

The Effectiveness of a Pinch Hitter Video in Helping Non-Pilots Survive a Pilot Incapacitation Emergency

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ABSTRACT

The goal of this research project was to determine the survival prospects of non-pilot passengers in light aircraft if the pilot suddenly became incapacitated. Specifically, two groups were studied; one that had no prior exposure to aircraft control, and one that viewed the Air Safety Foundation's Pinch Hitter Course. Thirteen Middle Tennessee State University students with no previous flight training were divided into an experimental group and a control group. After the experimental group had viewed the Pinch Hitter Course, each participant was placed into a flight training device with a pilot. The pilot conducted a take-off and flew normally for several minutes. At a predetermined point, the pilot simulated incapacitation, and the subject attempted to control and land the aircraft to the best of his or her ability. The results of the simulation were analyzed to determine if the experimental group more successfully controlled the aircraft, manipulated the radios, and navigated the aircraft. Additionally, the attitude and speed of the aircraft when it returned to Earth were used to determine each subject's probability of survival. The researcher hypothesized that there would be no difference between the two groups as to survivability. Results indicated that, though the experimental group was noticeably better at controlling the aircraft and had a lower average airspeed during touchdown than the control group, the video made no difference in overall survivability.

INTRODUCTION

While it is rare, general aviation pilots do occasionally become incapacitated during flight. Acute medical problems such as heart attack, stroke, and seizure are the most common causes of incapacitation amongst pilots (NTSB, 2008). According to the Aircraft Owners and Pilots Association (AOPA), general aviation accidents related to pilot incapacitation are very rare events. The AOPA states that medical incapacitation was responsible for only about .25% of all general aviation accidents between 1995 and 2004. During the same time period, medical incapacitation was found to be a probable cause in only 1.03% of fatal general aviation accidents (AOPA, 2007).

In 2007, the Australian Transport Safety Bureau released a study on pilot incapacitation in Australian civil aviation. This study sought to investigate the prevalence, type, nature, and significance of pilot incapacitation events that occurred in Australia between 1975 and 2006. They found a total of 98 occurrences. Interestingly, only 16 of the 98 occurrences were accidents; the other 82 were classified as incidents. These 98 accidents and incidents accounted for only 0.6% of all accidents and

incidents that occurred during that time frame. Ten of the occurrences resulted in a fatal accident (Australian Transport Safety Bureau, 2007)

A review of the National Transportation Safety Board's accident database has found that, since 1990, pilot incapacitation has been found as the probable cause of 32 general aviation accidents. Most of these involved a single-pilot operation and resulted in at least one fatality. The 2006 Nall Report, which reports yearly general aviation accident statistics, lumps pilot incapacitation accidents together with accidents where a probable cause could not be determined. The report states that, in 2005, these accidents accounted for 8.9% of all accidents and 9.6% of fatal accidents. The number of accidents directly attributable to pilot incapacitation is not reported (AOPA, 2006). The AOPA posits that the low rate of pilot incapacitation events is primarily due to the FAA's sanctioned medical examination that all pilots must pass at least once every three years. The requirements and standards of the medical exam increase proportionally to a pilot's age and flying responsibilities (AOPA, 2007). Still, pilot

incapacitation emergencies do occasionally happen, and they are often fatal (NTSB, 2008).

Common Causes of Pilot Incapacitation

Of the 32 pilot incapacitation related general aviation accidents that occurred in the U.S. between 1990 and 2007, the vast majority (23) were caused by an acute cardiovascular event. Other lesser causes included gastrointestinal illnesses, seizures, brain tumors, dehydration, and incapacitation due to fumes entering the cockpit (NTSB, 2008). The Australian Transport Safety Bureau's study found that the most common cause of pilot incapacitation (21% of the total cases) was gastrointestinal problems; most of these occurrences were the result of food poisoning. Fortunately, most of these instances did not result in a crash. The next most common cause was exposure to toxic fumes. These occurrences accounted for 12% of the total cases. Of these, 25% were the result of carbon monoxide poisoning. A total of eight cases of incapacitation were due to heart attack, and five of these resulted in a fatal accident. Other identified causes were loss of consciousness and head injury (Australian Transport Safety Bureau, 2007).

