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The Effects of UH-1 Experience on UH-60 Simulator Performance: A Preliminary Study

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Efforts to expand the pool of volunteers for research in the UH-60 simulator prompted USAARL to determine whether UH-1 pilots could be used as an alternative to UH-60 subjects. In this quasi-experimental preliminary study, eight UH-1 pilots were provided with training in the UH-60 simulator. Afterwards, they were required to fly a standardized profile, parts of which had been used in an earlier investigation with UH-60 pilots. The performance accuracy of the groups (UH-1 versus UH-60) were compared on equivalent maneuvers. Results showed that the UH-1 pilots used in this initial study actually performed better on most maneuvers than did the UH-60 pilots who were used in an earlier investigation. Thus, it appears that UH-1 pilots, who are easier to recruit than rated UH-60 pilots, may be suitable as subjects in future simulator studies involving basic instrument pilotage skills. However, before drawing definitive conclusions, these results should be replicated in a controlled study where the pilots are randomly assigned to training and testing conditions during a more limited time frame.

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Table of contents

List of tables

List of tables (continued)

Introduction

Military relevance

Pilot performance studies at USAARL provide operationally-relevant information to aviation units throughout the Army. Information has been disseminated on a range of topics including the effects of nerve agent treatments, the impact of sleep deprivation, and the effects of both stimulants and hypnotics on aviator performance. Studies that produce this information require that qualified helicopter pilots remain confined to USAARL for periods of several days. Because of the constant demand for research volunteers, it is essential that USAARL take advantage of the largest possible pool of Army aviators. In the past, volunteers have been restricted to UH-60 pilots because testing is conducted in a UH-60 simulator. However, this may be unneccessary if it can be determined that piloting skills are not specific to individual aircraft. The present study will address this comparibility issue by contrasting the performance of non UH-60 pilots and UH-60 pilots flying standardized maneuvers.

Previous research

Literature searches revealed no studies which directly addressed the specific issue of whether UH-1 pilots could be trained to asymptotic performance levels in the UH-60 flight simulator. Some studies (e.g., Ross and Mundt, 1988) have placed pilots of one type of aircraft into simulators of a different type, but the effects of this shift were not assessed; rather, the effects of other variables (blood alcohol level in the Ross and Mundt study) on flight performance were tested. Most previous test studies were done on the subject of transfer of learning, skill, or training among rotary-wing aviators and have dealt with the issue of transferring learning in the simulator to actual flight, i.e., the validity and usefulness of simulator training. For example, Kaempf and Blackwell (1990) studied the transfer of training from an AH-1 flight and weapons simulator (FWS) to emergency touchdown maneuvers (ETMs) in operational aircraft. They studied 20 aviators who, as a group, had deficient ETM scores on their initial check rides and were assigned to one of two groups to equalize their baseline scores. The control group trained to proficiency in the aircraft while the experimental group trained to proficiency in the simulator and then the aircraft. Afterwards, both groups were tested for final proficiency in the aircraft. Regaining proficiency took longer in the simulator than in the aircraft. The simulator training reduced the flight training required to reach proficiency in the aircraft, but did not eliminate the need for actual flight training. This study, then, found limited utility of simulator training or of its transfer to actual flight.

By contrast, Caro (1972) found great positive transfer of training from the Army's synthetic flight training system (SFTS) Device 2B24 to actual flight. The test subjects were 16 recent graduates of primary flight training in the TH-55 who were trained to proficiency in the 2B24 and then given checkrides in the UH-1 aircraft. The total training time (simulator and aircraft) averaged 49 hours for this test group versus 86 hours under the conventional training program. It should be noted, however, that this study employed only new, relatively inexperienced pilots.

Similarly, Weitzman et al. (1979) found that the same simulator (2B24) promoted positive transfer in maintaining instrument flight proficiency among experienced pilots, all of whom had between 400 and 600 hours of rotary-wing experience. This study compared pilots training in the simulator only with those training in the UH-1 aircraft only, and with those training in both. All three groups were matched for initial skills, and all subjects had 12 hours of instrument training spread out over 9 months. Each subgroup was further subdivided into those with high versus low initial skills, though for the simulator group, the two had highly similar results. Overall, the simulator group did best, followed by the mixed training group and the aircraft-alone group, though only the differences between the first and third group were significant at the $p<.05$ level. Since the correlation between simulator and aircraft checkride scores was 0.57 ($p<.001$), the study concluded that simulator performance accurately predicts instrument flight skills in aircraft.

