The post hoc analysis (Table 2) demonstrated a significant difference between the Memorization Group and the Chair Flying Group ($p < .05$). Memorization Group and Simulator Group as well as Simulator Group and Chair Flying Group showed no significant difference.

Time Gear Up

The mean time the subjects needed to retract the gear was 75.0 seconds (SD = 119.2) for the Memorization Group, 34.1 seconds (SD = 44.9) for the Simulator Group, and 29.8 seconds (SD = 19.0) for the Chair Flying Group (Table 1). Our analysis did not show a significant main effect among the three groups for retracting the gear ($F = 2.251$, $p = 0.115$).

Overshooting 120 Knots

Every subject which overshot 120 knots after reaching 7000 feet by at least 10 knots was counted. The mean number of subjects who overshot in the Memorization Group was 0.70 (SD = 0.47), 0.25 (SD = 0.44) in the Simulator Group, and 0.35 (SD = 0.49) in the Memorization Group (Table 1). Differences among the three groups were statistically significant ($F = 5.092$, $p = 0.009$). The post hoc analysis (Table 2) showed a significant difference between the Memorization Group and the Simulator group as well as between the Memorization Group and the Chair Flying Group ($p < .05$). Simulator Group and Chair Flying showed no significant difference.

Overshooting 7000 feet

Every subject which overshot 7000 feet after the initial climb by at least 50 feet was counted. The mean number of subjects who overshot in the Memorization Group was 0.50 (SD = 0.51), 0.30 (SD = 0.47) in the Simulator Group, and 0.50 (SD = 0.51) in the Chair Flying Group (Table 1). Our analysis showed no significant difference for this performance variable ($F = 1.07$, $p = 0.35$).

Deviation 120 knots and 7000 feet

The most important part of the instruction was to keep 7000 feet and 120 knots for 30 seconds and then press the 'p' button to stop the mission. Therefore we calculated the absolute difference from 120 knots and 7000 feet during the last 30 seconds to get a measure which showed how exact each subject had flown the mission. The software only allowed us to get an altitude or speed every two seconds so that we had a total of 15 measurements for the last 30 seconds. The mean deviation from 120 knots was 4.8 knots (SD = 8.9 knots) in the Memorization Group, 3.4 knots (SD = 4.1 knots) in the Simulator Group, and 2.6 knots (SD = 2.1 knots) in the Chair Flying Group (Table 1). Our analysis did not show any significant differences among the three groups for this performance variable ($F = 0.69$, $p = 0.506$).

The mean deviation from 7000 feet was 35.3 feet (SD = 43.8 feet) in the Memorization Group, 22.4 feet (SD = 28.4 feet) in the Simulator Group, and 26.2 feet (SD = 29.9 feet) in the Chair Flying Group (Table 1). Our analysis of the main effects and post-hoc analysis did not show any significant differences ($F = 0.732$, $p = 0.486$).

DISCUSSION

The results show that Chair Flying can be an effective preparation technique for a simple aviation related mission. Overall, the best performance was observed in the Simulator Group, followed by the Chair Flying Group and then the Memorization Group. Specifically, the two most sensitive measures in performance differences were total time and overshooting 120 knots.

When designing the experiment, we needed a measurement which had the potential to indicate whether mission quality was the same among the three groups. We decided to take the deviations from 120 knots and 7000 feet during the last 30 seconds of the mission as an indicator of quality because the main goal to accomplish as described in the instructions was to keep 7000 feet and 120 knots for 30 seconds and then stop the mission. Regarding the deviations from the given speed and altitude during the last 30 seconds of the mission, the small difference in values indicate that the quality of the mission accomplishment by all three groups was the same. With that given as a fact we focused our attention on the other performance data.

One of our hypotheses was that the Chair Flying Group and the Simulator Group would be statistically different from the Memorization Group. The results showed this difference to be true for some variables (total time and overshooting 120 knots). The Memorization Group needed the most time to accomplish the mission in the same quality as the Simulator and the Chair Flying Group. Regarding the individual mission characteristics it became clear that subjects in the Memorization Group oscillated more around the given altitude and speed than both other groups. In other words they did not fly as exactly as the Simulator Group and Chair Flying Group. In most cases, this caused the longer processing time. It is very common among student pilots during the initial stages of pilot training that they focus only on one variable in flight instead of paying attention to several necessary instruments. In our experiment many subjects focused on the altitude they were supposed to reach and they forgot about the right speed which was as crucial as the right altitude. Only those who had a sufficient distribution of attention and situational awareness were

able to keep both variables under control. These statements were supported by the fact that there were no differences between the three groups regarding the number of subjects who overshot 7000 feet. On the other hand, the number of subjects who overshot 120 knots after reaching the assigned altitude of 7000 feet was highest in the Memorization Group. As Koonce and Brambe (1998) stated, simulator training does not necessarily enhance the physical fidelity but improves the transfer of underlying cognitive principles. Measurements such as take off time and take off speed which are more closely related to motor skills weren't as sensitive as the total time and overshooting 120 knots. It seems as if only memorizing an instruction leads to a superficial understanding of what to do. Chair Flying as well as preparation with a real simulator appears to generate a deeper understanding of the mission and the corresponding actions to take.