Cases of Non-pilots Landing Aircraft

There are very few reported cases of a non-pilot successfully landing an aircraft following a pilot incapacitation. The Australian Transport Safety Bureau found only one case in the 98 cases that it studied. The one case involved a non-pilot successfully landing an aircraft following the pilot becoming incapacitated due to a minor heart attack. While the pilot was not able to fly the aircraft, he was able to provide intermittent help and instruction (Australian Transport Safety Bureau, 2007). A review of the NTSB database revealed only one instance in the previous 20 years where a non-pilot took over the controls of an aircraft during an incapacitation emergency (NTSB, 2008).

On June 17, 1998, the pilot of a Cessna 172 became incapacitated five minutes into a flight from Muncie, Indiana. The pilot's incapacitation and subsequent death was later determined to have been caused by a heart condition. Following the incapacitation, the passenger, an 81-year old non-pilot, took control of the

aircraft. He held the aircraft in straight-and-level flight, and immediately began transmitting his need for help over the radio. The non-pilot's calls for help were answered by another pilot operating a Piper PA-28 in the area. The pilot, who was commercial-rated, contacted Indianapolis approach and asked them for the location of the Cessna. He then intercepted the Cessna while staying in constant contact with the non-pilot. After locating the Cessna, the PA-28 pilot explained the basics of aircraft control and had the non-pilot make a series of climbs, descents, and turns. The PA-28 pilot then escorted the Cessna to the nearby Mount Comfort Airport. Concurrently, the pilot informed air-traffic control (ATC) of his plan so that emergency responders could be on the scene. After the non-pilot became somewhat comfortable maneuvering the aircraft, the PA-28 pilot had him make three increasingly lower practice approaches to the airport. On the fourth approach, the non-pilot was instructed to pull the throttle to idle and hold back on the yoke. The Cessna touched down about 700 feet past the approach end of the runway and on the runway centerline. The aircraft landed on its nosewheel causing that wheel to collapse and the propeller to strike the runway. Despite the damage to the aircraft, the non-pilot was uninjured (NTSB, 1998).

Statement of the Problem

The concerns of passengers who typically travel in small, single pilot aircraft have prompted the creation of many "pinch hitter" courses throughout the years. These courses are designed to give non-pilots basic instruction on aircraft control so that they can take over for the pilot if necessary. Most of these courses involve a classroom component as well as some actual flight training. For those not inclined or able to participate in a "hands-on" course, the Aircraft Owners and Pilots Association Air Safety Foundation (ASF) has developed a DVD Pinch Hitter Course. This 45-minute video is marketed to general aviation passengers who are concerned that their pilot could become incapacitated. While the course presents relevant information, its effectiveness in teaching a non-pilot how to deal with a pilot incapacitation emergency has not been studied. The purpose of

this study was to determine how successfully non-pilots deal with pilot incapacitation in light aircraft, and specifically if the ASF Pinch Hitter DVD course had a significant effect on a non-pilot's chances of surviving a pilot incapacitation emergency. The study also sought to determine if, prior to the study, the participants felt prepared to deal with a pilot incapacitation emergency, and if experiencing the simulation changed their opinions.

The AOPA/ASF Pinch Hitter Course

On its website, Sporty's Pilot Shop states that the ASF Pinch Hitter Course is intended for non-pilots who "want to know more about flying and learn how to control and land an airplane" (Sporty's, 2008). This course aims to teach non-pilots the basics of attitude flying, cockpit instrumentation, landing procedures, and pilot incapacitation emergency procedures in 45 minutes. The course, which was created by the Air Safety Foundation, begins by covering the standard practices and procedures of a normal flight in a small aircraft. Each phase of flight is covered in the order that it would happen on an actual flight starting with the preflight and ending with the landing. During each phase of flight, topics pertinent to that phase of flight are discussed (Air Safety Foundation, 2007).