Instead of comparing simulator flight to actual flight, Farrell and Fineberg (1976) compared one type of flight skill to another. They wanted to determine whether extensive experience in general flight navigation would transfer to extremely low level flight (nap-of-the-earth or NOE) navigation. This study addressed the question of whether experience on one type of aircraft would transfer to a different type of simulator. The Farrell and Fineberg study employed both highly experienced instructor pilots (IPs) with at least 2,000 hours of flight time each (14 pilots) and recent graduates of flight school with only 200 hours of flight time (7 pilots). The recent graduates' only advantage in training was in having a 15-hour block of instruction on NOE navigation; the experienced pilots lacked this, though most of them had some practice with low level flight. The results indicated that despite the large difference in overall experience, the new graduates were not significantly worse on performance than the highly skilled pilots. Furthermore, it appeared that only 15 hours of specialized training were required to match the effects of experience. This study suggests that the effects of extensive UH-60 flight experience on UH-60 simulator performance might be achieved by other pilots with only a relatively short period of training.

The previous research which comes closest in design to the current study concerns backward transfer. In contrast to forward transfer studies in which pilots train on the simulator and then train and/or test in aircraft, in backward transfer studies, the pilots train to proficiency in the aircraft and then are tested in simulators. High backward transfer suggests that the simulator is relatively similar to actual aircraft, while low backward transfer suggests one or more major discrepancies. According to Kaempf and Blackwell (1990), there are three major types of reasons for low backward transfer: (1) the simulator provides cues different from those used to fly aircraft, (2) the simulator controls require inputs different from those on aircraft, (3) the simulator requires different skills than does the aircraft. Kaempf et al. (1989) conducted a study of backward transfer using the FWS, finding among the 16 AH-1 instructor pilots a low degree of backward transfer. This suggests that almost any differences between simulator and aircraft may reduce backward transfer, with those most proficient in the aircraft experiencing the greatest initial problem in the simulator.

Experimental design

Subjects

In this preliminary study, subjects were 8 volunteer U.S. Army aviators, between the ages of 21 and 40. There were four pilots that recently completed flight school, and four pilots with more extensive experience. Specifically, the low-experience pilots possessed less than 500 hours of flight time and the high experience group had 500-1,500 hours of flight time.

Flight performance evaluation

All training and testing was conducted at the USAARL facility, using the UH-60 research flight simulator. This motion-base system includes an operational crew station, a computer-generated visual display, environmental conditioning, and a multichannel data acquisition system.

The UH-60 simulator incorporates an automatic flight control system (AFCS) to enhance its static stability and handling qualities. The stability augmentation system (SAS) incorporates two independent systems, one analog and one digital. SAS enhances dynamic stability through short-term rate dampening in the pitch, roll, and yaw axis. The flight path stabilization (FPS) system enhances static stability through long-term rate dampening in the pitch, roll, and yaw axis. The trim system consists of two electromechanical actuators (roll and yaw) and one electrohydromechanical actuator (pitch). Trim provides a gradient force and a control reference position. The stabilator is a variable angle of incidence airfoil which enhances the handling qualities. The automatic mode of operation positions the stabilator to the best angle of attack for existing flight conditions. These various systems assist the pilot in holding heading, altitude, rate of turn, etc. during flight maneuvers.

Flight data were acquired on a VAX 11/780* computer interfaced to a Perkin-Elmer digital computer* which controlled the UH-60 flight simulator. This system is capable of monitoring any aspect of simulator control from heading, airspeed, and altitude to doppler/global position system (GPS) readouts, switch positions, and operator console inputs. However, for the purposes of this study, only 17 channels of data were monitored (e.g., heading, airspeed, altitude, climb, slip, roll, aircraft position, and bearing/range/time to destination).

The acquired data points were stored on the VAX 11/780 and then transferred to the main USAARL computer, a VAX 11/785. Flight performance scores, including root mean square errors (RMSE), were derived from specialized software routines developed at USAARL by Jones and Higdon (1991).

The flight performance evaluations required the subjects to perform the maneuvers listed in Table 1. The first part consisted of tactical navigation that required the subjects to use visual cues, GPS or doppler information, and time information to correctly navigate the course. The second part consisted of nontactical maneuvers that required the subjects to perform precision maneuvers based on instrument information. These maneuvers are of the type typically flown in a UH-60 aircraft and are described in the aircrew training manual (ATM). Only the nontactical maneuvers were analyzed in the present study for reasons of comparability with results from a previous study involving UH-60 qualified aviators.

