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ABSTRACT

As part of the Army's effort to use synthetic devices to improve training, researchers evaluated a captive helicopter attached to a ground effects machine. Experimental groups received varying amounts of pre-flight practice tasks designed to develop flight skills, while control groups received no device training. Student flight performance during the 85 hour primary helicopter training program provided criterion measures. Significant results included that: 1) the attrition from flight training for the experimental groups was lower; 2) experimental groups required less time to qualify for solo flight; 3) experimental groups received higher grades from flight instructors; 4) individual performance on the device correlated positively with subsequent flight training performance; and 5) the flight experience of the device instructor did not affect student flight performance. It was concluded that the device lowered student failures, improved their performance, and served as a predictor of student flight proficiency levels. (PB)

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Technical Report 68-9

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The Captive Helicopter as a Training Device: Experimental Evaluation of a Concept

by

Paul W. Caro, Jr., Robert N. Isley, and Oran B. Jolley

HumRRO Division No. 6 (Aviation)

June 1968

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The George Washington University
HUMAN RESOURCES RESEARCH OFFICE

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DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT
WASHINGTON, D.C. 20310

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3 July 1968

SUBJECT: The Captive Helicopter as a Training Device: Experimental Evaluation of a Concept

TO: DR. WALLACE W PROPHET
DIRECTOR OF RESEARCH
HUMRRO DIVISION NO. 6 (AVIATION)
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1. This report describes training research conducted to explore the value of a captive helicopter attached to a ground effects machine as a synthetic flight training device for primary helicopter training. Performance on the device as a predictor of subsequent performance in the aircraft phase of training was also studied.

2. Students were divided into two experimental groups receiving differing hours of training on the device, and a control group receiving no device training. During subsequent flight training, the device-trained students performed better and fewer of them failed for reasons of flight deficiency. It was also found that performance during flight training was predictable from performance on the device.

3. This report should be of interest to personnel involved in synthetic devices for aviation training, to personnel in Army aviation training, and to those interested in methods of training.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

1 Incl
as

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HumRRO Division No. 6 (Aviation)
Fort Rucker, Alabama
The George Washington University
HUMAN RESOURCES RESEARCH OFFICE

Technical Report 68-9
Work Unit ECHO
Sub-Unit II

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FOREWORD

The overall objectives of Work Unit ECHO are to survey and evaluate current synthetic flight training in Army aviation; to determine experimentally the value of selected flight training devices; and to establish guidance for the development and effective utilization of flight training devices in present and future aviation training curricula. Activities directed toward these objectives were begun by the Human Resources Research Office in FY 1964 at Fort Rucker, Alabama.

In Sub-Unit I, a survey was conducted of synthetic flight training equipment and practices at the U.S. Army Aviation School and at aviation field units within the continental United States. Research conducted under Sub-Unit II is described in this Technical Report. Additional research under Sub-Units III and IV is concerned with the optimum utilization of present synthetic flight training devices and the optimum design and utilization of future devices.

Sub-Unit II reports include "Reduction of Helicopter Pilot Attrition Through Synthetic Contact Flight Training," presented at the American Psychological Association convention, September, 1965; Changes in Flight Trainee Performance Following Synthetic Helicopter Flight Training, HumRRO Professional Paper 1-66, April, 1966; and Helicopter Trainee Performance Following Synthetic Flight Training, HumRRO Professional Paper 7-66, November, 1966. This Technical Report supersedes an interim report of the results of this research delivered to the U.S. Continental Army Command and to the U.S. Army Primary Helicopter School in May, 1965.

The ECHO research is being performed by HumRRO Division No. 6 (Aviation), Fort Rucker, Alabama. The Director of Research is Dr. Wallace W. Prophet; Dr. Paul W. Caro, Jr. is the Work Unit Leader.

Military support for the study was provided by the U.S. Army Aviation Human Research Unit, Fort Rucker, Alabama. MAJ Donald J. Haid was the Unit Chief during the initial stages of the research, and secured the necessary support. LTC Berkeley D. More was the Unit Chief during the latter stages of the research.

In addition, Dr. Wiley R. Boyles, Mr. John O. Duffy, Mr. Warren P. Pauley, SP 4 Daryl R. Fisher, SP 4 Edgar Harmon, and SP 4 Richard C. Moore made significant contributions to the research effort.

The cooperation of commanders, directors, and personnel of the U.S. Army Aviation School, U.S. Army Primary Helicopter School, and Southern Airways Company of Texas, Inc., was of great value in the conduct of this research.

HumRRO research for the Department of the Army is conducted under Contract DA 44-188-ARO-2 and Army Project 2J024701A712 01, Training, Motivation, Leadership Research.

Meredith P Crawford
Director
Human Resources Research Office

SUMMARY AND CONCLUSIONS

Military Problem

Recent expansion of Army aviation and the emphasis on helicopter operations have increased the load on the Army's rotary wing training capability. These aviator training requirements have increased the need to study concepts and techniques that reasonably may be expected to improve the efficiency of rotary wing training. Synthetic flight training devices have been found useful in fixed wing training programs, and, although there have been relatively few applications of such equipment to rotary wing training problems, similar benefits might be expected to accrue from rotary wing applications.

Since most rotary wing flight training is contact flight training, the emphasis in this research was placed on the early, contact phase of rotary wing training; certain unique device concepts appropriate for rotary wing contact flight training were studied.

Research Procedures

A synthetic flight training device consisting of a captive helicopter attached to a ground effects machine was selected as a research vehicle. It embodied design concepts typical of several recently developed types of devices that appeared to be potentially useful in a rotary wing contact flight training program.

Two experimental programs of instruction were developed for the device, and these programs were administered to two groups of 33 Warrant Officer Candidates each during the preflight training phase of the Warrant Officer Rotary Wing Aviator Course. Two control groups received no device training. The experimental training consisted of 3¼ and 7¼ hours of practice on a progressively more difficult series of tasks designed to develop proficiency in the helicopter hovering maneuvers taught during early flight training.

Flight performance of the experimentally trained Warrant Officer Candidates and their control counterparts during the 85-hour primary helicopter training program provided the criterion measures for this research.

Results

The results indicated that:

(1) About 10% of the experimentally trained groups were eliminated from flight training for reasons of flying deficiencies, compared with about 30% for the control groups. The difference in attrition was statistically significant.

(2) The experimentally trained groups required approximately two hours less of flight training in order to attain the proficiency required to solo the helicopter. The difference in time to solo was statistically significant.

(3) During early flight training, the experimentally trained groups received higher grades from their flight instructors than did the control groups. The difference in flight grades was statistically significant.

(4) Trainees who performed well on the experimental training device tended to perform well during subsequent flight training.

(5) Students trained by device instructors with varying levels of flight experience did equally well during subsequent flight training.

Conclusions

It was concluded that the use of a helicopter contact flight training device of the type used in this study could result in:

(1) A significant reduction in rates of elimination from subsequent helicopter flight training.

(2) Significant improvements in trainee performance early in flight training.

(3) Prediction of proficiency level during subsequent helicopter flight training.

It was also concluded that instructors employing devices such as the one used in this study need not be required to be proficient in the helicopter used for subsequent flight training.

CONTENTS

The Captive Helicopter as a Training Device: Experimental Evaluation of a Concept

INTRODUCTION

Background

The use of synthetic flight training devices in avaiator training programs has become a widely accepted practice in both military and civilian organizations. The acceptance of such devices has been based on (a) apparent similarity to operational aircraft, as in the case of a commercial passenger jet simulator; (b) suitability for the presentation of part-task situations for student pilots, as in the case of the Basic Instrument Trainer, Device 2B12A; or (c) the results of transfer of training studies (e.g., Flexman, Matheny, and Brown, 1).

For the most part, however, the value of such devices to the Army has been found to be greatest in those programs of instruction and practice involving the procedural aspects of aircraft operation that are involved in instrument flight. An important factor that has tended to limit syntnetic flight training to procedural type training has been the expense and relatively low fidelity of extra-cockpit visual attachments appropriate for simulated contact flight training. The use of synthetic flight training devices with very rudimentary extra-cockpit visual attachments for teaching contact flight skills to student aviators has had some success, but the devices typically used in elementary training programs have low "face validity" for contact flight training (2).

Prior to this research, there were no operational or experimental synthetic flight training devices whose usefulness in rotary wing contact flight training programs had been objectively demonstrated. The state-of-the-art precluded the manufacture of an artificial visual display that would provide the cues believed desirable for contact flight training in the low-altitude, low-speed environment of the Army helicopter.

The need to investigate new concepts that might provide synthetic flight training in rotary wing contact training programs is important because (a) the expansion of Army aviation has put the greatest student load on the rotary wing flight training program; (b) rotary wing trainee attrition has been high, and training students who are later eliminated because they failed to learn to control the aircraft is an expensive burden on the Army's training resources; and (c) most rotary wing flight training is contact flight training.

Several recently developed devices operate in the real-world, out-of-doors environment of the helicopter, thereby obviating the requirement for an artifical visual display. The unique design concepts employed in these devices are those of a real or simulated helicopter "attached" to the ground by means of a mechanism that allows the trainee to operate in a real-world environment and to experience the visual, auditory, and kinesthetic sensations of flight—without becoming airborne.

One of these devices, the Whirlymite Helicopter Trainer, Model DHT-1,[1] was selected as a vehicle for research into the usefulness of such devices in

[1]The Whirlymite Helicopter Trainer, manufactured by Del Mar Engineering Laboratories, Los Angeles, California, is identified in this Technical Report for purposes of research documentation, and its use or citation does not constitute an official endorsement or approval by either the Human Resources Research Office or the Department of the Army.

the Army's rotary wing contact flight training program. The basis for the selection of this particular device was that the skills involved in its operation appeared, on a priori grounds, to be more like the skills involved in flying the primary training aircraft than were the skills involved in the operation of any other available synthetic device. This device, in fact, is a light helicopter operating in a captive mode.

A Whirlymite Helicopter Trainer "In Flight"

Figure 1

The Whirlymite Helicopter Trainer is pictured in Figure 1. It consists of a small, one-man helicopter attached to an independently powered Del Mar Ground Effects Machine, Model GET-1, by an articulated linkage assembly. This configuration allows the captive helicopter to translate with minimum friction in all directions, to climb to a hovering altitude, and to rotate (within limits) about all axes of helicopter flight. A novice is able to use this device to practice contact flight maneuvers which, at his proficiency level, would be unsafe in an aircraft.

Objectives

In view of the possible contribution of synthetic trainers like the Whirlymite Helicopter Trainer to a contact flight training program, a research project was undertaken with the following primary objectives: (a) to determine the training value of the captive helicopter device concept in Army rotary wing contact flight training, and (b) to determine whether performance on such a captive helicopter device prior to actual flight training could be used to predict subsequent student performance in the aircraft.

It was hypothesized that any transfer of training from a synthetic device to the flight training situation would lead to improvements in student performance during flight training, and indirectly to a reduction in the rate of attrition attributable to unsuccessful flight performance. Further, the identification prior to flight training of students who ultimately will fail could reduce the amount of training expended on such students and would, therefore, result in more efficient utilization of training resources.

A secondary objective of the research was to determine whether instructors using such devices should be required to meet the same aeronautical skill and experience levels as flight instructors. Traditionally, training device instructors in Army aviation programs are not required to be qualified pilots. The use of a real helicopter as a training device, as was the case in the present research, might place demands on the device instructor that could be met only through extensive aeronautical training. A lesser requirement, on the other hand, could result in the use of less skilled and, consequently, more readily available personnel.

Overview

The research activities were divided into two parts. During the first part, information was gathered concerning the rate and manner in which students acquired skills in the operation of the synthetic device. This information formed the basis for the development of experimental device training programs that were tested later. Methods of quantifying trainee performance on the device were also developed. These initial research activities were conducted at the U.S. Army Aviation School (USAAVNS), Fort Rucker, Alabama, during the third and fourth quarters of FY 1964.

During the second part of the research, the experimental programs of instruction (POIs) developed during the first phase were administered to selected Warrant Officer Candidates (WOCs) during the Warrant Officer Indoctrination Training (WOIT) phase of the Warrant Officer Rotary Wing Aviator Course (WORWAC). The second part of the research was conducted at U.S. Army Primary Helicopter School (USAPHS), Fort Wolters, Texas, during the first and second quarters of FY 1965.

Following successful completion of WOIT, WOCs involved in the research underwent Army rotary wing aviator training with other members of their WORWAC classes. This flight training, which began at USAPHS and continued through Advanced phases at USAAVNS, was completed during the first quarter of FY 1966.

At the conclusion of the flight training at USAPHS and USAAVNS, information was obtained from the records of the trainees involved in this research. This information—which concerned the performance of trainees during flight training—and the data obtained during the experimental training on the device during WOIT were analyzed to obtain answers to the questions raised by the stated objectives of this research.

The Warrant Officer Rotary Wing Aviator Course

At the time of this study, the WORWAC consisted of a four-week Warrant Officer Indoctrination Training Program (WOIT) and a 12-week Primary flight training program at USAPHS, in addition to 20 weeks of Advanced flight training at USAAVNS. During the four-week WOIT, WOCs were indoctrinated in the duties of a Warrant Officer, since upon graduation from WORWAC, they would be awarded a Warrant in the United States Army. The nature of WOIT was similar to that of OCS training. Its content was independent of subsequent flight training, and no flight-related subjects were taught during this four-week preflight phase.[1]

Following successful completion of WOIT, a WOC went immediately into a 12-week Primary helicopter flight training program. The POI required 85 hours of inflight dual instruction and solo practice as well as classroom training in subject matter related to flight performance. WOCs meeting the requirements of this training proceed to USAAVNS for Advanced flight training.

[1]Subsequent to this research, the content of WOIT was modified to include training intended to assist the WOC in adapting to the flight environment. Changes were made to the WORWAC also, but they consisted primarily of adding four weeks of flight training (previously included in Advanced phases at Fort Rucker) to the Primary phase at Fort Wolters.

Criterion measures described in this report were based on WOC performance during the 12-week flight training program at USAPHS.

The 12-week Primary flight training program is divided into three phases, each of which is terminated by an evaluation of the trainee's performance—a checkride. Upon successfully completing his checkride, the trainee progresses to the next stage of training. The Pre-Solo checkride is given when the WOC's flight instructor judges him to be "safe to solo" the helicopter and is the last flight of the Pre-Solo Phase of training. The Primary checkride is given when the WOC's flight instructor judges him proficient in the performance of flight maneuvers taught during the Primary Phase—the block of instruction and practice approximately 40 hours long that follows the first solo flight. The Basic checkride terminates the Basic Phase of training and covers maneuvers taught after satisfactory performance on the Primary checkride. A WOC able to pass the Basic checkride has met the objectives of Primary helicopter flight training and proceeds to Advanced training phases at USAAVNS.

METHOD

Subjects

The WOCs participating in this study were enrolled in three consecutive FY 1965 WORWAC classes—65-1W, 65-2W, and 65-3W.[1] Approximately 90% of the WOCs in these classes were enlisted personnel who had volunteered for flight training or were enlisted under the provisions of AR 601-108, Warrant Officers Flight Training Option, specifically for Army flight training. The other 10%, also enlisted personnel, were volunteers from Reserve or National Guard units.