The course begins by using the preflight phase of flight to explain the basic components of an aircraft. During the cruise portion of the flight, basic aircraft control is discussed. This includes an overview of how to achieve level flight, how to initiate climbs, descents, and turns, how to use the throttle, how to trim the aircraft, and how to maneuver using outside references. Next, aircraft instrumentation is discussed. In this section, each of the basic flight instruments is described and explained. The non-pilot is given basic instruction on how to read and interpret the attitude indicator, the airspeed indicator, the altimeter, the compass, and the heading indicator. Radio and transponder operation is also discussed in this section. The landing portion of the flight teaches the basic concepts of landing an aircraft. Throttle manipulation and attitude control are stressed in this section.

After the explanatory flight, specific instruction is given on how to handle an

incapacitation emergency. An eight-step checklist for dealing with the situation is presented. According to the course, the first step is to remain calm and take control of the aircraft. The second step is to hold straight-and-level flight and trim the aircraft if necessary. The third step is to get the pilot away from the controls if he or she is leaning on the controls. Step four involves trying to communicate on 121.5 MHz, the emergency frequency. Step five is to enter 7700 in the aircraft's transponder. Step six reminds the non-pilot to tell ATC what is happening and to follow their advice. The penultimate step is not to worry about damaging the aircraft. Finally, step eight is a reminder to stay calm (Air Safety Foundation, 2007).

METHODOLOGY

Participant Selection

All of the study participants were students at Middle Tennessee State University (MTSU). Any student who had received no previous flight training was eligible for the study. All prospective participants were briefly interviewed before the study to determine their level of experience with aviation. An effort was made to have an equal number of males and females. A total of 13 students participated in the study. Seven of them were male and six were female.

The Flight Training Device

The flight training device used during the simulated flight was a Frasca Diamond DA-40 flight training device (FTD). It is a level six FTD. It has a realistic cockpit that accurately represents the Diamond DA-40, which is a single-engine, four seat training aircraft. The FTD is equipped with a full Garmin 1000 glass cockpit system and an autopilot. Frasca's Truvision visual system with a 220 degree wraparound screen provides an accurate visual representation of Murfreesboro Municipal Airport and the surrounding area.

The Experiment

The experimental group participants were taken to a room where they watched the DVD course on a laptop computer. They were told to pay careful attention to the video. Two participants watched each time the video was shown. The participants were told that they

could discuss the topics covered by the video with each other. While the experimental group was watching the course, the members of the control group each took part in the simulated flight. No participant was allowed to watch another group member fly the FTD prior to his or her own flight. The members of the experimental group were given their turn in the FTD within 30 minutes following the conclusion of the DVD course.

Methodology for the Simulated Flight

Each simulated flight began on runway 36 at Murfreesboro Municipal Airport. The participant was seated in the right seat of the simulator and a licensed pilot was seated in the left seat. At the beginning of the flight, the pilot briefly explained the nature of the flight as a local pleasure flight. The pilot then started the aircraft and briefly explained the procedures that he was using as he performed a standard take-off and climb. The pilot flew the runway heading until he reached 1000 feet AGL. The pilot then made a turn to the east and continued his climb to 2500 feet AGL. Prior to reaching 2500 feet, the pilot turned the aircraft towards the airport so that the participant had a chance to see it. After the participant acknowledged seeing the airport, the pilot continued on a generally eastbound heading. When the aircraft was about two miles east of the airport and at 2500 feet AGL, the pilot reduced power for cruise flight. Shortly afterwards, the pilot stated that he just had a heart attack and was incapacitated. The subject was told to do the best he or she could to land the aircraft. No further help or instruction was given by either the pilot or the investigator.