Procedure

Each subject received 1 hour of ground training regarding UH-60 system operations and a 1.5-hour UH-60 simulator orientation flight. Then the subject flew 2 1-hour simulator test flights each day over a 4-day period (eight total flights).

The flight performance data were divided into a specific series of maneuvers, and the various control parameters (heading, altitude, etc.) were scored using locally developed computerized

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*See list of manufacturers.

Table 1.

Flight profile maneuver specifications.

Man	Hdg	Alt	Asp	From	To	Comments
SL	000	2000	120			2000ft 000deg 120kias
LSRT		2000	120	000	000	Left 360° turn
SL	000	2000	120			2000ft 000° 120kias
CLIMB	000		120	2500	2000	500fpm
RSRT		2500	120	180	000	Right 180° turn
SL	180	2500	120			2500ft 180° 120kias
RSRT		2500	120	000	180	Right 180° turn
CLIMB	000		120	3500	2500	500fpm
DEACTIVATE AFCS						
DESC	000		120	3000	3500	500fpm
LDT			120	2500	3000	500fpm
DESC	180		120	2000	2500	500fpm
LSRT		2000	120	000	180	Left 180° turn
SL	000	2000	120			2000ft 000° 120kias
RSRT		2000	120	000	000	Right 360° turn
DESC	000		120	1000	2000	500fpm

Note: See Appendix B for a list of abbreviations.

routines. The scoring consisted of calculating RMSE for each parameter from each maneuver and storing RMSE in data files which were subjected to statistical analyses.

In order to calculate RMSE for each of these parameters, an ideal value was selected against which the actual control accuracy was evaluated. For instance, if a straight-and-level segment was supposed to be flown at a heading of 180 degrees, an altitude of 1000 feet, and an airspeed of 90 knots, RMSE were calculated by determining the actual control deviations around each of these values for each of the parameters (heading, altitude, and airspeed). In this study, the ideal values were either specified directly, or were determined via computer algorithm as outlined below.

For some of the maneuvers, a computerized algorithm was used in which a dynamic ideal value was selected from the first sample of data (on heading, altitude, and airspeed) which occurred after the safety pilot marked the start point of each maneuver. However, if the first sample did not deviate more than a set amount from the values shown in Table 1, the actual table value was used. For a dynamic value to have been selected, the control deviation on heading had to exceed 10 degrees of the table value, the deviation on altitude had to exceed 100 feet, and the airspeed value had to exceed 10 knots. If this occurred, the dynamic value used for RMS error calculation was rounded to the nearest 10 degrees for heading, 10 knots for airspeed, or the nearest 100 feet for altitude. This dynamic value then was used as the ideal standard for the specific parameter throughout the entire maneuver. It should be noted that regardless of whether a dynamic or table value was used, the RMSE calculation still yields an index of control stability about a specified value.

Flight data collected from the subjects were analyzed with a series of BMDP statistical programs (Dixon, et al, 1990). First, data estimations were completed by using BMDP-AM where the means of available data were substituted for missing values. Following the data estimation, RMSEs were transformed into log naturals (a 1.0 was added prior to each transformation to avoid possible problems with zero values) in order to reduce the impact of occasional extremely large error values. Upon completion of data transformation, a series of repeated measures analyses of variance (ANOVAs) using BMDP4V were conducted. When required, simple effects and contrasts were conducted to followup significant main effects and/or interactions.

Data collected from this study were compared to baseline data collected from an earlier study of the Aircrew Uniform Integrated Battlefield (AUIB). All nine AUIB subjects selected for this data comparison were qualified Black Hawk pilots and flew the flight profile used in this study (while wearing standard flight clothing). However, the hover maneuvers were not deemed equivalent because of different types of external references available in the two studies, and they are not discussed or analyzed here. The primary purpose for this data comparison was to perform an initial assessment of how well qualified UH-60 pilots compared to nonqualified UH-60 pilots in flying standardized profiles in the UH-60 flight simulator.