WOCs are not typical of the Army enlisted population. The procedures used in their selection have been described by Kaplan (3). WOCs are above average in ability and aptitude, and they are considered by USAPHS personnel to be highly motivated to become both Warrant Officers and pilots.

At the beginning of each of the three classes involved in this study, 44 WOCs were selected randomly from Flight A, and 11 each were assigned to two experimental and two control groups. Flight A consisted roughly of the first half of the alphabetical roster of the members of each class. The only restriction placed on the sample was that each group consist of equal numbers of WOCs from each class. Each of the four experimental and control groups, therefore, contained 33 WOCs, 11 from each of the three classes, for a total N of 132.

Experimental Design

The research described here was based on two overlapping experimental designs. The first was a 4 x3 analysis of variance, where the experimental variables consisted of Training Condition (two experimental and two control groups) and Class (three WORWAC classes). The second design was a 3 x 3 x 2 analysis of variance, where the experimental variables were Instructor (three experience levels), Class (three WORWAC classes), and Training Condition (two experimental groups). The data from these two overlapping designs could

[1]During the course of this study, WORWAC class designations were changed by USAPHS. The designation 65-1W was unchanged; 65-2W remained the same for the WOIT Phase but was changed to 65-3W for the Flight Phase; 65-3W was changed to 65-3WP for the WOIT Phase and 65-4WF for the Flight Phase. The original designations will be used in this report.

not be treated as a single three-classification analysis of variance because the instructor variable did not apply to the two control groups, as indicated below.

Training Condition

Experimental Groups. Two experimental groups, designated A and B, received training on the device. Group A received a mean of 3 hours 17 minutes (range: 3:02—3:43) of training time spaced over 4 or 5 training periods of up to 1 hour in duration; Group B received a mean of 7 hours 13 minutes (range: 7:00—7:36)[1] spaced over 9 to 11 training periods of similar duration. The first 3¼ hours of training received by Group B were the same as those received by Group A. Group B WOCs continued to practice the same tasks beyond the 3¼-hour level, and also practiced two precision control maneuvers not practiced by Group A WOCs.

Control Groups. Two control groups received no training on the synthetic device, and they constituted the third value for the amount-of-training variable. Members of the two experimental groups missed portions of the four weeks of WOIT in order to participate in this research. To determine whether missing this OCS-type training itself might affect subsequent performance at the School, a control group, Group C, was treated administratively like experimental Group A. For each member of Group A, a counterpart member was assigned in Group C. When members of Group A were removed from WOIT for training on the device, counterparts from Group C also were removed from that program and were allowed to engage in activities of their own choosing.

A second control group, Group C′, was not identified to USAPHS personnel. This group was to serve as a hidden control to detect possible special treatment of WOCs engaged in this research.

Instructors

All device training was conducted by three civilian HumRRO research staff members trained (i.e., standardized) in the administration of the experimental programs of instruction (POI). These instructors represented three levels of proficiency in the operation of a helicopter: Instructor 1 was an FAA-rated rotary wing instructor, an ex-Army aviator with several thousand hours of military Instructor Pilot time; Instructor 2 held an FAA private pilot rating and was a recent graduate of the Officer Rotary Wing Qualification Course offered at the USAPHS; Instructor 3 had no aeronautical background other than approximately 15 hours of dual instruction in a single rotor helicopter.

Each instructor was thoroughly familiar with the operation of the device used in this research and had participated in the development of the POI. An assistant was assigned to each instructor to record the data described in subsequent sections of this report. The assistant did not engage directly in instructional activities.

Class

Previous experience with WORWAC classes had suggested that significant differences existed among groups of flight instructors in terms of such

[1]Means and ranges of training time here exclude six WOCs who were eliminated from the course during the four-week WOIT and consequently received no flight training. The reasons for elimination during WOIT are discussed in the section on device training.

factors as mean daily flight grade assigned and requirements for clearance for solo flight. For this reason, it was decided that three separate classes (and consequently three separate groups of flight instructors) would be used in this study.

Where statistically significant differences among classes were found in the present study, and in the absence of significant interaction effects, such differences were attributable to the previously noted difference among groups of flight instructors or other variations in flight training practices. Thus, the introduction of the Class variable in this research was a means of reducing the statistical variance that might otherwise contribute to a less precise measure of the effects of the Training Condition and Instructor variables. Significant differences among classes in performance on the training device during WOIT were not anticipated, since each class was treated uniformly with respect to the experimental and control conditions.

Device Training

The experimental training on the device, which was administered entirely during WOIT, was designed to take advantage of the stimulus and response similarity of the device and the primary training helicopter, the OH-23D. The device training was more like the earlier or Pre-Solo Phase of flight training, where WOCs initially learned to control the vehicle, than like the latter phase, where they concentrated on operational helicopter maneuvers such as maximum performance takeoffs and confined area operations. The device training consisted of hovering over a spot; turns; forward, backward, and lateral flight; and take-off to and landing from a hover.

The experimental device POI was designed (on *a priori* basis) to permit the trainee to advance from one skill level to the next entirely on the basis of his own proficiency on the device. Criteria were adopted defining acceptable performance on each task, and, after satisfying these criteria, the trainee was introduced to the next task. Each succeeding task required the development of a greater degree of device control skill. The criteria for advancement from one task to another were objectively defined measures of performance that were readily observable and scorable, for example, time on (off) target, errors per unit of time, and errors per trial. The primary instructional technique was that of behavior shaping,[1] using verbal feedback from the instructor (via radio) to augment the feedback intrinsic to the task of learning to operate the device. An outline of the POI for the device training and the criteria of performance for each task are given in Appendix A.

Fifteen WOCs were eliminated during WOIT, the period during which the experimental training program was administered: one from Group A, five from Group B, four from Group C, and five from Group C′. Reasons for these eliminations included medical defects, discipline, and academic failure, but no WOC was eliminated for reasons related to performance on the device. Fisher Exact

[1]In behavior shaping, an instructor differentially reinforces successive approximation to a final form of behavior. In the present instance, only trainee behavior that was progressively more desirable was reinforced—with praise and encouragement from the instructor. For example, a trainee who moved the controls in the proper direction initially would be reinforced for doing so. Then, only responses in the proper direction and of approximately the correct magnitude would be reinforced. Finally, through successive approximation, he would be reinforced for successively more exact control manipulations until the desired skill was acquired.

Probability Tests indicated that differences between groups in number of preflight eliminations were not statistically significant.[1]

Performance Criteria

Following successful completion of WOIT, the experimental and control group members underwent Primary rotary wing flight training with the other members of their classes. Performance during that flight training constituted the criterion by which the value of the experimental device training was evaluated. Ten measures of flight performance were used as the principal dependent variables in this research: pass-fail; instructor-assigned grades during each of the three phases of training; checkpilot-assigned grades on each of the three end-of-phase checkrides; and the cumulative flight time to each checkride. These measures were obtained from the flight records of the experimental and control group WOCs upon completion of the first 12 weeks of flight training at the USAPHS.

The conduct of this study did not require any changes in the flight portion of the WORWAC, and the flight training of WOCs involved in this study did not differ from that of their fellow class members. Flight training and performance evaluation, as well as assignment to flight instructors and evaluation personnel, followed procedures that were routine at USAPHS and were unrelated to this research. The relative performance of experimental WOCs on the training device was not known to USAPHS personnel. Although no attempt was made to conceal the identity of members of Groups A, B, and C, no emphasis was placed on their role in the research. Personnel at USAPHS remained unaware of the existence and identity of Group C′ throughout the study.

RESULTS

Training Value of the Device Concepts

The first objective of this research, to determine the training value of the captive helicopter device concept in Army rotary wing contact training, was met by determining how the performance of the experimentally trained groups of WOCs compared with that of the control groups. The data involved in this analysis consisted of pass vs. fail—the number of WOCs in each group eliminated frc n training because of flight deficiencies; time to checkride—the cumulative amount of inflight training required to pass each of the three checkrides described above; and flight grades—the mean daily grades assigned by flight instructors during each phase of training, and the grades assigned by checkpilots on each of the three checkrides.[2]

Elimination From Flight Training

The eliminations that occurred among experimental and control groups during flight training are reported in Table 1. The figures in the column headed "Number Entering Flight Training" were obtained by subtracting the preflight

[1]The $p<.05$ level was used as the criterion for statistical significance throughout this report.

[2]Similar measures of flight performance were also available during the Advanced Phase of training at USAAVNS. No statistically significant differences occurred among any of the experimental or control groups on these Advanced training measures. The data presented in this report, therefore, are limited to measures describing the earlier flight training phases.

Table 1

Elimination by Group During Primary Flight Training

Group	Number Entering Flight Training	Eliminations					
		Total		Flying Deficiency		Other	
		Number	Percent	Number	Percent	Number	Percent
A	32	5	16	2	6	3	9
B	28	5	18	4	14	1	4
C	29	11	38	8	28	3	10
C′	28	10	36	9	32	1	4
A + B	60	10	17	6	10	4	7
C + C′	57	21	37	17	30	4	7

eliminations from 33—the number in each group at the beginning of the study. The "Total" column includes all WOCs who entered flight training but failed to graduate. The "Flying Deficiency" column includes only those WOCs eliminated by Faculty Board action for unsatisfactory flying performance. The "Other" column is the difference between the two preceding columns and would account for eliminations due to academic failures, disciplinary problems, medical problems—that is, all reasons except flying deficiency. For ease of comparison, the percentages corresponding to the various frequencies are also shown.

Fisher Exact Probability Tests were performed on the data in Table 1; none of the differences between Groups A and B and between Groups C and C′ in number of eliminations for Flying Deficiency, Other, or Total reasons was significant. The difference in number of eliminations for flying deficiency between the combined experimental Groups (A+B), where 6 (10%) were eliminated, and the combined control groups (C+C′), where 17 (30%) were eliminated, was statistically significant ($\underline{p} < .01$). The difference between the combined experimental and the combined control groups in Total eliminations was also significant, but this may be attributed to the difference in Flying Deficiency eliminations, since the corresponding difference in Other eliminations was not significant.

Time to Checkride

The cumulative flight time required to reach the three end-of-phase checkrides was obtained from each WOC's flight record. The mean cumulative time in hours and minutes to the Pre-Solo, Primary, and Basic checkrides for each group by class is shown in Table 2. Group A soloed after approximately 12 hours and 40 minutes of dual instruction, Group B after 13 hours and 25 minutes, Group C after 15 hours and 16 minutes, and Group C′ after 14 hours and 43 minutes.

Table 3 is the summary table for the Training Condition by Class analysis of variance for the time to Pre-Solo checkride data summarized in Table 2. The $\underline{F}$ ratio for Training Condition was significant in this analysis. Similar analyses of time to the Primary checkride and time to the Basic checkride did not yield significant differences, and summary tables are not presented for them.

The significant Training Condition $\underline{F}$ in Table 3 resulted primarily from the difference between the means of the combined experimental and the combined control groups. This was determined by a comparison of the means of 13 hours for Groups A+B combined, and 15 hours for Groups C+C combined, using the S-Method (4) and the .05 level of significance. The smaller mean differences between the two experimental groups and between the two control groups were determined by similar analyses not to be significant.

Table 2

Mean Total Flight Time to Each Checkride by Group and Class

Group	Class	Pre-Solo			Primary			Basic		
		N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
A	1	10	12:28	1:57	8	58:30	3:10	8	85:59	5:47
	2	10	14:08	2:25	10	57:45	3:42	10	83:34	2:40
	3	9	11:15	2:11	9	58:06	4:49	9	81:35	6:53
	Total	29	12:40	2:25	27	58:01	3:46	27	83:37	5:24
B	1	8	12:54	1:56	7	57:57	3:14	7	79:42	2:16
	2	9	14:21	4:22	8	56:59	4:30	8	83:40	5:31
	3	8	12:52	3:22	8	62:12	4:52	8	84:18	3:55
	Total	25	13:25	3:21	23	59:05	4:44	23	82:41	4:29
C	1	6	14:22	2:38	5	58:24	2:23	5	81:50	7:41
	2	7	17:21	4:24	6	60:57	3:51	6	81:30	4:07
	3	8	14:08	5:13	7	59:01	3:06	7	81:12	3:40
	Total	21	15:16	4:24	18	59:29	3:12	18	81:29	5:07
C′	1	4	11:22	2:06	4	53:35	4:08	4	80:30	2:09
	2	9	16:35	2:19	8	58:51	4:22	8	84:57	5:10
	3	8	14:18	2:44	7	60:44	5:06	6	81:41	2:12
	Total	21	14:43	3:03	19	58:26	5:09	18	82:52	4:08

The significant F ratio for Class reported in Table 3 reflects the previously noted variation in flight training across classes and is unrelated to the experimental device training under consideration. The F ratio for Class also was significant in the analysis of variance of the flight time to the Primary checkride data summarized in Table 2.[1]

Grades

Table 3

Analysis of Variance of Time to the Pre-Solo Checkride

Source	df	MS	F	p
Condition	3	104225	2.92	<.05
Class	2	256529	7.19	<.01
Class by Condition	6	30585	<1.	NS
Within	84	35663		
Total	95			

Daily Grades. Daily grades were assigned by each WOC's instructor and had four values: U (unsatisfactory, that is, fail), BA (below average), A (average), and AA (above average). Table 4 presents the means of instructor-assigned daily grades received by members of each experimental and control group during the Pre-Solo, Primary, and Basic Phases of flight training, respectively. The values of Table 4 were derived from a four-point scale that assigned four points for each AA grade received, three points for each A, two points for each BA, and one point for each U. The sums thus obtained were divided by the number of graded flights to derive a score for each WOC during each phase of training, and the means and standard deviations of these scores by class are summarized in Table 4. Daily grades received by

[1]Except where specific reference is made in the text to differences in measures of flight performance (including attrition) among classes, none of the differences was found to be significant at the .05 level.

Table 4

Mean Daily Grades by Phase of Training, Group, and Class

Group	Class	Pre-Solo			Primary			Basic		
		N	Mean	Standard Deviation	*N*	Mean	Standard Deviation	*N*	Mean	Standard Deviation
A	1	10	2.5	.5	8	2.5	.2	8	2.5	.3
	2	10	2.6	.5	10	2.7	.3	10	2.7	.2
	3	9	3.0	.4	9	2.9	.2	9	3.0	.4
	Total	29	2.7	.5	27	2.7	.2	27	2.7	.3
B	1	8	2.5	.4	7	2.5	.3	7	2.7	.4
	2	9	2.8	.5	8	2.7	.3	8	2.8	.3
	3	8	2.7	.3	8	2.7	.4	8	2.8	.4
	Total	25	2.7	.4	23	2.6	.3	23	2.8	.3
C	1	6	2.3	.4	5	2.5	.3	5	2.5	.4
	2	7	2.0	.4	6	2.7	.2	6	2.8	.3
	3	8	2.6	.4	7	2.7	.2	7	2.9	.2
	Total	21	2.3	.4	18	2.6	.2	18	2.8	.4
C′	1	4	2.7	.2	4	2.8	.3	4	2.9	.2
	2	9	2.3	.4	8	2.8	.3	8	2.5	.4
	3	8	2.4	.5	7	2.6	.3	6	2.9	.2
	Total	21	2.4	.4	19	2.6	.3	18	2.7	.4

WOCs eliminated during a phase are not included in means for that phase. These grades, as well as the checkride grades, also were obtained from the WOC's flight records.