Evaluation of the Simulated Flight

Participants were evaluated on whether they performed certain critical tasks. The tasks closely corresponded to the DVD course's pilot incapacitation emergency checklist. The evaluation sheet (Appendix A) was composed of five questions about the subject's ability to control the aircraft in the air, five questions about the subject's attempts to communicate with air traffic control, two questions about the subject's willingness and ability to navigate to an airport, and four questions about the subject's landing attempt. The final question asked if the landing appeared survivable. The attitude and

airspeed of the aircraft when it impacted the ground were used to determine survivability. Any impact that occurred at an airspeed of 90 knots (103 MPH) or greater was considered not survivable. Survivability was the major test metric used to determine the video's overall effectiveness.

The Surveys

Two Likert scale surveys (Appendix B and C) were given to each subject. The first survey was administered to the participants before they experienced their simulated flight. It posed two questions about the subject's comfort with and knowledge of small aircraft and one question about the subject's perceived ability to deal with a pilot incapacitation emergency. The post-experiment survey was given immediately at the conclusion of the subject's simulated flight. It asked the same questions as the pre-experiment survey. The surveys were given to see if the subject's responses changed as a result of their experience in the FTD. The subjects who watched the DVD course were also asked how well they felt that the DVD course prepared them to take control of the aircraft. To evaluate the survey, each of the five possible responses was assigned a value. The most negative response for a given question, very uncomfortable or very low, was assigned a value of one, and the most positive response, very comfortable or very high, was assigned a value of five. This allowed a mean to be taken of the responses for each question, which created easily comparable data. T-tests were performed to see if the two group's responses differed significantly on any of the pre-treatment questions. The results of the tests showed no significant difference on any of the questions (question 1: $t(9)=-.70$, $p=2.26$, question 2: $t(10)=-.77$, $p=2.22$, question 3: $t(10)=-.44$, $p=2.23$). The responses to the qualitative question that asked about the effectiveness of the pinch hitter course were used to determine if the participants had a generally favorable or unfavorable opinion of the course.

RESULTS

Table 1 compares the two groups of participants based on the extent to which they were able to control the aircraft, navigate, and

communicate with ATC. It is interesting to note that both groups performed at essentially the same level. Some differences between the control group and the experimental group were seen regarding the participants' ability to manipulate the throttle and to hold straight-and-level flight. A Fisher Exact Probability Test was performed for throttle use at the .10 level of significance, and a significant difference was found between the control group and the experimental group, $F(1), P=.0699$. Another Fisher test was used to determine what difference existed between the two groups regarding the participants' ability to hold straight-and-level flight at the .10 level of significance; no significant difference was found, $F(1), P=.5594$. None of the participants were able to successfully operate the aircraft's radio or the transponder. Every participant took control of the aircraft and made an attempt to navigate back to Murfreesboro Airport using pilotage. Several also attempted to interpret the global positioning system with varying degrees of success. No participant attempted to navigate to another airport.

Table 1. *Comparison of Participant Groups: Aircraft Control, Navigation, and Communication*

Evaluation criteria	Control group		Experimental group	
	Yes	No	Yes	No
Did the subject take control of the aircraft?	7	0	6	0
Did the subject hold straight-and-level?	4	3	5	1
Did the subject trim the aircraft?	0	7	0	6
Did the subject maneuver the aircraft?	5	2	6	0
Did the subject manipulate the throttle?	3	4	6	0
Did the subject try to contact ATC?	0	7	1	5
Did the subject squawk 7700?	0	7	0	6
Did the subject try to navigate to an airport?	7	0	6	0
Did the subject attempt to land the aircraft?	7	0	6	0

Table 2 shows the results pertaining to the participants' landings. While no difference was observed between the two groups regarding whether the landing took place on a runway or whether the landing was survivable, the experimental group landed an average of 18.26 knots slower than the control group. A t-test was done at the .05 level of significance to evaluate whether this difference in landing speed was statistically significant. No significant difference was found, $t(10)=.978, p=1.81$. Interestingly, all

of the survivable landings occurred on the runway, though the fact that a landing occurred on a runway was not a factor in determining the landing's survivability. Four unsurvivable landings also occurred on the runway. Intuitively, the experimental group's slower touchdown airspeed should have led to a greater probability of survivability; however, the results of this experiment do not support that idea.