The factors analyzed in this investigation were group, flight, and iteration. The grouping factor was AUIB UH-60 qualified pilots versus UH-1 qualified pilots. The first within-subjects factor (flight) consisted of four levels; flights 1, 3, 4, and 5. For comparability reasons, the first flights from the training days for the AUIB pilots were considered comparable to the last flights from the UH-1 pilots. After speaking with the aviator who trained the UH-1 pilots in the UH-60 simulator, it was decided that by the third day of the training week (one orientation flight and three training flights), the UH-1 pilots were capable of flying the simulator without significant intervention from the training aviator. Thus, flights 4, 5, 6, 7, and 8 from the UH-1 pilots were selected as comparable to flights 1, 2, 3, 4, and 5 from the AUIB UH-60 pilots (who were, of course, familiar with the UH-60 simulator from the outset). Ultimately, however, AUIB flight 2 and UH-1 flight 5 were dropped because of excessive missing data in the AUIB group. Therefore, in the statistical analyses, the flight factor had only four levels. The second within-subjects factor (iteration) had a different number of levels from one maneuver to another depending on how many times that specific maneuver was performed in each profile.

Finally, it should be noted that some iterations of some maneuvers differed depending on whether the AFCS was engaged or not. In these cases, only the maneuvers under identical AFCS conditions (engaged/not engaged) were analyzed together.

Results

Straight-and-level (SL) with activated AFCS

The three straight-and-level flight maneuvers conducted with the AFCS engaged were analyzed with a three-way ANOVA (groups x flight x iteration). Results indicated a group by iteration interaction on altitude control ($F(2,30)=5.75$, $p=0.0077$) which was due to iteration differences in both the UH-1 group ($F(2,30)=4.28$, $p=0.0232$) and the UH-60 group ($F(2,30)=27.23$, $p<.0001$). In the UH-1 group, there was poorer altitude control in the second and third iterations than in the first, although the second and third iterations did not differ from one another ($p<.05$). In the UH-60 group, performance declined throughout the flights so that all three straight-and-levels differed from each other ($p<.05$).

There were group main effects in which the UH-1 group performed better than the AUIB group on heading control ($F(1,15)=14.79$, $p=0.0016$) and slip control ($F(1,15)=7.90$, $p=.0132$). There was also a flight main effect on altitude control ($F(3,45)=3.39$, $p=0.0258$). Contrasts indicated significant differences between flights 1 and 4 and flights 1 and 5 in which the first flight had the largest RMSE mean. Contrasts are listed in Table 2 and means are listed in Table 3.

Table 2.

SL with AFCS flight main effect (altitude).

Contrast	F	p
Flt 1 vs Flt 4	5.36	0.0352
Flt 1 vs Flt 5	6.22	0.0248

Table 3.

SL with AFCS altitude control variable means.

Flight	Altitude control Mean
1	3.0720
3	2.9771
4	2.7957
5	2.7885

Additionally, there were iteration main effects on the heading ($F(2,30)=10.43$, $p=0.0004$), altitude ($F(2,30)=24.41$, $p<0.0001$), airspeed ($F(2,30)=16.10$, $p<0.0001$), and roll control variables ($F(2,30)=14.39$, $p<0.0001$). Contrasts for the heading control variable indicated significant differences among all iterations with iteration 2 having the highest RMSE mean. For altitude control, there were significant differences between iterations 1-2, 1-3, and 2-3 with iteration 1 having the lowest RMSE mean. For airspeed control, there were also significant differences between iterations 1-2 and 1-3 with iteration 1 having the lowest RMSE mean. For roll control, significant differences again were found between iterations 1-2 and 1-3 with iteration 1 having the lowest RMSE mean. Contrasts are listed in Table 4 and means are listed in Table 5.

Table 4.

SL with AFCS iteration main effect.

Contrast	F	p
Heading control		
Itr 1 vs Itr 2	15.71	0.0012
Itr 1 vs Itr 3	9.07	0.0088
Itr 2 vs Itr 3	4.84	0.0440
Altitude control		
Itr 1 vs Itr 2	14.34	0.0018
Itr 1 vs Itr 3	29.19	0.0001
Itr 2 vs Itr 3	21.44	0.0003
Airspeed control		
Itr 1 vs Itr 2	15.94	0.0012
Itr 1 vs Itr 3	25.79	0.0001
Roll control		
Itr 1 vs Itr 2	20.38	0.0004
Itr 1 vs Itr 3	18.11	0.0007

Table 5.

SL with AFCS iteration means.