Table 5 is the summary table for the Training Condition by Class analysis of variance for the Pre-Solo daily grade data summarized in Table 4. The F ratio for Training Condition was significant in this analysis ($p < .01$). Similar analyses of daily grades during the Primary and Basic Phases of flight training did not yield significant differences, and summary tables are not presented for them.

Table 5

Analysis of Variance of Mean Daily Grades During the Pre-Solo Phase

Source	*df*	MS	*F*	*p*
Condition	3	.7174	4.04	<.01
Class	2	.6426	3.62	<.05
Class by Condition	6	.3806	2.14	NS
Within	84	.1775		
Total	95			

The significant Training Condition F in Table 5 resulted primarily from the differences between the combined experimental and the combined control groups. This was determined by a comparison of the mean daily grades of 2.68 for Groups A+B and 2.36 for Groups C+C′, using the S-Method (4) and the .05 level. The smaller mean differences between experimental groups and between control groups were determined by similar analyses not to be significant.

The significant F ratio for Class reported in Table 5 reflects the previously noted variations in flight training practices across classes and is unrelated to the treatments under consideration. The F ratio for Class also was significant in the analysis of variance of the mean daily grades during the Basic Phase of flight training data summarized in Table 4.

Checkride Grades. Checkride grades are assigned numerical values from 70 to 100, or, if the checkride is failed, a letter grade (U) is assigned. Except in the case of the Pre-Solo checkride, these grades are assigned by specially trained checkpilots from an independent performance evaluation section at the Primary Helicopter School. The Pre-Solo checkride grades are assigned by each WOC's instructor or another instructor in the same training flight.

The mean checkride grades for each group and class are shown in Table 6. In computing these values, U grades were assigned a value of 65, five points below the minimum passing score.[1] Training Condition by Class analyses of variance of these checkride grades yielded no significant F ratios for the treatment condition of amount of device training on either the instructor-evaluated Pre-Solo checkride or the Primary or Basic checkrides evaluated by the specially trained checkpilots.

Table 6

Mean End-of-Phase Checkride Grades by Group and Class

Group	Class	Pre-Solo			Primary			Basic		
		N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
A	1	10	79.9	5.3	8	78.6	6.9	8	76.8	9.0
	2	10	80.3	6.5	10	77.6	5.1	10	80.3	4.4
	3	9	85.8	4.4	9	81.1	6.5	9	79.7	6.8
	Total	29	81.9	6.0	27	79.1	6.1	27	79.0	6.7
B	1	8	80.6	5.7	7	81.1	6.0	7	79.7	5.2
	2	9	79.7	6.5	8	81.1	7.5	8	82.0	3.9
	3	8	80.5	7.2	8	77.8	6.1	8	79.4	5.1
	Total	25	80.2	6.2	23	80.0	6.5	23	80.4	4.7
C	1	6	79.5	6.2	5	79.0	6.6	5	80.6	8.1
	2	7	80.0	4.2	6	80.2	5.7	6	78.3	3.1
	3	8	80.9	7.1	7	81.1	6.9	7	83.1	7.1
	Total	21	80.2	5.8	18	80.2	6.1	18	80.9	6.4
C'	1	4	83.0	9.5	4	81.2	6.2	4	78.8	7.1
	2	9	78.2	4.7	8	79.4	6.0	8	78.5	8.2
	3	8	79.0	5.7	7	80.6	7.7	6	82.2	2.6
	Total	21	79.4	6.1	19	80.2	6.4	18	79.8	6.5

Prediction

The second objective of this research was to determine whether performance on the device prior to actual flight training could be used to predict subsequent performance in the aircraft. To determine whether such predictions could be made, measures of performance on the training device were correlated with measures of performance during subsequent flight training.

Predictor Variables

The data recorded to describe WOC performance on the synthetic device are identified in the description of the device training program contained in

[1]The choice of 65 as the numerical equivalent of a U grade was arbitrary; however, due to the small number of cases involved, it is not considered to have had any great effect on the values reported in Table 6.

Appendix A. Because little justification could be provided for rejecting any particular score that could be derived from these data, 50 such scores, which appeared to be reasonable and representative indices of performance at various levels of device training, were derived and considered as potential predictor variables. Descriptions of these 50 scores (or predictors), identification of the measures from which they were derived, and an intercorrelation matrix of them are contained in Appendix B. In several instances these predictors are not independent measures of student performance. Predictor 10, z-Score[1] Cumulative Time to Tethered Tracking, for example, is related to the time scores identified as Predictors 1 and 3 through 9.

Criterion Variables

The 10 flight performance measures described in the section dealing with transfer of training served as the criterion variables in the determination of the predictive value of the device training. These measures were pass vs. fail, time to checkride, instructor-assigned daily grades, and checkpilot-assigned checkride grades. An intercorrelation matrix for the criterion variables, excluding pass vs. fail,[2] is presented in Table 7.

It would appear from the intercorrelation matrix of these nine criterion variables that performance during the Pre-Solo stage of training correlates only moderately with performance during the Primary Phase and even less with performance during the Basic Phase of training. This would suggest that the skills involved in each of the three phases of training are moderately to markedly different, and students who do well early in training are not necessarily the students who do well in later phases of flight training. For example, the

Table 7

Intercorrelations of Nine Flight Criterion Variables

	Pre-Solo			Primary			Basic	
	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade
Pre-Solo								
Checkride Grade	-.59							
Mean Daily Grade	-.54	.61						
Primary								
Time to Criterion	.40	-.29	-.32					
Checkride Grade	-.31	.18	.38	-.33				
Mean Daily Grade	-.51	.62	.61	-.34	.17			
Basic								
Time to Criterion	.31	-.06	-.11	.43	-.44	-.13		
Checkride Grade	-.22	.16	.25	-.34	.41	.02	-.37	
Mean Daily Grade	-.24	.35	.47	-.19	.28	.50	-.15	.23

[1]A z-score is a type of standard score in which deviation of raw scores from the mean are expressed in terms of the standard deviation of the distribution. A distribution of z-scores has mean = 0, standard deviation = 1.

[2]The pass-fail variable was not included in the intercorrelation matrix because scores on the time to checkride and the checkride grade criteria were not available for WOCs who failed, and the instructor-assigned daily grades were available for a student only up to the time that he was eliminated.

correlation between the Pre-Solo Checkride Grades and the Basic Checkride Grades is low—only .16. On the other hand, there is moderate agreement between the Primary and the Basic Checkride Grades where r = .41.[1]

The three Time to Checkride measures reported in Table 7 reflect a similar pattern, although the correlations, which range from .31 to .43, are slightly higher. This may occur because they are part-whole relationships, that is, the time to the Basic Phase checkride includes the time required to meet the Pre-Solo and Primary Phase criteria.[2]

The Mean Daily Grade criterion appears to be the most consistent measure across Phases of Training. Instructor-assigned Pre-Solo grades correlate .61 with those of Primary and .47 with those of Basic, and Primary Phase Daily Grades correlate .50 with those of the Basic Phase. The size of these correlations, however, is probably inflated by the fact that many students keep the same flight instructor throughout their flight training.

Because of the relatively low relationships among criterion variables across (and within) phases of training, a single set of predictor variables would not be equally efficient with respect to all criteria of flight performance. For this reason, no attempt has been made to select a single criterion of flight performance. Rather, all 50 predictors were correlated with each criterion variable to see which, if any, device measures might be useful in predicting various criteria of performance during each phase of training and could therefore be considered in future research.

Prediction of Elimination From Flight Training

Biserial correlation coefficients were computed between pass vs. fail and the 50 device training scores contained in Appendix B. Since only six WOCs were eliminated for flying deficiency, the pass-fail split involved in these biserial correlations is extreme. Consequently, although the correlations ranged from .00 for Predictor No. 26 to a high of −.90 for Predictor No. 43, none of these correlations was significant at the .05 level, and they are not reported here. The sampling error involved in such unequal splits of the pass vs. fail variable is too large, for the number of WOCs involved, for statistically significant results to be possible.

Prediction of Performance During Flight Training

In order to determine whether performance on the tethered device could be used to predict subsequent performance on the remaining nine criterion variables, product-moment correlation coefficients were computed between the variables and each of the 50 device scores identified in Appendix B. Appendix C contains a 50 x 9 matrix of these coefficients, with an indication of the number of WOCs involved in each. Only those WOCs who successfully completed Primary flight training are included. The values of the correlation coefficients contained in Appendix C ranged from .00 to .62.

[1]It should be noted that the Primary and Basic checkrides were administered by specially trained checkpilots using a flight performance checklist, or Pilot Performance Description Record (PPDR), whereas the Pre-Solo checkrides typically were administered by the trainee's own instructor or other instructor from the same administrative flight. A description of the PPDR is given by Greer, Smith, and Hatfield (5), and its use at USAPHS as a quality control device is reported by Duffy and Colgan (6).

[2]Because the variance of the Time to Basic distribution is, in part, made up of the variance present in the Time to Pre-Solo and Time to Primary distributions, this fact alone may introduce some degree of positive correlation.

To determine which of the 50 predictor variables had the highest relation to the flight performance measures, the coefficients reported in Appendix C were ranked separately for each criterion measure. The 10 (or 11 in cases of ties) predictor variables that correlated most highly with each of the nine criterion variables were selected for further examination and are identified in Table 8.[1] Since the sign of the correlation was a function of the type of measurement taken—high time scores indicated poor performance whereas high grade scores indicated good performance—the ranking of the predictor variables was without regard to sign. However, all of the relationships represented in Table 8 are consistent with the pattern that "good" performance on the device will predict "good" performance during subsequent flight training.

The range of magnitude of the correlation coefficients between the predictor variables and the nine criterion variables are also shown in Table 8. The value of the coefficients are shown for the first (highest) and tenth ranking variables. The highest relationship between any predictor and flight performance, as represented by these coefficients, is with Mean Daily Grade at the Pre-Solo Phase of flight training. This coefficient is .62, which indicates a substantial relationship that could be used to predict relative class standing at that stage of training should such information be required.

Table 8

Rank Order and Range of 10 Highest Correlations Between Flight Criteria and 50 Predictor Variables[a b]

Item	Pre-Solo			Primary			Basic		
	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade
Rank Order									
1	10	6	45	10	16	6	44	41	42
2	8	10	41	8	39	41	45	18	45
3	6	5	10	6	17	45	41	43	32
4	41	8	6	41	32	10	10	19	37
5	45	1	42	44	1	4	50	17	4
6	46	4	4	50	20	1	20	42	6
7	5	11	8	5	36	33	32	44	40
8	4	50	44	1	12	30	36	50	8
9	9	45	49	45	33	11	8	45	10
10	17	47	1	4	31	8	31	14	17
					37			15	
Correlations									
1st	.60	.52	.62	.44	.38	.47	.44	.48	.52
10th	.34	.32	.42	.24	.28	.33	.20	.33	.38

[a]Correlations were ranked without regard to algebraic sign (+ or –) in order to show magnitude of relationship, regardless of direction.

[b]Numbers in the rank order section indicate predictor variable identification numbers; brackets indicate tied rankings.

[1]The relatively small sample size necessitated reducing the number of predictor variables used in each multiple correlation. Although the selection procedures used in this instance may have exploited chance relationships, the approach represents the best available method to estimate what might have obtained given a large N.

Multiple correlation provides a way to combine two or more variables to improve prediction of a criterion. Prediction studies of the type reported here lend themselves to such techniques, since using multiple predictors typically yields a higher coefficient (indicating better prediction) than does using any of the individual variables it incorporates.

To illustrate the utility of multiple correlational techniques for the prediction of class standing, multiple correlations were computed between the nine flight performance criterion variables (pass vs. fail was not included) and selected predictors from Table 8. The bases for the selection of the predictor variables for a particular multiple correlation were size of correlation and independence of measurement. For each of the criterion variables, all predictors from Table 8 that could be considered independent[1] measures of performance on the device (although they were not necessarily independent in the statistical sense, as indicated in Appendix B) were selected, and multiple correlation coefficients were computed for each. Each multiple correlation was based on from four to seven predictors. The predictors used in each multiple, as well as the values of the individual coefficients and the N for each, are indicated in Table 9

Table 9

Predictors Used in the Computation of Multiple Correlation Coefficients

Criterion Variable	Predictor Variable Number	Pearson r	N
Pre-Solo Phase			
Time to Checkride	10	.60	48
	41	.46	23
	45	-.40	22
	46	-.38	23
	17	.34	45
Checkride Grade	10	-.50	48
	11	-.36	50
	50	.34	22
	45	.32	22
	47	-.32	23
Mean Daily Grade	45	.62	22
	41	-.57	23
	10	-.53	48
	49	.44	22
Primary Phase			
Time to Checkride	10	.44	48
	41	.35	23
	44	-.34	22
	50	-.33	22
Checkride Grade	16	-.38	45
	39	-.38	44
	32	-.33	44
	1	-.30	50
	12	-.29	48

Criterion Variable	Predictor Variable Number	Pearson r	N
Mean Daily Grade	41	-.46	23
	45	.46	22
	10	-.42	48
	33	-.37	44
	11	-.34	50
Basic Phase			
Time to Checkride	44	-.44	22
	41	.35	23
	50	-.25	22
	10	.24	48
	20	.23	45
	32	.22	44
	36	.22	44
Checkride Grade	41	-.48	23
	18	-.43	45
	43	-.42	22
	50	.36	22
Mean Daily Grade	42	-.52	23
	45	.44	22
	32	-.41	44
	37	-.41	44
	10	-.38	48
	17	-.38	45

[1]The predictors were derived from measures of performance on the device, and some measures were reflected in more than one predictor. Predictor 10, z-Score Cumulative Time to Tethered Tracking, has been cited above as an example of a predictor that is not independent of certain other predictors. Predictors could not be considered independent when they were derived in part from the same performance measure.

Because the N in the various predictor variables in Table 9 varied widely, Pearson correlation coefficients for the predictor variables were recomputed, using only those WOCs whose scores were available for all of the predictors used for a given criterion variable. Consequently, each multiple correlation (R) is based on an N equal to the lowest N of any of the individual correlations used in its computation. A further reduction of the N was necessary in the present instance where data were missing.

Using only those WOCs for whom complete data were available, that is, Ns determined in the manner described above, the Pearson rs were recomputed. These recomputed rs then were used in the computation of multiple correlation coefficients between the predictor and criterion variables identified in Table 9. The recomputed Pearson rs and the multiple correlation coefficients obtained when they were used are contained in Table 10. It should be noted that many of the recomputed rs are lower than the rs reported in Table 9. This is particularly noticeable in cases where the N changes from a relatively high to a much lower value, for example, from 50 to as low as 21 in the case of Predictor No. 11. In spite of this, however, the multiple correlation coefficients (corrected for shrinkage) in Table 10, which are as high as .57 for the Primary Phase checkride grade criterion, indicate substantial relationships do exist between performance on the captive helicopter training device and subsequent performance in the training helicopter.

Table 10

Multiple Correlations Between Item and Flight Performance Criteria[a]

Criterion Variable	*N*	Predictor Variable Number	Recomputed Pearson *r*	Multiple Correlation (*R*)	Corrected *R*[b]
Pre-Solo Phase					
Time to Checkride	22	10	.55	.70*	.51
		41	.52		
		45	-.40		
		46	-.38		
		17	.35		
Checkride Grade	21	10	-.27	.52	.40
		11	-.43		
		50	.33		
		45	.31		
		47	-.31		
Mean Daily Grade	21	45	.63	.67*	.56
		41	-.51		
		10	-.49		
		49	.42		
Primary Phase					
Time to Checkride	21	10	.47	.51	.27
		41	.36		
		44	-.36		
		50	-.33		

(Continued)

[1]One subject in Group B did not progress beyond maneuver 10a, and consequently was dropped from all multiple correlations involving Predictors 47-50.