Table 2: *Comparison of Participant Groups: Landing, Airspeed, and Survivability*

Evaluation criteria	Control group		Experimental group	
	Yes	No	Yes	No
Did the landing occur on a runway?	4	3	4	2
Did the landing appear survivable?	2	5	2	4
Average airspeed during touchdown (knots)	122.43		104.17	

Survey Results

The survey results indicated that the simulation experience did not change the participants' perceived comfort level with small aircraft. T-tests of the post-treatment survey revealed that, just as in the pre-treatment survey, there was no significant difference between the two group's responses to any of the questions (question 1: $t(11)=.61, p=2.20$, question 2: $t(11)=.87, p=2.20$, question 3: $t(10)=.11, p=2.22$). Furthermore, additional t-tests were done to determine if the simulation experience significantly changed either group's responses to any of the three questions. These six t-tests compared each group's pre-treatment response with their post-treatment response to the three questions. The t-tests revealed no significant change for either group on any question. While not statistically significant, a slight change in the mean response of both groups to questions two and three was recorded. Table 3 shows the pre-treatment and post-treatment mean response to each question.

Table 3: Mean Response to the Pre-treatment and Post-treatment Survey Questions

Question	Control group		Experimental group	
	Pre-treatment mean	Post-treatment mean	Pre-treatment mean	Post-treatment mean
Question 1	3.29	3.83	3.29	3.83
Question 2	1.86	2.17	2.00	2.50
Question 3	1.86	2.17	2.43	2.33

The participants who watched Air Safety Foundation's course were asked how well the

course prepared them to take control of the aircraft during a pilot incapacitation emergency. The answers were mostly positive. In general, the participants felt that the course explained aircraft control well. The negative comments suggested that the course was not specific enough and included unnecessary information. Table 4 gives the participants' comments.

Table 4: *Participants' Comments Regarding the Pinch Hitter Course*

Positive	Negative
Gave me info, but it's so much different actually flying a plane.	Not that great, I would need to watch it about 20 times and pay closer attention.
I feel it helped me gain knowledge of flight controls.	It had a lot of unneeded information. I thought, if the pilot was incapacitated and the video was specifically for that situation, it has too much information.
Good enough to be able to control the plane	
I think it gives you the basics you need to be able to land a small aircraft.	

DISCUSSION

The results of the simulated flight tests seem to indicate that non-pilots are not likely to survive a pilot incapacitation emergency. In addition, the ASF Pinch Hitter Course did not affect a non-pilot's ability to survive such a situation. Despite the fact that the video had no effect on overall survivability, the results indicated that it did slightly improve the participants' ability to control the aircraft. The experimental group was statistically more likely to manipulate the throttle. They also landed at an average airspeed that was almost 20 knots slower than the control group.

Even though the value of communication was stressed in the course, the experimental group did not show an increased ability to communicate their situation to ATC. No participant in either group successfully contacted ATC by radio or by placing 7700 in the transponder. One experimental group participant unsuccessfully tried to use the radio to call for help. She even mentioned after the flight that she had learned about the aviation emergency frequency, 121.5 MHz, from the video. Unfortunately, she could not figure out how to dial the radio while maintaining control of the aircraft.

Overall, failure to properly use the aircraft's throttle was the leading cause of fatal

crashes in this simulation. All of the participants who crashed either improperly used the throttle or did not attempt to manipulate the throttle at all. This led the participants to attempt to land at an average airspeed of 113.3 knots, which is 43.3 knots faster than the recommended touchdown airspeed (70 knots) for the aircraft. In contrast, all of the successful participants manipulated the throttle and landed at a slower airspeed. The average touchdown airspeed of survivors was 74.5 knots.