Another hypothesis was that the Simulator Group and the Chair Flying Group were equally qualified to prepare subjects for a simple aviation related simulator mission. In our study, we didn't find any statistical differences between the Chair Flying Group and the Simulator Group. Furthermore, Dennis and Harris (1998) showed that PC based training could be beneficial in the initial stages of pilot training. Dennis and Harris compared a group who had no computer based training to one group who used a computer with a representative set of flight controls and another group who used a computer controlled by cursor and function keys. These two computer groups showed superior performance in real aircraft performing basic flying maneuvers. Our study adds some additional information, showing that Chair Flying can be equally effective in preparing for a simulator mission. What is not known is whether Chair Flying can be equally effective as PC-based simulators for preparing for a real mission. This question should be verified by further research, where the efficiency of Chair Flying is evaluated in a real flying environment.

CONCLUSION

As we found out during many discussions about Chair Flying and pilot training, almost every instructor pilot recommended Chair Flying to his students but most of the time there was an insufficient explanation of how to use the technique and/or the benefits associated with such a technique. Despite the fact that most military pilots and a significant number of private pilots have been convinced of the efficiency of Chair Flying prior to this study, this was, as far as we could find out, the first study to examine such a comparison. Furthermore, this initial study could lead the way to a better understanding of the underlying principles of Chair Flying as well as how to apply it the most efficient way. It might also contribute to the questions Salas et al. (1998) asked, whether there are some misconceptions or invalid assumptions in the simulation community which make them rely on high-fidelity simulation instead of focusing on individual and team training and cognition. Additional questions which should be answered by doing more research on that topic include:

- How long should a Chair Flying session be?
- When is the best time to do Chair Flying referring to the mission to be accomplished?
- Is Chair Flying a learning technique to use for preparing complex missions?
- Does it help to use a cockpit poster while applying the Chair Flying technique?

Furthermore, this learning technique has the potential to be applied in other fields. Vehicle operators could benefit from the physical and mental rehearsal techniques found in Chair Flying, especially in the military environment. A further area might even be surgery training. In many cases, surgeons need some of the same cognitive and physical skills pilots have to work successfully. For example, procedures such as endoscopic surgical training can benefit from a learning technique which combines mental rehearsal with actual physical movements. The techniques used in Chair Flying could be a helpful tool for this profession to improve the quality of their work.

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REFERENCES

Driskell, J.E., Copper, C. & Moran, A. (1994). Does mental practice enhance performance? *Journal of Applied Psychology*, 79, 481-492.

Glass, G.V., Hopkins, K.D. (1996). Statistical methods in education and psychology (3rd ed.). Boston: Allyn and Bacon.

Heines , V. (2004). Low-end simulation. Armed Forces Journal, 20-21.

Homan, W., Williams, K. (1998). PC-based flight simulators: No more games. Tech Directions, 58(2), 33-36.

Howe, B.L. (1991). Imagery and sport performance. Sports Med, 11, 1-5.

Keppel, G. (1991). Design and Analysis. A Researcher's Handbook (3rd ed.). New Jersey: Prentice Hall.

Kerry, A.D., Harris, D. (1998). Computer –Based Simulation as an Adjunct to Ab Initio Flight Training. The International Journal of Aviation Psychology, 8(3), 261-276.

Koonce, J.M., Bramble, W.J. (1998). Personal Computer-Based Flight Training Devices. The International Journal of Aviation Psychology, 8(3), 277-292.

Lee, C. (1990). Psyching up for a muscular endurance task: Effects of image content on performance and mood state. Journal of Sport and Exercise Psychology, 12, 66-73.

Linden, C.A., Uhley, J.E., Smith, D. & Bush, M.A. (1989). The effects of mental practice on walking balance in elderly population. The Occupational Therapy Journal of Research, 9, 155-169.

McDonald, T. (2000). Picture Perfect. Successful Meetings, 49, 22.

Salas, E., Bowers, C.A., Rhodenizer, L. (1998). It is not how much you have but how you use it: Toward a rational use of simulation to support Aviation Training. The International Journal of Aviation Psychology, 8(3), 197-208.

Shanks, D.R. & Annabel, C. (2000). The effect of mental practice on performance in a sequential reaction time task. Journal of Motor Behavior, 32, 305-313.