Table 10 *(Continued)*

Multiple Correlations Between Item and Flight Performance Criteria[a]

Criterion Variable	N	Predictor Variable Number	Recomputed Pearson r	Multiple Correlation (R)	Corrected R[b]
Checkride Grade	44	16	–.39	.63**	.57*
		39	–.38		
		32	–.33		
		1	–.26		
		12	–.34		
Mean Daily Grade	22	41	–.40	.63	.46
		45	.46		
		10	–.49		
		33	–.54		
		11	–.34		
Basic Phase Time to Checkride	21	44	–.43	.66	.37
		41	.51		
		50	–.28		
		10	.46		
		20	.13		
		32	.14		
		36	.08		
Checkride Grade	21	41	–.34	.46	.11
		18	–.12		
		43	–.39		
		50	.36		
Mean Daily Grade	22	42	–.40	.50	N/A
		45	.44		
		32	–.29		
		37	–.05		
		10	–.35		
		17	–.24		

[a]** indicates $p<.01$; * indicates $p<.05$.
[b]Corrected for shrinkage.

Although in the present case the data are insufficient for definitive statements about the true relationship existing between predictor and criterion performance, the results presented above suggest a promising area for further research with larger samples.

Instructor Experience Level

A secondary objective of this research was to determine whether instructors using devices such as the one used in this research should meet the same aeronautical skill and experience requirements as flight instructors. The device instructor experience levels studied here are described in an earlier section of this report. The qualifications of the three instructors who participated in this research ranged from no aeronautical rating and only 15 hours of dual instruction in a helicopter to a fully qualified, highly experienced, rated helicopter instructor pilot.

Table 11

Elimination by Device Instructor During Primary Flight Training

Instructor	Number Entering Flight Training	Eliminations		
		Total	Flying Deficiency	Other
1	18	6	4	2
2	21	1	1	0
3	21	3	1	2
Total	60	10	6	4

Elimination From Flight Training

The eliminations that occurred during flight training among the WOCs trained by each device instructor are reported in Table 11.[1] Fisher Exact Probability Tests were performed on these data, and none of the differences among instructors in number of eliminations for Flying Deficiency, Other, or Total reasons was statistically significant.

Performance During Flight Training

Instructor by Class by Training Condition (3 x 3 x 2) analyses of variance were performed on the nine flight performance variables (Time to Checkride, Daily Grades, and Checkride Grades for each phase of training). None of these analyses yielded significant $\underline{F}$ ratios for the Instructor variable or for the Training Condition[2] variable.

For the Class variable, significant $\underline{F}$ ratios were found for the Pre-Solo and the Basic Phase Mean Daily Grade analyses. These significant $\underline{F}$ ratios reflect previously noted variations in flight training across classes and are unrelated to the device instructor experience level or the experimental device training under consideration.

DISCUSSION

Training Value

A primary objective of this research was to determine the training value of a captive helicopter device in Army rotary wing contact flight training. It was found that the device could lead to improved trainee performance during subsequent flight training. The most important improvement that occurred during this research was the two-thirds reduction in eliminations due to flying deficiency. There were no significant differences between experimental and control groups, after the first solo flight, on any of the flight performance measures cited. Thus, the experimental and control students were of equivalent flight proficiency. The reduction in elimination rate from 30% to 10%, without lowering the quality of course graduates, has considerable practical significance in a course that graduates more than 500 aviators per month.

Previous research by Fleishman (7) indicated that the factorial structure of complex psychomotor skills performance may change markedly as a function of level of training and proficiency. At the early stages of learning, factors such as reaction time and general psychomotor coordination are relatively important, whereas at later stages these factors decline in importance, and other factors more specific to the given task emerge as important. In view of

[1]Only Group A and Group B WOCs were involved in this analysis. The Instructor variable did not apply to the control groups.

[2]Only Groups A and B were involved in this analysis.

the fact that the performance of experimental WOCs on the training device indicated they were in the early stages of learning to control the device, it is likely that their performance depended on somewhat the same factors as would their early (Pre-Solo) flight performance on the helicopter. Also, the general elements of the device task were more like those of the early flight periods than those of the later portions of flight training. Thus, it is reasonable to expect the greatest differences between experimental and control WOCs to occur early in flight training.

The number of eliminations, time to checkride, and grade data support these expectations. The only significant performance differences between experimental and control WOCs occurred during the Pre-Solo Phase when the gross skills involved in helicopter control are developed. The device-trained WOCs acquired the skills necessary to operate the helicopter safely in solo flight with significantly less inflight training than did the control WOCs. They also tended to perform more satisfactorily while acquiring those skills, as reflected in their Pre-Solo Phase daily grades.

The Pre-Solo checkride performance of the control WOCs was approximately equal to that of the experimentals, although the controls required an additional two hours to reach this level of proficiency. It is hypothesized that such a reduction in the time to solo could lead to further savings in a flight program designed to take advantage of individual rates of learning. Although the Primary Helicopter School waived the usual experience requirements for checkrides for the specific classes involved in this study,[1] post-experiment interviews with instructors and flight commanders indicated that the waiver tended to be disregarded by training supervisors. The possibilities of reduced Primary helicopter flight training time through preflight device training, where advancement in flight training is based on individual proficiency rather than a combination of proficiency and experience, merit investigation.

The lack of significant differences between Groups A and B on any of the flight training performance measures is also of interest. Although only 3 ¼ hours of device training were given to Group A WOCs, it probably enabled some of those who would not otherwise have been successful to complete flight training. The practical import of this result is great because, like flight training, device training is expensive. Amounts of device training of fewer than 3 ¼ hours might be investigated.

The synthetic training device under consideration—in fact, a light helicopter operating in a captive mode—is rather unlike other synthetic trainers used in earlier studies on transfer of flight training, such as the 12BK Landing Trainer and the C-3 Link Trainer (2). Comparatively, it is much more like the light aircraft used in some Air Force and Naval ROTC pre-primary flight training programs. In one evaluation of the light aircraft as a pre-primary flight training device (8, 9) results similar to those reported here were obtained. The students trained on light aircraft experienced a lower flight attrition rate than the control students, and they were superior to the controls on measures of performance that occurred during earlier periods of primary flight training. After the 18-hour flight check, however, no statistically significant differences were found between the flight performance of the light aircraft-trained and the control groups. It would appear that the training received by the experimental WOCs in the present study is of similar value, in terms of subsequent flight

[1]Pre-Solo not before 10 hours, Primary not before 50 hours, Basic not before 75 hours at the time this study was conducted.

performance, to that received by Air Force and Navy students in light fixed wing aircraft.

The present research did not attempt to investigate the cause of the results obtained. The reader may attribute the transfer of training that occurred to a variety of factors, including the Hawthorne Effect.[1] The influence of that particular factor, however, is believed to be relatively minor because of the manner in which Group C was treated. Also, the transfer of training portion of this study was replicated (with minor variations) during a user test conducted by USAPHS personnel, and essentially the same results were obtained (10). The similarity of the device and the helicopter used during subsequent flight training obviously is an important factor, but similarity alone cannot account for the reduction in flight attrition that occurred. An additional 3 ¼ hours of training in the training helicopter itself does not result in a similar reduction in flight attrition. The training received on the device would appear to be qualitatively different from that which can be obtained in a free-flying helicopter.

One factor that appeared relevant to the results obtained was the opportunity provided the trainee to develop confidence in his ability to succeed in a situation very similar to that which he later encountered in the training aircraft. The device used in this research is in every respect a real helicopter, operating in the real world, and requiring the development of real-world skills to control it. It provides a safe opportunity for the trainee to develop the situational confidence hypothesized by Kern (11) to be important in the performance of tasks involving complex skills.

Another factor of possible relevance to the results obtained is that the present device provides a situation in which the trainee is able—safely—to make errors of a magnitude that could not be tolerated in a free-flying helicopter. A characteristic of early stages in the learning of psychomotor skills is overcontrol. The trainee typically makes gross errors; when the task to be learned is to fly a helicopter, the instructor pilot must take vehicle control away from the trainee whenever a gross error occurs in order not to endanger the helicopter and the personnel on board. As a result, the trainee is relieved of control a large proportion of the time during initial training periods. Often he is relieved of control before he has perceived that a control error has been committed.

In the present device, however, the instructor is physically removed from the helicopter and cannot take control away from the trainee. As a result, the trainee not only is exposed to the results of any improper control input (within the limits of movement of the device), but also is required to counter that input in order to return the helicopter to a normal attitude. Thus, he receives training in this particular type of device that may be superior to that which he can safely receive in the training helicopter. Research concerning the relevance of these and other factors to the results obtained from the use of such training equipment was outside the scope of the present research, but such studies would be highly desirable.

Prediction

The second objective of this research, to determine whether performance on the training device could be used to predict performance during subsequent flight training, was predicated on the assumption that it would be desirable to identify WOCs whose probability of successfully completing flight training was

[1]The Hawthorne Effect is a temporary improvement in performance which results from the knowledge that one is being treated differently from others and is being observed.

low. They might then be given special attention or be eliminated from flight training as early as possible. This objective was appropriate for consideration prior to the conduct of this research when the expected attrition rate was 30% or greater. The objective became less appropriate for consideration when it was found that the use of the device resulted in a two-thirds reduction in attrition. Based on the transfer of training data above, it is possible to predict that students who receive such device training probably will succeed at subsequent flight training.

Even though prediction of failure was not appropriate from the present data, prediction of flight performance on the other nine flight criteria was possible. The estimated relationship between the predictors and the flight performance criterion variables may be considered quite high. The use of multiple correlations in this investigation was intended only to illustrate the fact that substantial relationships may exist between trainee performance in the device and in the training helicopter.

Attempts to predict student performance during flight training, particularly passing performance, on the basis of preflight test performance have a long history (12). The largest single program associated with the development of pilot selection tests has been that of the U.S. Air Force. In that program correlation coefficients as high as .45 have been obtained with an individual predictor test, the Complex Coordination Test, and multiple correlations as high as .70 have been obtained between a battery of written and psychomotor tests and pass-fail criteria (7). Similar results have been achieved by the U.S. Navy (13).

The results of the present study suggest that a helicopter pilot selection test that incorporates measures of performance on a captive helicopter device would compare favorably with the selection procedures developed by the Air Force and Navy for selecting fixed wing aviators. A device such as that used in this study could also be used as a secondary selection tool to identify (for early elimination) trainees whose probability of success during flight training was low.

The Air Force and Navy pilot selection tests were developed for the selection of fixed wing rather than rotary wing aviators. The Army has based its fixed wing pilot selection battery on the Air Force tests. Tests developed by other services for the selection of fixed wing trainees, however, have been unsatisfactory for the selection of Army rotary wing trainees (14). Multiple correlations as high as .54 are found between present specially developed Army rotary wing pilot selection tests and successful completion of helicopter training (3).[1] It would appear that measures of performance on the device used in the present research could be expected to increase the predictive efficiency of Army rotary wing pilot selection procedures.[2] Or, as a secondary selection test after WOCs have arrived at USAPHS for helicopter training, appropriate use of such a device might make possible earlier elimination of inept trainees from the flight training program.

The similarity of the captive helicopter training device concept to the concept of using a light aircraft as a training device prior to actual flight training

[1]At the time of the research reported here, an interim rotary wing selection battery, ARWAB-1, was administered to all applicants for the WORWAC. It was being used in a selection research program conducted by the Behavioral Sciences Research Laboratory rather than as a selection device, however, and it was not a factor in the qualification of applicants for the WORWAC.

[2]No attempt was made to incorporate measures of performance on the device studied here into the WORWAC selection procedures. Such an attempt was outside the scope of the present investigation.

has been noted earlier in this report. Evaluations of performance during such light plane training also have been correlated with subsequent success at flight training in ttempts to increase the efficiency of pilot selection techniques. In one such study (15), checkpilot reports of student error scores after about 15 hours of light plane training correlated .45 with success—passing—in a subsequent Air Force pilot training program.

In addition to the prediction of passing or failing during subsequent flight training, the light plane studies also attempted to predict relative performance within the "pass" category. Correlations up to .46 were obtained between measures of performance in the light plane and measures of performance during subsequent flight training. Although measures obtained as early as the fifth hour of light plane training showed appreciable validity in those studies, measures obtained during the 15th and 25th hours allowed more accurate prediction of performance in Primary and Basic flight training (15). Such Air Force data suggest the possibility that higher correlations might be obtained between performance on the captive helicopter device and subsequent helicopter flight training when the device training is extended beyond the 7¼ hours administered in the present study. The economic gains resulting from any increased predictive efficiency, however, probably would not justify the cost of the extended device training.

Generally, it would appear that the synthetic device used in this research has a potential value as a predictor of flight training performance equal to or exceeding that of apparatus test performances or light plane performances studied in previous attempts to predict flight training performance. Used in connection with other selection techniques, it may be expected to improve both the prediction of success at flight training and the prediction of relative performance among students who are successful at flight training.

Instructor Experience Level

T' Army, in the past, has taken advantage of the relative simplicity of its synth... flight training equipment and has used non-pilot-rated personnel to provide synthetic flight instruction. Other services and commercial airlines have been using relatively more complex equipment, and, with increasing frequency, they are requiring that their device instructors be rated or formerly rated pilots. The device concepts studied in this research are as complex as those incorporated in any training devices, when complexity is defined as the extent to which the synthesized task corresponds to the real-world task. What then are the instructor skill or experience requirements for personnel using devices of the type studied here?

The answer to this question, in the present instance, was that the device instructor need not be a flight instructor or even a rated pilot. All groups of WOCs who participated in the synthetic device training phase of this research were equally proficient, in terms of the flight performance measures previously cited; yet only one-third of them received device training from a rated instructor pilot. The requirement for any type of aeronautical rating or aeronautical experience level per se would appear to be unnecessary for instructors who will be employing similar devices.

The results cited above should not be generalized to other types of synthetic trainers. The tasks being learned by WOCs in the present study were primarily psychomotor in nature, that is, the WOCs were learning to manipulate complex equipment. They were not learning, for the most part, the other aspects of helicopter flight, such as procedures involved in approaches, or time sharing between psychomotor functions and inflight planning functions. Instructing in these aspects of helicopter flight might well lead to a requirement for highly skilled pilots, whereas instructing in the mechanics of device operation did not.

All three device instructors participating in this research, although not necessarily proficient operators of the training helicopter, were well versed in all other relevant aspects of helicopter flight, were highly motivated to teach the assigned WOCs how to operate the devices, and were committed to meeting the objectives of the research program. In fact, each device instructor had contributed to the development of the training being administered. It cannot be inferred from the results of this research that a lower level of instructing competence, familiarity with the training task, or motivation would have led to the same results. The only valid conclusion is that instructors used to administer training on devices of the type involved in this research need not be required to have aeronautical ratings or experience per se; they may be trained as device instructors only.

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80 x 100-yard concrete apron near the flight line at USAPHS. Each area was approximately 60 x 100 feet in size and was marked as is illustrated in Figure A-1 and described below. An instructor and an assistant instructor were assigned to each area.