Hdg		Alt		Asp		Rol	
Itr	Mean	Itr	Mean	Itr	Mean	Itr	Mean
1	0.5356	1	2.6274	1	0.6062	1	0.5013
2	0.8029	2	2.8651	2	0.7869	2	0.7081
3	0.6661	3	3.2325	3	0.8844	3	0.6964

Straight-and-level (SL) with deactivated AFCS

The one straight-and-level flight maneuver conducted with the AFCS deactivated was analyzed with a two-way (groups x flight) ANOVA. Results indicated a significant group by flight interaction on slip control (F(3,45)=2.94, p=0.0434). Simple effects revealed this was due to a difference among the flights in the UH-60 group (F(3,45)=4.54, p=0.0073), but not in the UH-1 group. Contrasts indicated that flight 1 was worse than flights 3 and 4, but none of the others differed from one another (see Table 6).

Table 6.

SL with deactivated AFCS flight x iteration effect at UH-60.

Contrast	F	p
Flt 1 vs Flt 3	11.68	0.0091
Flt 1 vs Flt 4	8.38	0.0200

Right standard rate turn (RSRT) with activated AFCS

The two right standard rate turn maneuvers conducted with the AFCS engaged were analyzed with a three-way ANOVA (groups x flight x iteration). Results indicated a group main effect on slip control (F(1,15)=5.07, p=0.0397), (AUIB=0.4189, UH-1=0.3451) and roll control (F(1,15)=5.57, p=0.0322), (AUIB=0.7216, UH-1=0.5133). Further analysis indicated a flight main effect on roll control (F(3,45)=4.88, p=0.0050). Contrasts indicated significant differences between flights 1-5, and 3-5 with flight 5 having the lowest RMSE mean. Contrasts are listed in Table 7 and means are listed in Table 8.

Table 7.

RSRT with AFCS flight main effect (roll).

Contrast	F	p
Flt 1 vs Flt 3	15.72	0.0012
Flt 1 vs Flt 5	10.58	0.0054

Table 8.

RSRT with AFCS flight means (roll).

Flt	Mean
1	0.7253
3	0.6930
4	0.5990
5	0.4770

Finally, an iteration main effect was found on slip control where iteration 1 (mean=0.4364) was worse than iteration 2 (mean=0.3319), (F(1,15)= 32.62, p=0.0077).

Right standard rate turn (RSRT) with deactivated AFCS

The one right standard rate turn maneuver conducted with the deactivated AFCS was analyzed with a two-way ANOVA (groups x flight). Results indicated there were no significant interactions, but there was one main effect because of differences between the groups on rate of turn (F(1,15)=5.5.3, p=0.0328). The AUIB group (mean=0.2172) performed better than the UH-1 group (mean=0.3047).

Left standard rate turn (LSRT) with activated AFCS

The one left standard rate turn conducted with the AFCS engaged was analyzed with a two-way (groups x flight) ANOVA. Results indicated a group main effect on roll control (F(1,15)= 14.41, p=0.0018). This was due to better performance in the UH-1 group (mean=0.4432) than in the AUIB group (mean= 0.6712).

Additional analysis found a flight by group interaction on altitude control (F(3,45)=3.27, p=0.0298) and airspeed control (F(3,45)=4.43, p=0.0082). Simple effects analysis indicated a significant difference among flights within the AUIB group on both altitude control (F(3,45)=5.39, p=0.0030) and airspeed control (F(3,45)=5.88, p=0.0018), but these effects were not present in the UH-1 group. Contrasts for the AUIB group indicated altitude control typically improved across flights, and airspeed control improved significantly from the first flight to the last two flights. Contrasts are listed in Table 9, and means are listed in Table 10.

Table 9.

LSRT with AFCS (flight at AUIB) contrasts.

Contrast	F	p
Altitude		
Flt 1 vs Flt 4	10.26	0.0125
Flt 1 vs Flt 5	5.59	0.0456
Flt 3 vs Flt 4	6.03	0.0396
Flt 3 vs Flt 5	5.58	0.0458
Airspeed		
Flt 1 vs Flt 4	5.09	0.0541
Flt 1 vs Flt 5	5.27	0.0508

Table 10.

LSRT with AFCS means.

	Altitude		Airspeed	
	AUIB	UH-1	AUIB	UH-1
Flt 1	3.3875	2.6513	1.0818	0.7884
Flt 3	3.1812	2.9449	0.5703	0.9511
Flt 4	2.6834	2.8276	0.6266	0.9077
Flt 5	2.7187	2.7624	0.6222	0.8579

Left standard rate turn (LSRT) with deactivated AFCS

The one left standard rate turn conducted with the AFCS deactivated was analyzed with a two-way (groups x flight) ANOVA. Results indicated no main effects or interactions.