Limitations of the Simulation

Two factors that would be present in a real pilot incapacitation emergency could not be simulated in this experiment. First, participants could not feel the g-forces that their maneuvering was placing on themselves and the aircraft. This led the participants to make some unrealistic maneuvers such as diving and climbing at very high airspeeds. In real life, these maneuvers would have been very disconcerting and uncomfortable. A future study could produce a more realistic simulation by using a full motion flight simulator that is capable of simulating the effects of abrupt, high-speed maneuvering on the human body. The second, and most important, factor that could not be simulated was the emotion that a non-pilot would feel if he or she were forced to take control of an aircraft. While participants took the simulation seriously, they knew that, in reality, they were in a FTD and could not be harmed. In a real pilot incapacitation, the non-pilot would quickly realize that his or her life was in grave danger. This would obviously affect performance. If the non-pilot panicked, that could have a crippling affect on his or her ability to land the aircraft. Finally, a small number of participants were used in this study due to budget and time constraints. In order to strengthen the validity of the results, the study would need to be repeated with a larger number of participants.

Recommendations

Based on the results of the simulation and the participants' comments, the Air Safety Foundation's Pinch Hitter video might have been more helpful if it had focused more time on the specifics of dealing with a pilot incapacitation emergency. Since these results indicate that the

video course alone does not adequately prepare non-pilots to control and land an aircraft, non-pilots who desire the ability to land an aircraft need to seek out additional training. Furthermore, future pinch hitter course videos should place more emphasis on airspeed control. Non-pilots need to know that slowing the aircraft down is crucial to surviving a landing. If a small aircraft is landed at a level attitude and at an appropriate airspeed, the chances for survival are fairly good.

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APPENDIX A

Pilot Incapacitation Evaluation Sheet

- 1) State the altitude and location of the incapacitation.

- 2) Did the subject take control of the aircraft? Yes ___ No ___
 - 2-A) Did the subject hold straight and level? Yes ___ No ___
 - 2-B) Did the subject attempt to trim the aircraft? Yes ___ No ___
 - 2-C) Did the subject attempt to practice maneuvering the aircraft? Yes ___ No ___
 - 2-D) Did the subject practice manipulating the throttle? Yes ___ No ___

- 3) Did the subject attempt to communicate with ATC? Yes ___ No ___
 - 3-A) Did the subject transmit on the frequency that the pilot had been using? Yes ___ No ___
 - 3-B) Did the subject attempt to communicate on 121.5? Yes ___ No ___
 - 3-C) Did the subject enter 7700 in the transponder? Yes ___ No ___
 - 3-D) If ATC assistance was given, was the subject able to follow the *instructions*? Yes ___ No ___

- 4) Did the subject attempt to navigate to an airport? Yes ___ No ___
 - 4-A) If yes, How did the subject attempt to navigate?

- 5) Did the subject attempt to land the aircraft? Yes ___ No ___
 - 5-A) Did the landing take place on a runway? Yes ___ No ___
 - 5-B) Describe the landing.
 - 5-C) Note the aircraft's airspeed and attitude during landing.

Airspeed _____ Attitude _____
 - 5-D) Did the landing appear survivable? Yes ___ No ___

APPENDIX B

Pre-Treatment Survey Questions

1. How comfortable do you feel about the prospect of flying in a small aircraft?

Very Comfortable Comfortable Not Very Comfortable Uncomfortable Very Uncomfortable

2. How would you rate your current knowledge of flight in small aircraft?

Very High High Some Knowledge Low VeryLow

3. If you were a passenger in a small aircraft and the pilot was incapacitated, how comfortable would you be dealing with the situation?

Very Comfortable Comfortable Not Very Comfortable Uncomfortable Very Uncomfortable

APPENDIX C

Post Treatment Survey Questions

1. How comfortable do you feel about the prospect of flying in a small aircraft?

Very Comfortable Comfortable Not Very Comfortable Uncomfortable Very Uncomfortable

2. How would you rate your current knowledge of flight in small aircraft?

Very High High Some Knowledge Low Very Low

3. If you were a passenger in a small aircraft and the pilot was incapacitated, how comfortable would you be dealing with the situation?

Very Comfortable Comfortable Not Very Comfortable Uncomfortable Very Uncomfortable

4. How well do you feel the Pinch-Hitter training course prepared you to take control of a small aircraft if the pilot was incapacitated?