Each rectangle was bordered on all sides by a series of 4 ½-inch wide stripes (see inset, Figure A-1). The center stripe was used as the "flight path" for the tracking maneuvers described below. Except for the tracking maneuvers, all training took place within the rectangles. Four tie-downs were available 30 feet from the center of each rectangle, as indicated in Figure A-1. Only two opposing tie-downs were used during a given training period; the selection of tie-downs to be used was determined by wind direction. Nylon tethers 26 feet long were attached to opposing outriggers on the GEM platform of the device and were fastened to the two tie-downs in use. This allowed the captive helicopter training device to move approximately 5 ½ feet laterally and 12 feet rearward-forward from the center of the rectangle.

Diagram of Training Rectangle

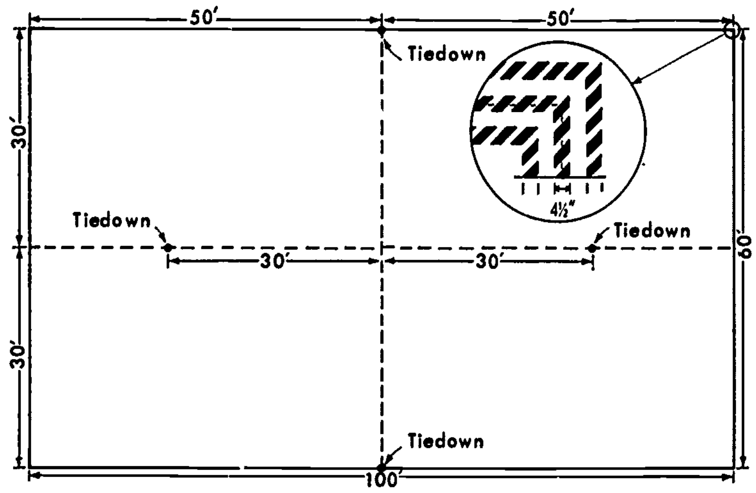

Figure A-1

Description of the Training Programs

General Considerations

The training programs consisted of practice of the tasks or maneuvers described below. The amount of practice received by each group consisted of means of approximately 3 ¼ hours for Group A and 7 ¼ hours for Group B. The orientation session was not included in the training times, nor were times required for briefings and debriefings given by the instructors when the devices

Unclassified

Security Classification

14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Flight Instructor						
Flight Training						
Helicopter Trainer						
Instructor Qualification						
Performance Prediction						
Simulation						
Training						
Training Devices and Simulators						

the three training areas.

Practice on a particular maneuver was independent of scheduling, except that the first training session began with Maneuver 1 as described below. All subsequent training sessions began at the point in training where the preceding session ended, and this point more often was in the course of a maneuver rather than between maneuvers. No "warm-up" periods were provided at the beginning of any session. The interrupted training maneuvers were begun by reminding the WOC of the requirements of the particular maneuver he was to perform, and he immediately began where he had left off.

Orientation for Groups A, B, and C[1]

On the day preceding the start of the experimental training for each WORWAC class involved in this study, the randomly selected experimental and control WOCs were assembled at the training site for a briefing on the objectives of the research and a demonstration of the Whirlymite Helicopter Trainer. At that time, two mimeographed handouts were distributed, which the WOCs were instructed to study before their first training period.[2] The first of these, entitled "Helicopter Controls and Their Use on the Whirlymite Helicopter Trainer," was a general introduction to the use and effects of helicopter control with particular application to the device under study. The second handout, "Primary Hovering Maneuvers for the Whirlymite Helicopter Trainer," described in detail the maneuvers: takeoff and landing, hovering over a spot, hovering forward, backward, and lateral flight, and left and right hovering turns.

After the briefing and a short flight demonstration of the trainer by a research staff member, the WOCs were divided into three groups of approximately equal size (without respect to experimental or control group assignment), and each group assembled around one of three trainers. An instructor then explained the mechanics of the device. The orientation program ended with an informal question and answer period.

Device Familiarization for Groups A and B

At the first training session, each WOC was introduced to his instructor and assistant instructor and taken to his training area. He was seated on

[1]All 99 WOCs in Groups A, B, and C were given the orientation portion of the training. They were told how they were selected to participate in the study, but they were not inform-' ' their group assignments until the following day. WOCs in Group C ', of course, were not included.

[2]Copies of both handouts may be obtained from the HumRRO Division No 6 (Aviation) library.

DISTRIBUTION LIST

2 DIR GASD MANPOWER (PPEGR)
1 CHF OASA ATTN DOC LIB BR
1 DIR WSEG WASH., D.C. 20305
1 DIR OASD MANPOWER & RESERVE AFFAIRS
2 COMDR FLD COMD DEF ATOMIC SPT AGY SANDIA BASE ATTN FCTG7
2 NASA SCI & TECH INFO FACILITY COLLEGE PARK MD
1 CINC US EUROPEAN COMD ATTN SUPPORT PLANS BR J3
1 CINC US ARMY PACIFIC APO 96558 SAN FRAN ATTN G3 CBT DEVEL DIV
2 CG SOUTHERN EUROPEAN TASK FORCE APO 09168 NY
1 CG US ARMY JAPAN APO 96343 SAN FRAN ATTN G3
10 CG US ARMY FORCES SOUTHERN COMD ATTN SCARCD APO 09834 NY
1 CG US ARMY ALASKA ATTN ARACD APO 98749 NY
2 CG US ARMY EUROPE A- 09403 NY ATTN OPNS DIV
1 CO ARMY TRANS RES C -, FT EUSTIS ATTN TECH LIB
1 CG US ARMY AD COMD ENT AFB ATTN ADGCB
6 CG 1ST ARMY FT GEORGE G MEADE
1 CG 3RD US ARMY FT MCPHERSON GA
1 CG FOURTH ARMY FT SAM HOUSTON ATTN G3
7 CG FIFTH ARMY FT SHERIDAN ATTN ALFGC TNG
1 CG SIXTH ARMY PRES OF SAN FRAN ATTN AMAAV
1 CG EUSA ATTN AG-AC APO 96301 SAN FRAN
1 CLIN PSYCHOL SERV DEPT OF NEUROPSYCHIAT WALTER REED GEN HOSP
1 DIR HEL APG MD
1 CG USA CDC EXPERIMENTATION COMD FT ORD
2 ENGNR PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
1 TECH LIB ARMY NATICK LABS NATICK MASS
1 CO USA CDC INST OF LAND CBT FT BELVOIR
1 REDSTONE SCIENTIFIC INFO CTR US ARMYMSL COMD ATTN CHF DOC SEC ALA
1 CO USAPA MBLTY DET TOBYHANNA ARMY DEPOT
1 CG ARMY ELEC PG FT HUACHUCA ATTN TECH LIB
12 CO 1ST AIR DEF GUIDED MSL BRGD TNG FT BLISS
2 CG US ARMY CDC EXPERIMENTATION COMD FT ORD
1 SIXTH U S ARMY LIB DEPOT BLDG M 13 14 PRES OF SAN
1 PLANS OFFICER PSYCH HOQTRES USACDCECFORT ORD
5 CG FT ORD ATTN G3 TNG DIV
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
2 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR ATTN NEUROPSYCHIAT DIV
1 CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1 DPTY FOR BIOASTRONAUT PG AIR PG CTR EGLIN AFB
1 CO USA MOBILITY EQUIP RED CTR ATTN TECH DOC CTR FT. BELVOIR
1 CO FRANKFORD ARSNL ATTN SMUFA-N6400/202-4
1 CG 5TH RGN USARADCOM ATTN G3 TNG GUNTER AFB ALA
3 6TH RGN USARADCOM FT BAKER
1 4TH ARMY MSL COMD AIR TRANSPORTABLE SAN FRAN
1 PERS SUBSYS DIV CREW SUBSYS DRCT AERONAUT SYS DIV WRIGHT-PATTERSON AFB
1 DIR ARMY BD FOR AVN ACCIDENT RES FT RUCKER
2 CO PICATINNY ARSNL DOVER N J ATTN SURPA VCI
1 DEF SUPPLY AGY CAMERON STATION ATTN LIB
1 CO ARMY CBT DEVEL COMD FT BENJ HARRISON ATTN ADJ GEN AGY
1 REF M MS IS NASA ALA
1 CBT OPNS RES GP CDC FT BELVOIR ATTN SR OPNS ANLS HUMAN FACTORS
1 CO ARMY CDC INF AGY FT BENNING
1 CO ARMY CDC ARMOR AGY FT KNOX
8 ARMY CDC SPEC WARFARE AGY FT BRAGG
1 EVAL DIV DAO ARMY SIG CTR + SCH FT MONMOUTH
1 CO US ARMY CDC AVN AGCY FT RUCKER
1 CHF CURRICULUM BR RESIDENT INSTR DEPT ARMY LOGISTICS MANGT CTR FT LEE
1 SPEC WARFARE SCH LIB FT BRAGG
4 USA SPEC WARFARE SCH ATT: COUNTERINSURGENCY DEPT FT BRAGG
1 ARMY SIG CTR + SCH FT MONMOUTH ATTN TNG LIT DIV DAD
2 SECY US ARMY MSL & MUNITIONS CTR & SCH REDSTONE ARSNL
2 COMDT-WOMENS ARMY CORPS SCH + CTR FT MCCLELLAN
2 HQ ABERDEEN PG ATTN TECH LIB
1 COMDT US ARMY INTEL SCH FT HOLABIRD
1 COMDT ARMY QM SCH OFC DIR OF NONRESID ACTVY FT LEE ATTN TNG MEDIA DIV
2 DIR BRGD + BN OPNS DEPT USAIS FT BENNING
1 DIR COMM ELEC USAIS FT BENNING
1 DIR ABN-AIR MOBILITY DEPT USAIS FT BENNING
2 DIR COMPANY TACTICS DEPT USAIS FT BENNING
1 CG US ARMY SIGNAL CTR & SCH ATTN SIGOTL-3 (CORET II)
1 SECY OF ARMY, PENTAGON
1 DCS-PERS DA ATTN CHF C+S DIV
1 DIR OF PERS STUDIES + RES ODCSPER DA ATTN BG WALLACE L CLEMENT
1 CO FOREIGN SCI + TECH CTR MUN BLDG
2 ACS FOR FORCE DEVEL DA ATTN CHF TNG DIV
1 CG USA MAT COMD ATTN AMCRD-TE
1 CHF OF ENGNRS DA ATTN ENGTE-T
1 HQ ARMY MAT COMD R+D DRCTE ATTN AMCRD-RC
2 CG ARMY MED R+D COMD ATTN BEHAV SCI RES BR
1 US ARMY BEHAVIORAL SCI RES LAB WASH. D.C. ATTN: CRD-AR
1 OPO PERS MGT DEV OFC ATTN MOS SEC (NEW EQUIP) OPOMD
1 ARMY PROVOST MARSHAL GEN
1 DIR CIVIL AFFAIRS DRCTE ODCSOPS
1 OFC RESERVE COMPON DA
2 CHF ARMY SECUR AGY ARLINGTON HALL STA ATTN AC OF S G1
50 ADMIN DDC ATTN: TCA (HEALY) CAMERON STA ALEX., VA. 22314
1 CO US ARMY MED RES LAB FT KNOX
1 CG ARMY ELECT COMD FT MONMOUTH ATTN AMSEL CB
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
2 CG ARMY MED R+D COMD ATTN MEDDH-SR
1 U S ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN CRD-AIC
1 COMDT ARMY CBT SURVEIL SCH FT HUACHUCA ATTN ATSUR S3
2 TNG + DEVEL DIV ODCS-PERS
1 CO US ARMY MAT COMD WASH D.C. ATTN: AMCPI-CM ROBT DETIENNE
1 PRES ARMY ARMOR BD FT KNOX
1 PRES ARMY MAINT BD FT KNOX
2 PRES ARMY AVN TEST BD FT RUCKER
2 PRES ARMY ARTY BD FT SILL
1 DPTY PRES ARMY MAT COMD BD ABERDEEN PG
1 CO ARMY CBT DEVEL COMD MILIT POLICE AGY FT GORDON
1 US ARMY ARCTIC TEST CTR R & D OFFICE SEATTLE
1 CG 2D ARMORED DIV FT HOOD ATTN DIV AVN OFCR
6 CG 4TH ARMORED DIV APO 09326 NY
4 CO 2D ARMORED CAV REGT APO 09696 NY
1 CO 3D ARMORED CAV REGT APO 09034 NY
1 CO 14TH ARMORED CAV REGT APO 09026 NY
2 CG ARMY ARMOR & ARTY FIRING CTR FT STEWART ATTN AC OF S TNG OFCR
1 1ST ARMORED DIV HQ & HQ CO FT HOOD ATTN AC OF S G2
10 1ST INF DIV 1ST MED TANK BN 63D ARMOR FT RILEY
4 3D INF DIV 1ST BN 64TH ARMOR APO 09036 NY
2 1ST TANK BN 73D ARMOR 7TH INF DIV APO 96207 SAN FRAN
8 8TH INF DIV 2D BN 68TH ARMOR APO 09034 NY
1 CO COMPANY A 3D BN 32D ARMOR 3D ARMORED DIV (SPEARHEAD) APO 09039 NY
1 CO 5TH BN 33D ARMOR FT KNOX
1 CO 3D MED TANK BN 37TH ARMOR APO 09066 NY

ing some lift into the rotor blades, activate the pedal controls. A series of pedal commands followed, in the order left, right, left, right, left, again given to ascertain proper radio contact and to demonstrate the action of the pedal controls. No data were recorded during this maneuver.

A WOC's progress through the remainder of the training program was determined by his own proficiency. As he met the criterion of performance for a given maneuver, he went on to the next maneuver. Two types of criteria were utilized: performance at a predetermined, objectively evaluated skill level (Maneuvers 2, 3, 4, 5, 6, 9a, and 10a); and number of trials performed (Maneuvers 7, 8, 9b, and 10b). In the case of Maneuver 5, however, the requirement to perform at a particular skill level was waived for any WOC not meeting the criterion within 20 trials. In such cases, the number of trials performed—20—became the criterion.

Device Training for Group A

The seven device training maneuvers performed by Group A WOCs are described below. Along with each description, the specific data collected during the training are indicated. All data collection was performed by the assistant instructor. The function of the instructor during the training sessions was to instruct. The device was tethered, and the emergency cutoff cable, operated by the assistant instructor, was attached at all times during Maneuvers 1 through 5.

Maneuver 2: 60-Second Hover. To accomplish this maneuver, the WOC was allowed an unlimited number of trials to hover the helicopter above the ground effects machine platform for a 60-second period. The instructor maintained constant radio contact with him, giving control instructions as needed. Each trial began when all four pads of the helicopter left the platform and ended when one or more pads touched down on the platform. If the WOC completely lost control of the device, the assistant instructor activated an emergency cutoff switch, causing the helicopter engine to stop and the helicopter to settle back on the GEM platform. The assistant instructor timed each trial, and, when the criterion of a 60-second trial was reached, recorded the number of trials required to reach criterion performance and the elapsed training time since the beginning of the first training session, that is, since the start of Maneuver 1. All WOCs were required to meet the 60-second hover criterion before going on to the next maneuver.

[1]The text of the standardized instructions may be obtained from the HumRRO Division No. 6 (Aviation) library.

1 US ARMY TROPIC TEST CTR PO DRAWER 942 ATTN BEHAV SCIENTIST FT CLAYTON
2 CINC US PACIFIC FLT FPO 96514 SAN FRAN
1 CINC US ATLANTIC FLT CODE 312A NORFOLK ATTN LTC DOTY
1 CINC PACIFIC OPNS ANLS SECT FPO 96610 SAN FRAN
1 COR TNG COMMAND US PACIFIC FLT SAN DIEGO
1 CHF BUR OF MED + SURG DN ATTN CODE 513
1 HEAD CLIN PSYCHOL SECT PROFESNL DIV BUR OF MED + SURG DN
5 TECH LIB PERS 11B BUR OF NAV PERS ARL ANNEX
3 DIR PERS RES DIV BUR OF NAV PERS
1 TECH LIB BUR OF SHIPS CODE 210L NAVY DEPT
1 HUMAN FACTORS BR PSYCHOL RES DIV ONR
1 ENGNR PSYCHOL BR ONR CODE 455 ATTN ASST HEAD WASH DC
3 CO + DIR NAV TNG DEVICE CTR ORLANDO ATTN TECH LIB
1 CO FLT ANTI-AIR WARFARE TNG SAN DIEGO
1 CO NUCLEAR WEAPONS TNG CTR PACIFIC U S NAV AIR STA SAN DIEGO
1 CO NAV AIR DEVEL CTR JOHNSVILLE PENNA ATTN NADC LIB
2 FLT ANTI-AIR WARFARE TNG CTR DAM NECK VA BEACH
2 CO FLT TNG CTR NAV BASE NEWPORT
2 CO FLT TNG CTR NORFOLK
1 CO FLEET TNG CTR U S NAV STA SAN DIEGO
1 CLIN PSYCHOL MENTAL HYGIENE UNIT US NAV ACAD ANNAPOLIS
1 PRES NAV WAR COLL NEWPORT ATTN MAHAN LIB
2 CO + DIR ATLANTIC FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1 CO NUCLEAR WEAPONS TNG CTR ATLANTIC NAV AIR STA NORFOLK
2 CO FLT SONAR SCH KEY WEST
1 CO FLT ANTI-SUB WARFARE SCH SAN DIEGO
1 CHF OF NAV RES ATTN SPEC ASST FOR R & D
1 CHF OF NAV RES ATTN HEAD PERS + TNG BR CODE 458
1 CHF OF NAV RES ATTN HEAD GP PSYCHOL BR CODE 452
1 DIR US NAV RES LAB ATTN CODE 5120
5 CO OFF OF NAV RES BR OFFICE BOX 39 FPO 09510 NY
1 CHF OF NAV AIR TNG TNG RES DEPT NAV AIR STA PENSACOLA
1 CO NAV SCH OF AVN MED NAV AVN MED CTR PENSACOLA
1 CO MED FLD RES LAB CAMP LEJEUNE
1 COR NAV MSL CTR POINT MUGU CALIF ATTN TECH LIB CODE 3022
1 DIR AEROSPACE CREW EQUIP LAB NAV AIR ENGNR CTR PA
2 OIC NAV PERS RES ACTVY SAN DIEGO
1 NAV NEUROPSYCHIAT RES UNIT SAN DIEGO
2 COR NAV MSL CTR CODE 5342 POINT MUGU CALIF
1 DIR PERS RES LAB NAV PERS PROGRAM SUPPORT ACTIVITY WASH NAV YD
1 NAV TNG PERS CTR NAV STA NAV YD ANNEX CODE 83 ATTN LIB WASH
1 COMDT MARINE CORPS HQ MARINE CORPS ATTN CODE AO-1B
1 HQ MARINE CORPS ATTN AX
1 DIR MARINE CORPS EDUC CTR MARINE CORPS SCH QUANTICO
1 DIR MARINE CORPS INST ATTN EVAL UNIT
1 CHF OF NAV OPNS OP-01P1
1 CHF OF NAV OPNS OP-03T
1 CHF OF NAV OPNS OP-07T2
2 COMDT HQS 8TH NAV DIST ATTN EDUC ACV NEW ORLEANS
1 CHF OF NAV AIR TECH TNG NAV AIR STA MEMPHIS
1 DIR OPS EVAL GRP OFF OF CHF OF NAV OPS OP03EG
2 COMDT PTP COAST GUARD HQ
1 CHF OFCR PERS RES + REVIEW BR COAST GUARD HQ
1 OPNS ANLS OFC HQ STRATEGIC AIR COMD OFFUTT AFB
1 AIR TNG COMD RANDOLPH AFB ATTN ATFTM
1 CHF SCI DIV DRCTE SCI + TECH DCS R+D HQ AIR FORCE AFRSTA
1 CHF SPEC WARFARE DIV DRCTE OF PLANS + OPNS DCS-PLANS+OPNS HQ AIR FORCE
1 CHF OF PERS RES BR DRCTE OF CIVILIAN PERS DCS-PERS HQ AIR FORCE
1 CHF ANAL DIV (AFPDPL (R) DTR OF PERSONNEL PLANNING HQS USAF
1 AFSC-STLO (RTSAW) CO DEPT OF THE NAVY
1 FAA CHF INFO RETRIEVAL BR WASH D.C.
1 FED AVN AGY MED LIB HC-640
1 HQ AFSC SCBB ANDREWS AFB
2 COR ELEC SYS DIV L G HANSCOM FLD BEDFORD MASS ATTN ESRHA
1 HQ SAMSO (SMSIR) AF UNIT POST OFC LA AFS CALIF
2 MILIT TNG CTR OPE LACKLAND AFB
2 6570TH AERO MED RES LAB MRPT WRIGHT-PATTERSON AFB
1 AIR MOVEMENT DESIGNATOR AMRH BROOKS AFB
1 HQS ATC DCS/TECH TNG (ATTMS) RANDOLPH AFB
4 HQ AIR TRANS COMD ATCIO-M RANDOLPH AFB
1 COR ELEC SYS DIV LG HANSCOM FLD ATTN ESTI
1 R M STOGDILL OHIO STATE UNIV
1 EDITOR TNG RES ABSTR AMER SOC OF TNG DIRS U OF TENN
1 U OF CHICAGO DEPT OF SOC
1 HUMAN FACTORS SECT R+D GEN DYNAMICS ELECTRIC BOAT GROTON
1 CTR FOR RES IN SOCIAL SYS AMER U
6 BRITISH EMBSY BRITISH DEF RES STAFF WASHINGTON
3 CANADIAN JOINT STAFF OFC OF DEF RES MEMBER WASHINGTON
3 CANADIAN ARMY STAFF WASHINGTON ATTN GSO2 TNG
2 CANADIAN LIAISON OFCR ARMY ARMOR BD FT KNOX
1 GERMAN LIAISON OFCR ARMY AVN TEST BD FT RUCKER
5 ACS FOR INTEL FOREIGN LIAISON OFCR TO NORWEG MILIT ATTACHE
1 ARMY ATTACHE ROYAL SWEDISH EMBSY WASHINGTON
1 NATL INST FOR ALCOHOL RES OSLO
1 DEF RES MED LAB ONTARIO
2 FRENCH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 BRITISH LIAISON OFCR ARMY AVN TEST BD FT RUCKER
1 OFC OF AIR ATTACHE AUSTRALIAN EMBSY ATTN: T.A. NAVGN WASH. D.C.
1 YORK U DEPT OF PSYCHOL
2 AUSTRALIAN EMBSY OFC OF MILIT ATTACHE WASHINGTON
2 U OF SHEFFIELD DEPT OF PSYCHOL
1 MENNINGER FOUNDATION TOPEKA
2 AMER INST FOR RES SILVER SPRING
1 AMER INST FOR RES PGH ATTN LIBN
1 DIR PRIMATE LAB UNIV OF WIS MADISON
1 COLUMBIA U SCH OF BUS
3 MATRIX CORP ALEXANDRIA ATTN TECH LIBN
1 AMER TEL+TEL CO NY
1 U OF GEORGIA DEPT OF PSYCHOL
1 DR GEORGE T HAUTY CHMN DEPT OF PSYCHOL U OF DEL
1 GEN ELECTRIC CO SANTA BARBARA ATTN LIB
1 VITRO LABS SILVER SPRING MD ATTN LIBN
1 HEAD DEPT OF PSYCHOL UNIV OF SC COLUMBIA
1 TENN VALLEY AUTHORITY ATTN CHF LABOR RELATIONS BR DIV OF PERSONNEL KNOXVILLE
1 U OF GEORGIA DEPT OF PSYCHOL
1 U OF UTAH DEPT OF PSYCHOL
1 CS CO WASH D C
1 AMER INST FOR RES PALO ALTO CALIF
1 MICH STATE U COLL OF SOC SCI
1 N MEX STATE U
1 ROWLAND + CO HADDONFIELD NJ ATTN PRES
1 NORTRONICS DIV OF NORTHROP CORP ANAHEIM CALIF
1 OHIO STATE U SCH OF AVN
1 AIRCRAFT ARMAMENTS INC COCKEYSVILLE MD
2 OREGON STATE U DEPT OF MILIT SCI ATTN ADJ
1 TUFTS U HUMAN ENGNR INFO + ANLS PROJ
1 HUMAN FACTORS RES GP WASH U ST LOUIS
1 AMER PSYCHOL ASSOC WASHINGTON ATTN PSYCHOL ABSTR
1 NO ILL U HEAD DEPT OF PSYCHOL
1 BELL TEL LABS INC TECH INFO LIB WHIPPANY LAB NJ ATTN TECH REPORTS LIBN
1 ENGNR LIB FAIRCHILD HILLER REPUBLIC AVN DIV FARMINGDALE N Y
1 WASHINGTON ENGNR SERV CO INC KENSINGTON MD
1 LIFE SCI INC FT WORTH ATTN PRES
1 AMER BEHAV SCI CALIF
2 DIR INSTR RESOURCES STATE COLL ST CLOUD MINN
1 COLL OF WM + MARY SCH OF EDUC
1 SO ILLINOIS U DEPT OF PSYCHOL
2 COMMUNICABLE DISEASE CTR DEVEL + CONSULTATION SERV SECT ATLANTA
2 WASH MILITARY SYS DIV BETHESDA MD
1 NORTHWESTERN U DEPT OF INDSTR ENGNR
1 HONEYWELL ORD STA MAIL STA 606 MINN
1 NY STATE EDUC DEPT ABSTRACT EDITOR AVCR
1 AEROSPACE SAFETY DIV U OF SOUTHERN CALIF LA
1 MR BRANDON B SMITH RES ASSOC U OF MINN
1 CTR FOR THE ADVANCED STUDY OF EDUC ADMIN ATTN IONE PIERRON U OF OREG
1 A A HEYL ASSOC DIR CAREL WASH DC
1 CHF PROCESSING DIV DUKE U LIB
1 U OF CALIF GI - LIB DOCU DEPT
1 FLORIDA STATE U LIB GIFTS + EXCH
1 HARVARD U PSYCHOL LABS LIB
1 U OF ILL LIB SER DEPT

Maneuver 3: Tethered Turns. The criterion for this maneuver was performance of a 360° turn, a 180° turn, a 90° turn, and a 720° turn, in that order, while remaining at a hovering altitude, that is, without running the trainer up against the built-in stops governing freedom of movement in an upward direction (indicated to the instructor by a signal light mounted above the gas tank), or contacting the platform. With reduced pressure on the platform, the WOC was instructed to "follow the instructor" as he paced off a 90° arc, first to the student's left, then back to the right. This was done to demonstrate the desired rate of turn. The student was then instructed to hover the device and make a 360° turn to the left. If successful, he went on to 180°, 90°, and 720° turns. If unsuccessful, he continued to make alternating left and right 360° or 180° or 90° or 720° turns until the criterion for each turn was met. The assistant instructor recorded the elapsed training time since meeting the criterion for the preceding maneuver. All WOCs were required to meet the tethered turns criterion before proceeding to the next maneuver.

Maneuver 4: Slack Hover. A slack hover was defined as a hover 60 seconds long in which neither of the restraining tethers became taut. A criterion of two consecutive slack hovers was required before proceeding to the next maneuver. At the completion of the first successful trial, the student was directed to land from a hover and then to take the device back to a hover for a second 60-second period while maintaining slack in the tethers. Each trial began when the captive helicopter left the platform and ended when (a) one or both tethers became taut, (b) one or more pads touched the platform, or (c) 60 seconds had elapsed. When the criterion for this maneuver was reached, the elapsed training time since meeting the criterion for the preceding maneuver was recorded. All WOCs were required to meet the slack hover criterion before proceeding to the next maneuver.

Maneuver 5: Slack Turns. A slack turn was defined as a 360° turn, made at a rate of approximately 15° per second, in which neither of the restraining tethers became taut. The WOC was instructed to establish a hover, head the device toward the instructor, check for slack in the safety tethers, and then make a 360° turn at the rate demonstrated during Maneuver 3, maintaining slack throughout the turn. The assistant instructor timed each turn and noted the presence or absence of slack in the two restraining tethers. After each unsuccessful trial the student was informed of his relative turn rate and tether slack condition. This procedure was continued until the WOC made a slack turn within 22-26 seconds or until 20 trials of alternating left and right turns had been completed. Upon reaching the criterion, or after 20 unsuccessful trials, the elapsed training time since the slack hover criterion had been met was recorded, and the WOC proceeded to the next maneuver.

Maneuver 6: Rectangular Tracking With Tether. For this maneuver, one tether was completely removed. The instructor hand-carried the other while the assistant instructor carried the safety cutoff cable. The WOC was required to traverse one side of the rectangle (see Figure A-1) in each of four directions of movement—forward, backward, laterally to the left, and laterally to the right. Along each side he was given a "stop" command via the radio and was required to bring the device to a stationary position within a ground distance of approximately six feet. At the end of each side, he was required to come to a stop without running over the border of the rectangle.

The relative position of the "stop-on-signal" commands was varied along each side to prevent anticipatory responses. For each side of the rectangle, or trial, the assistant instructor recorded as satisfactory or unsatisfactory the WOC's responses to the stop-on-signal command and the stop-at-end requirement. The WOC was required to have one satisfactory trial in each direction of movement to meet the criterion. Upon successful completion of this maneuver, the safety cutoff cable and the remaining tether were removed, and the WOC was ready to "solo" the device. The elapsed time since meeting the criterion for the preceding maneuver was recorded. All subsequent maneuvers were performed without tethers or emergency cutoff cable attached to the device.

Maneuver 7: Rectangular Tracking. In this maneuver, the WOC again tracked around the border of the training area shown in Figure A-1. He was instructed that the 4 1/2-inch wide center stripe was the proper "flight path," and this line was to be centered under the trainer, that is, under the seat of his pants. He tracked completely around the rectangle in each of the four directions of movement in turn: forward, backward, laterally to the left, and laterally to the right.

The data recorded by the assistant instructor during the rectangular tracking maneuver consisted of the number of times per side of the rectangle that the WOC deviated from the flight path and the cumulative time per side that he remained off the flight path. The WOC was judged to be off the flight path whenever a reference plumb suspended beneath the seat of the trainer moved away from the 4 1/2-inch center stripe. In order to keep time per trial constant for all WOCs, the instructor walked parallel to the flight path at a rate of approximately 100 feet per 35 seconds and instructed the WOC to keep abreast of him at all times. At each corner of the rectangle the trainer was stopped and realigned as necessary before starting down the next side.

There was no criterion for this maneuver. It and Maneuver 8, Precision Turns, were practiced alternately by Group A WOCs throughout the remainder of their approximately 3 1/4 hours of device training.

Maneuver 8: Precision Turns. This maneuver consisted of a series of 11 left and 11 right 360° turns, in an alternating LRLR sequence, and at a prescribed constant rate of 15° per second. The assistant instructor recorded the time of each 180° of each turn, and the instructor provided verbal feedback concerning the rate of turn and its constancy to the WOC.

There was no criterion for this maneuver, and Group A WOCs continued to practice it alternately with Maneuver 7 for the remainder of their approximately 3 1/4 hours of device training.

Device Training for Group B

The first approximately 3 1/4 hours of training on the captive helicopter device received by Group B was identical to that received by Group A. In addition, any Group B WOC who had not completed Maneuvers 1 through 6 and had not performed Maneuvers 7 and 8 at least one time each prior to having received 3 1/4 hours of training was given training identical to that of Group A until he had done so. Upon completion of approximately 3 1/4 hours of training and having performed Maneuvers 7 and 8 at least one time each, members of Group B began practicing an abbreviated form of these latter two maneuvers. The abbreviated form of Maneuver 7 consisted of tracking one long and one short side of the rectangle in each of the four directions instead of all four sides. The abbreviated form of Maneuver 8 consisted of a series of five left and five right 360° turns instead of 10 of each. The procedures and the data collected on these abbreviated maneuvers, however, remained the same.

In addition to these two maneuvers, Group B WOCs performed two additional two-part maneuvers (9 and 10) not performed by Group A WOCs. These maneuvers were performed alternately with Maneuvers 7 and 8. This procedure continued until Group B WOCs had received approximately 7 $^1/_4$ hours of training, at which point the device training program for Group B was terminated.

14-Inch Hoop With 10-Inch Reducing Ring Mounted on the Synthetic Device

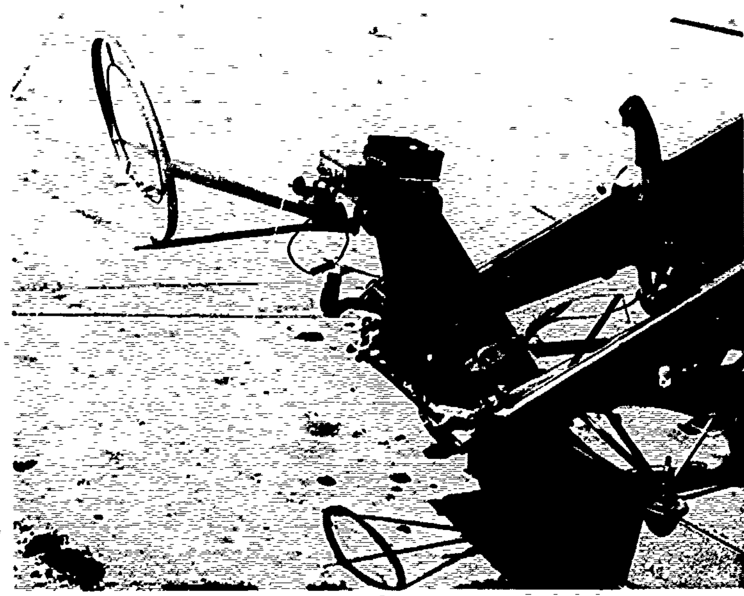

Figure A-2

Maneuvers 9 and 10 involved an apparatus designed and constructed specifically for the present research program. It served two purposes: (a) the apparatus provided a task requiring a more highly developed level of device control skill than was required otherwise, and (b) it enabled the researcher to measure more accurately the differences in performance of WOCs during the latter stages of their training on the device. This apparatus is pictured in Figures A-2 and A-3 and is described below.

A metal hoop 14 inches in diameter, with a removable reducing ring of 10-inch diameter, was mounted on the instrument pedestal of the helicopter portion of the device as shown in Figure A-2. At the bottom center of the hoop a metal rod protrudes 2$^1/_2$ inches in front of and perpendicular to the 14-inch hoop. This rod served as a "pointer" during Maneuver 9; the 14-inch hoop and the 10-inch reducing rings were used in Maneuver 10. Both the pointer and the hoop with its reducing ring were used in conjunction with a roll-about stand.

The roll-about stand, which is shown in Figure A-3, was constructed of 2 x 4-inch lumber, a 1-inch aluminum tube, a flexible 30-inch radio antenna, and rubber casters. Half-inch colored plastic tape was used to mark off a 6-inch segment of the upright tube. The center of the

Roll-About Stand

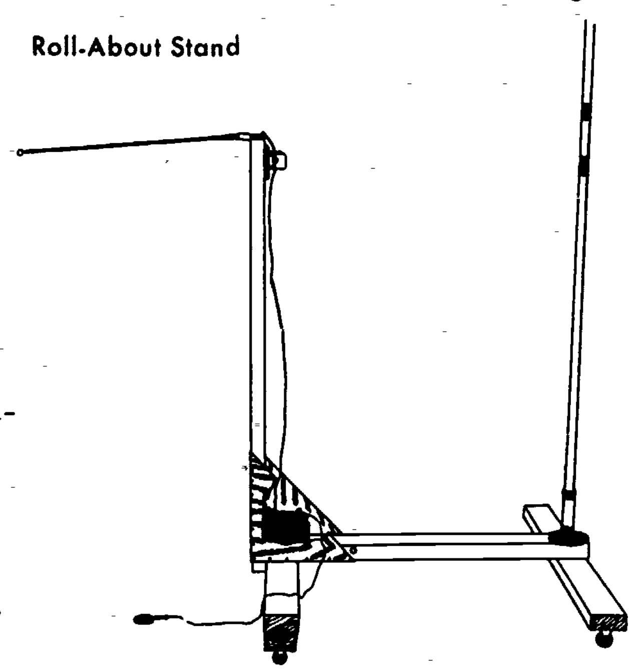

Figure A-3

segment was at a medium hovering height above the ground for the device. Centered within the 6-inch segment of the tube was a 4-inch segment marked off by plastic tape of another color. A 6-volt dry cell battery was mounted at the base of the stand (not visible in Figure A-3), and one pole of the battery was wired to the flexible antenna. An electromechanical digital counter was placed in the circuit between the battery and the antenna. (The second pole was wired to the 14-inch hoop during Maneuver 10).

Maneuver 9a: 6-Inch Altitude Control. This maneuver involved the pointing rod at the bottom of the 14-inch hoop and the 6-inch segment marked off on the upright pole attached to the roll-about stand. The stand was placed in front of the device, and the WOC was instructed to hover the helicopter so that the pointer remained within the 6-inch altitude range indicated on the rod, as shown in Figure A-4. The WOC was given seven trials of 30 seconds duration. The criterion for this maneuver was maintaining the pointer between the specified altitude limits for 25 seconds out of the 30-second trial for three consecutive trials. The assistant instructor timed each trial, and, sighting over the 2 x 4 upright on the opposite end of the stand, he recorded the time within the 6-inch tolerance for each trial. Upon reaching the criterion of hovering within the 6-inch altitude range for 25 out of 30 seconds for three consecutive trials, the WOC proceeded to Maneuver 9b and did not return to Maneuver 9a at a later time. If he failed to reach criterion performance, he proceeded to Maneuver 10 and returned to Maneuver 9a for up to seven more trials immediately following his next performance of Maneuver 8.

Precision Altitude Control (Maneuver 9)

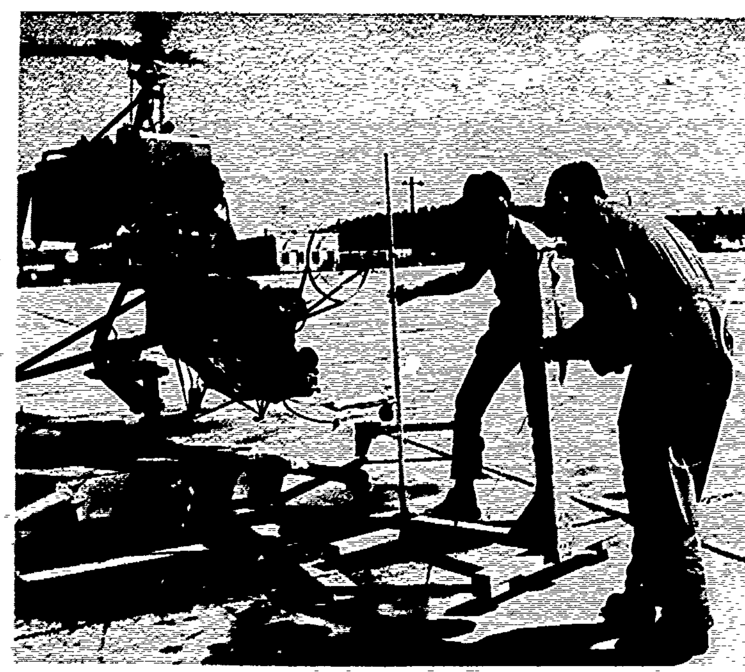

Figure A-4

Maneuver 9b: 4-Inch Altitude Control. This maneuver was identical to Maneuver 9a, except that the altitude tolerance was reduced to four inches instead of six, that is, the tapes on the upright tube denoting the 4-inch altitude range constituted the upper and lower tolerances of altitude for this maneuver. There was no criterion. The WOC continued to practice this maneuver, after each performance of Maneuver 8, until his device training was terminated at approximately the 7 1/4-hour level. The assistant instructor recorded the time that the pointer remained within the 4-inch altitude range during each of the seven 30-second trials that constituted the maneuver.

Maneuver 10a: 14-Inch Hoop. For this maneuver, the 10-inch reducing ring was removed from the hoop mounted on the device, and a lead from the battery mounted on the roll-about stand was attached to the rim of the hoop.

Thus, any time the antenna mounted on the stand contacted the hoop, the circuit was completed, and the electromechanical counter registered the contact.

The task of the WOC during this maneuver was to bring the device to a hover, "fly" up to the stand so that the antenna was inserted inside the hoop, and remain in that position until 60 seconds had elapsed, as shown in Figure A-5. A trial consisted of 60 seconds during which the antenna was inside the hoop. In cases where the WOC was unable to maintain this condition for 60 consecutive seconds, the time the antenna was in the hoop was accumulated until the full 60 seconds had been reached. The maneuver consisted of five trials, and the assistant instructor recorded the number of contacts, as indicated by the electromechanical counter, at the end of each trial.

The criterion for this maneuver was five contacts or less during a 60-second trial. Upon reaching this criterion, the WOC proceeded to Maneuver 10b and did not return to Maneuver 10a at a later time. If he failed to reach criterion performance within the five trials which constituted the maneuver, he returned to Maneuver 7 and repeated Maneuver 10a for up-to-five-more-trials immediately following his next performance of Maneuver 9b (or of Maneuver 9a if he continued to fail to reach criterion performance on that maneuver).

Maneuver 10b: 10-Inch Hoop. This maneuver was identical to Maneuver 10a, except that the 10-inch reducing ring was placed inside the 14-inch hoop, and the WOC was required to keep the antenna within this smaller hoop. There was no criterion for Maneuver 10b. The WOC continued to practice this maneuver, after each performance of Maneuver 9a or 9b, until his device training was terminated at the 7 1/4-hour level. The assistant instructor recorded the number of contacts, as indicated by the electromechanical counter, at the end of each of the five trials that constituted this maneuver.

Precision Hovering (Maneuver 10)

Figure A-5

Appendix B

TABLES FOR IDENTIFICATION AND DERIVATION OF PREDICTOR VARIABLES AND THE INTERCORRELATION OF PREDICTOR VARIABLES AND OF CRITERION VARIABLES

Table B-1

Identification of Device Training Maneuver From Which Predictor Variables Were Derived

Maneuver		Predictor Variable Number
Number	Name	
1	Device familiarization	None
2	Sixty-second hover	1 and 2
3	Tethered turns	3 and 4
4	Slack hover	5 and 6
5	Slack turns	7 and 8
6	Tracking with tether	9 – 12
7	Rectangular tracking	13 – 28
8	Precision turns	29 – 40
9a	Six-inch altitude control	46 and 47
9b	Four-inch altitude control	48 – 50
10a	Fourteen-inch hoop	41 and 42
10b	Ten-inch hoop	43 – 45

Table B-2

Synthetic Device Performance Scores of Predictor Variables

Number	Predictor Variables
1	Time to 60-second hover (z-score)
2	Trials to 60-second hover
3	Absolute time to tethered turns criterion (z-score)
4	Cumulative time to tethered turns criterion (z-score)
5	Absolute time to slack hover criterion (z-score)
6	Cumulative time to slack hover criterion (z-score)
7	Absolute time to slack turn completion (z-score)
8	Cumulative time to slack turn completion (z-score)
9	Absolute time to tethered tracking (z-score)
10	Cumulative time to tethered tracking (z-score)
11	Errors to criterion stop at end, tethered tracking
12	Errors to criterion stop on signal, tethered tracking
	First performance rectangular tracking time off target:*
13	Forward
14	Aft
15	Lateral left
16	Lateral right
	Mean time off target per trial:*
17	Forward
18	Aft
19	Lateral left
20	Lateral right
	First performance rectangular tracking frequency off target:*
21	Forward
22	Aft
23	Lateral left
24	Lateral right
	Mean frequency off target per trial:*
25	Forward
26	Aft
27	Lateral left
28	Lateral right
	First performance precision turns deviation scores left turn:**
29	First 180°
30	Second 180°
31	Difference score (29 minus 30)
	Mean errors all left turns:**
32	First 180°
33	Second 180°
34	Difference score (32 minus 33)
	First performance precision turns deviation scores right turns:**
35	First 180°
36	Second 180°
37	Difference score (35 minus 36)
	Mean errors all right turns:**
38	First 180°
39	Second 180°
40	Difference score (38 minus 39)
41	Number of contacts per trial on 14-inch hoop
42	Trials to 10-inch hoop
43	10-inch hoop errors per trial
44	10-inch hoop number of perfect trials
45	10-inch hoop number of trial series performed
46	Altitude 6 inches time per trial
47	Trials to altitude 4 inches
48	Time per trial altitude 4 inches
49	Altitude 4 inches number of perfect trials
50	Altitude 4 inches number of trial series performed

* Per side.

** Deviation from 12 seconds per 180° of turn.

Table B-3

Intercorrelations of 50 Predictor Variables

Predictor Variable Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1
2	.75
3	.34	.25
4	.89	.66	.66
5	.26	.20	.13	.25
6	.79	.55	.54	.84	.66
7	-.28	-.23	-.20	-.28	-.16	-.26
8	.64	.50	.46	.69	.63	.85	.00
9	.22	.10	.09	.16	-.02	.19	-.11	.12
10	.67	.49	.42	.69	.59	.86	-.06	.97	.30
11	.37	.18	.03	.31	-.03	.30	-.15	.11	.54	.26
12	.17	.01	.15	.14	-.04	.17	-.12	.07	.74	.24	.59
13	.17	.10	-.12	.08	.02	.03	-.02	.08	-.01	.09	-.12	-.13
14	.12	.05	-.24	.01	.08	.04	-.07	.11	.14	.13	-.04	-.14	.75
15	.14	.00	-.17	.08	-.03	.02	-.05	-.03	-.09	.00	.01	-.09	.53	.54
16	.14	.05	-.08	.12	-.09	-.01	.10	.10	-.02	.07	-.03	-.03	.46	.34	.66
17	.22	.16	-.08	.15	.11	.10	-.07	.22	.07	.23	-.10	-.01	.78	.63	.35	.40
18	.14	.10	-.14	.09	.04	.01	-.12	.15	.18	.15	-.04	-.06	.59	.78	.37	.35	.81
19	.18	.10	-.11	.15	.15	.10	-.12	.14	-.14	.16	-.04	-.19	.53	.55	.77	.55	.60	.66
20	.17	.14	-.05	.16	.05	.04	.07	.20	-.01	.15	-.09	-.12	.43	.33	.48	.72	.51	.51	.60
21	.10	-.01	.11	.16	-.04	.09	-.12	-.03	.07	.00	-.16	-.21	.39	.36	.24	.15	.40	.36	.34	.18
22	.24	.10	-.15	.15	.03	.13	-.02	.05	-.10	.06	.06	-.09	.30	.24	.32	.18	.09	-.01	.17	.08	.41
23	-.07	-.13	.00	-.09	.15	-.09	.01	.04	-.16	-.02	-.38	-.23	.15	.04	-.07	.04	.25	.10	.07	.06	.29	.18
24	.20	-.03	-.06	.16	.09	.13	.03	.16	-.04	.12	-.05	-.06	.29	.06	.03	.15	.36	.13	.14	.16	.44	.33	.61
25	.21	.04	-.07	.15	.07	.12	-.08	.04	.05	.07	-.04	-.13	.57	.39	.18	.21	.72	.54	.41	.34	.75	.32	.42	.60
26	.24	.08	-.11	.18	-.02	.12	-.04	.08	-.12	.07	-.03	-.05	.41	.20	.19	.17	.41	.18	.24	.26	.52	.70	.46	.69	.66
27	-.01	-.05	.01	-.01	.17	-.02	.11	.10	.02	.08	-.21	-.07	.29	.08	-.14	.05	.48	.28	.13	.15	.32	.06	.83	.68	.57	.47
28	.17	.01	.06	.15	.13	.12	.05	.24	-.02	.18	-.10	-.09	.32	.13	-.03	.11	.45	.25	.18	.02	.47	.24	.63	.87	.62	.58	.76
29	.08	-.09	.08	.08	-.05	-.03	.13	.13	.10	.13	-.04	.02	.28	.22	.18	.37	.46	.43	.38	.38	.23	.05	.34	.09	.38	.19	.37	.16
30	.23	-.11	.02	.22	.00	.16	-.08	.05	.18	.07	.31	.16	.24	.21	.14	.04	.32	.32	.23	.23	.20	-.01	.19	.33	.38	.29	.27	.25	.39
31	.16	-.02	.04	.14	.04	.15	.06	.23	.04	.21	.04	.04	.15	.16	.10	.07	.25	.25	.22	.28	.00	-.12	.18	.04	.15	.16	.12	-.01	.58	.71
32	.00	-.16	-.04	.02	.02	-.04	.10	.06	.09	.11	-.05	.08	.40	.33	.17	.14	.58	.52	.35	.24	.18	.01	.38	.18	.39	.20	.51	.22	.72	.48	.52
33	.14	.03	.05	.16	-.01	.05	-.12	.09	.13	.13	.14	.22	.21	.22	.17	.06	.49	.55	.41	.18	.07	-.08	.24	.18	.30	.20	.42	.29	.50	.69	.57	.68
34	.06	-.01	.08	.08	.06	.06	.06	.24	.03	.26	-.02	.09	.22	.25	.21	.08	.43	.48	.46	.29	.04	-.08	.30	.02	.22	.14	.38	.14	.60	.48	.71	.73	.83
35	.07	-.04	.05	.01	.16	.03	-.01	.15	-.01	.11	-.15	-.13	.25	.23	-.10	-.04	.42	.41	.19	.13	.25	-.12	.28	.18	.41	.13	.28	.23	.54	.38	.52	.47	.35	.39
36	.06	-.02	-.20	-.05	.03	-.12	-.03	-.06	.10	.00	-.04	-.05	.47	.34	.31	.09	.55	.51	.43	.39	.15	-.19	.16	.18	.39	.10	.33	.11	.42	.44	.35	.59	.46	.40	.56
37	.09	-.01	.15	.12	-.08	.00	.06	.01	-.11	-.02	-.07	-.11	.34	.11	.30	.22	.36	.24	.30	.22	.15	-.17	.02	.06	.30	-.03	.09	.02	.47	.25	.27	.47	.21	.24	.54	.65
38	.09	.04	.08	.09	.21	.08	-.06	.24	.08	.27	-.01	-.01	.32	.34	.20	.10	.56	.61	.54	.27	.32	-.17	.24	.23	.48	.08	.39	.39	.54	.41	.39	.57	.64	.63	.64	.57	.44
39	.12	.02	-.19	-.01	.12	-.05	.10	.17	.04	.17	-.12	.03	.29	.26	.27	.18	.51	.53	.46	.39	.06	-.12	.29	.20	.28	.10	.43	.23	.47	.45	.45	.65	.70	.73	.40	.67	.34	.c5
40	.08	.00	.21	.14	-.11	-.05	.00	.04	.01	.04	.03	.07	.22	.12	.27	.16	.33	.33	.33	.21	-.05	-.31	.09	-.04	.10	-.23	.20	.04	.39	.25	.21	.54	.47	.46	.28	.57	.70	.54	.58
41	.39	.38	.33	.46	.24	.45	.21	.46	.15	.50	.22	.31	.19	.01	.08	.07	.33	.37	.40	.24	.01	-.31	-.17	.04	.08	.06	.15	.10	.00	.18	.22	.26	.46	.46	.05	.21	.10	.28	.49	.39
42	.31	.42	.29	.33	.18	.32	-.01	.34	.24	.38	.17	.37	.48	.17	.12	.00	.56	.48	.37	.15	-.01	-.10	-.04	-.01	.15	.12	.31	.13	.17	.08	.11	.51	.49	.56	.17	.40	.30	.30	.57	.53	.76
43	.36	.50	.57	.43	.31	.40	-.48	.51	-.12	.41	.04	.04	-.29	-.37	-.39	-.06	-.13	-.06	-.08	-.09	-.10	-.33	-.03	-.26	-.14	-.29	-.12	-.08	.20	-.20	.03	-.05	-.02	.13	.21	-.30	.11	.28	-.06	.22	.37	.29
44	-.52	-.45	-.36	-.53	-.37	-.55	.56	-.46	-.03	-.47	-.28	-.13	-.06	.03	.21	-.07	-.25	-.33	-.24	-.16	-.17	.10	-.21	-.41	-.33	-.28	-.34	-.46	.04	-.19	-.08	-.13	-.38	-.29	-.07	.11	.03	-.33	.08	-.06	-.52	-.35	-.63
45	-.64	-.60	-.59	-.69	-.26	-.68	.40	-.65	-.37	-.69	-.20	-.36	-.10	-.11	.14	.14	-.46	-.58	-.32	-.12	-.23	.18	-.06	-.18	-.23	-.21	-.33	-.35	-.04	-.15	-.17	-.29	-.55	-.42	-.07	-.04	.10	-.24	-.10	-.18	-.64	-.67	-.36	.63
46	-.18	-.01	-.24	-.22	-.03	-.28	.07	-.21	-.04	-.29	-.26	.25	-.34	-.33	-.22	.01	-.52	-.45	-.32	-.02	-.15	.15	.30	.27	-.24	-.04	.07	.17	-.40	-.20	-.12	-.36	-.46	-.36	-.11	-.31	-.20	-.41	-.31	-.40	-.36	-.36	-.10	.10	.28
47	.22	.18	.34	.27	.16	.25	-.32	.24	.16	.30	.38	.34	.27	-.09	.05	.02	.33	.21	.22	.18	-.11	-.09	-.13	-.06	.17	.06	.18	.05	.31	.02	-.10	.32	.34	.26	.04	.41	.20	.31	.20	.42	.42	.60	.47	-.43	-.39	-.55
48	.18	.15	-.03	.12	-.02	.11	-.02	.07	-.16	-.04	.06	-.26	-.18	-.26	.02	-.17	-.36	-.36	.02	.10	-.37	.23	-.19	-.10	-.19	-.02	-.24	-.20	-.26	-.04	.10	.29	-.34	-.14	-.20	-.17	.02	-.46	-.35	-.21	-.28	-.09	-.15	.27	.17	.55	-.17
49	-.32	-.37	-.65	-.45	-.10	-.29	.11	-.33	-.11	-.23	-.12	-.23	.07	.18	-.07	-.35	-.09	-.21	-.24	-.40	-.14	.06	.04	.03	.00	.00	-.13	-.03	-.12	-.03	-.03	-.12	-.30	-.32	-.06	.13	-.24	-.19	-.01	-.41	-.38	-.26	-.45	.45	.40	.00	-.24	.13
50	-.60	-.44	-.68	-.68	-.19	-.62	.42	-.59	-.30	-.61	-.46	-.41	-.11	.09	.01	-.19	-.37	-.44	-.36	-.30	-.01	.18	.10	-.09	-.24	-.14	-.21	-.23	-.40	-.23	-.20	-.21	-.54	-.42	-.23	-.22	-.32	-.45	.05	-.40	-.54	-.59	-.57	.67	.70	.44	-.83	.11	.43

Appendix C

PEARSON CORRELATION COEFFICIENTS BETWEEN DEVICE MEASURES AND NINE FLIGHT PERFORMANCE CRITERIA[a]

Predictor Variable Number	N	Pre-Solo			Primary			Basic		
		Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade
1	50	.32*	−.37*	−.42*	.31*	−.30*	−.39*	.03	−.18	−.36*
2	49	.17	−.18	−.37*	.21	−.09	−.28	−.11	−.18	−.18
3	49	.12	−.06	−.30*	−.01	.07	−.10	−.16	.05	−.23
4	49	.34*	−.36*	−.48*	.24*	−.17	−.41*	−.04	−.09	−.40*
5	50	.37*	−.46*	.34*	.32*	−.19	−.27	.18	−.30*	−.23
6	50	.50*	−.52*	−.52*	.36*	−.26	−.47*	.09	−.19	−.40*
7	48	.06	.00	.03	.09	.19	.00	.05	.06	−.07
8	48	.54*	−.43*	−.48*	.42*	−.20	−.33*	.20	−.29*	−.38*
9	47	.34*	−.20	−.32*	.13	−.20	−.25	−.14	−.13	−.06
10	48	.60*	−.50*	−.53*	.44*	−.24	−.42*	.24	−.32*	−.38*
11	50	.20	−.36*	−.23	.15	−.03	−.34*	−.12	−.07	−.10
12	48	.33*	−.26	−.29*	.19	−.29*	−.26	−.07	−.12	−.09
13	45	.18	.01	−.14	−.02	−.23	.04	.10	−.14	−.23
14	45	.15	.06	−.10	−.01	−.17	.04	.15	−.33*	−.23
15	45	.14	.00	.08	−.02	−.24	−.02	.16	−.33*	−.24
16	45	.01	.08	−.02	.13	−.38*	.07	.15	−.28	−.19
17	45	.34*	−.16	−.31*	.07	−.36*	−.12	.14	−.38*	−.38*
18	45	.17	−.08	−.28	.09	−.26	−.12	.16	−.43*	−.37*
19	45	.21	−.09	−.06	−.02	−.20	−.17	.19	−.39*	−.34*
20	45	.15	.03	−.02	.10	−.30*	.00	.23	−.21	−.09
21	45	.17	.06	−.03	−.09	.01	.05	−.09	.01	−.02
22	45	.12	−.12	.07	.00	.05	−.14	.00	.11	.02
23	45	−.10	−.08	.00	−.13	.03	−.04	.16	.00	−.07
24	45	.16	−.31*	−.11	.12	−.10	−.25	.03	.03	−.15
25	45	.26	−.16	−.14	.02	−.19	−.12	.06	−.06	−.15
26	45	.15	−.08	.05	.06	−.05	−.15	.10	.14	.00
27	44	.14	−.26	−.17	−.08	−.05	−.14	.13	−.08	−.18
28	45	.12	−.28	−.13	.02	.03	−.17	−.06	−.02	−.25
29	44	.02	.02	−.07	−.05	−.22	.00	.12	−.14	−.23
30	44	.11	−.12	−.16	−.08	−.22	−.35*	−.01	.15	−.27
31	44	.03	.14	−.02	.03	−.28	−.14	.20	−.02	−.06
32	44	.24	−.20	−.30*	−.20	−.33*	−.22	.22	−.17	−.41*
33	44	.19	−.29	−.34*	−.15	−.29	−.37*	.02	−.14	−.32*
34	43	.16	−.13	−.19	−.19	−.27	−.17	.17	−.25	−.26
35	44	−.01	.02	−.21	.17	−.31*	−.05	.16	−.06	−.22
36	44	.14	−.11	−.12	−.05	−.30*	−.10	.22	−.16	−.28
37	44	.04	−.02	−.24	.06	−.28	−.05	.07	−.07	−.41*
38	44	.26	−.20	−.28	.01	−.23	−.13	−.01	−.27	−.28

(Continued)

Appendix C *(Continued)*

Predictor Variable Number	N	Pre-Solo			Primary			Basic		
		Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade	Time to Check-ride	Check-ride Grade	Mean Daily Grade
39	44	.16	–.18	–.20	–.09	–.38*	–.13	.16	–.32*	–.30*
40	44	.11	–.09	–.36*	–.09	–.20	–.04	.13	–.24	–.40*
41	23	.46*	–.28	–.57*	.35	–.02	–.46*	.34	–.48*	–.29
42	23	.30	–.30	–.51*	.04	–.02	–.28	.08	–.38	–.52*
43	22	–.15	.09	–.21	.22	–.12	.02	.19	–.42	–.08
44	22	–.16	.27	.44*	–.34	.23	.36	–.44*	.36	.19
45	22	–.40	.32	.62*	–.27	.07	.46*	–.40	.34	.44*
46	23	–.38	.16	.12	–.04	–.03	–.11	–.10	.06	.09
47	23	.13	–.32	–.01	–.02	.04	.00	.14	–.19	–.10
48	22	–.19	–.03	.27	–.15	.19	–.19	–.10	.25	–.12
49	22	.00	–.02	.44*	–.16	.11	.13	.07	.33	–.02
50	22	–.19	.34	.30	–.33	.14	.27	–.24	.36	.32

[a]* indicates $p < .05$.

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13. ABSTRACT

The research objective was to determine the effectiveness of a new device concept for helicopter contact flight training and the usefulness of such a device for predicting performance during subsequent flight training. The device was a commercially available captive helicopter attached to a ground effects machine. Two experimental groups of trainees received 3¼ or 7¼ hours of device training prior to primary helicopter training. In comparison with control groups, both device trained groups (a) were significantly less likely to be eliminated from subsequent flight training for reasons of flying deficiency; (b) required less flight training to attain the proficiency required to solo the helicopter; and (c) received higher grades during early training. Trainees who performed well on the training device tended to perform well during subsequent flight training. Instructors using devices such as this one need not be proficient in the helicopter used for subsequent flight training.

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