Left descending turn (LDT)

Results indicated a difference between the UH-1 and AUIB groups on airspeed control ($F(1,14)=5.65$, $p=0.0323$) which was due to better performance in the UH-1 pilots (1.3319) than in the AUIB pilots (1.5496). There were also several main effects on the flight factor for turn rate ($F(3,42)=3.68$, $p=0.0194$), airspeed ($F(3,42)=3.49$, $p=0.0237$), roll ($F(3,42)=3.09$, $p=0.0373$), and rate of climb (F(3,42)=3.98, p=0.0139). In every case, performance on the first flight was worse than performance on the fifth flight. For airspeed, roll, and rate of climb, performance on the first flight also was poorer than performance on the third; and for both turn rate and rate of climb there was lower performance on the fourth flight than the fifth. Contrasts are listed in Table 11.

Table 11.

LDT with AFCS deactivated (flight main effects).

Contrast	F	p
Turn rate		
Flt 1 vs Flt 5	8.05	0.0132
Flt 4 vs Flt 5	8.13	0.0128
Airspeed		
Flt 1 vs Flt 3	10.42	0.0061
Flt 1 vs Flt 5	11.51	0.0044
Roll		
Flt 1 vs Flt 3	5.50	0.0342
Flt 1 vs Flt 5	8.11	0.0129
Rate of climb		
Flt 1 vs Flt 3	6.62	0.0221
Flt 1 vs Flt 5	8.46	0.0114
Flt 4 vs Flt 5	5.84	0.0300

Climb (CL) with activated AFCS

Two climb maneuvers were analyzed with a three-way ANOVA (groups x flight x iteration). Results indicated a three-way interaction on slip control (F(3,45)=3.87, p=0.0152) which was due to a flight by iteration effect in only the AUIB group (F(3,45)=4.57, p=0.0071). Subsequent analyses indicated this effect in the AUIB group was because iteration 1 was worse than iteration 2 in the third flight (p<.05), whereas the iterations did not differ in the other flights (see Table 12).

Table 12.

Climb with AFCS activated (group x flight x iteration) on slip.

		Itr 1	Itr 2
AUIB			
	Flt 1	0.2685	0.4165
	Flt 3	0.5384	0.3731
	Flt 4	0.3226	0.3499
	Flt 5	0.3685	0.3721
UH-1			
	Flt 1	0.1671	0.2467
	Flt 3	0.1717	0.3514
	Flt 4	0.1458	0.3346
	Flt 5	0.2307	0.3058

There was also a flight by iteration interaction on heading control ($F(3,45)=3.29$, $p=0.0291$) becausw the first iteration was better than the second in flights 3, 4, and 5 ($p<.05$), but there was no difference between the two in the first flight (Table 13).

Table 13.

Climb with AFCS iteration x flight means (heading).

	Itr 1	Itr 2
Flt 1	0.6823	0.7565
Flt 3	0.4998	0.7929
Flt 4	0.5156	0.8267
Flt 5	0.5778	0.6770

There were also group main effects on heading control ($F(1,15)=15.14$, $p=0.0014$) and slip control ($F(1,15)=12.71$, $p=0.0028$) because the UH-1 group performed better than the AUIB group. There were iteration main effects on heading ($F(1,15)=17.89$, $p=0.0007$), airspeed ($F(1,15)=26.09$, $p=0.0001$), roll ($F(1,15)=40.59$, $p<0.0001$), and rate of climb ($F(1,15)=5.99$, $p=0.0272$). In every case, the second iteration was worse than the first.

Descent with AFCS deactivated

Three descents were analyzed in a three-way ANOVA (group x flight x iteration). The results indicated there were two-way interactions between group and iteration on roll control ($F(2,30)=4.14$, $p=0.0258$) and rate of descent ($F(2,30)=3.80$, $p=0.0339$). In both cases, the interactions were due to the fact that there were differences among the iterations within the AUIB group (roll: $F(2,30)=3.68$, $p=0.0373$; rate of descent: $F(2,30)=5.63$, $p=0.0084$) but not in the UH-1 group. Contrasts indicated that the effect on roll control was because iterations 1 and 2 were worse than iteration 3. The effect on rate of descent was similar in that there was a steady improvement in performance from the first iteration to the second and third. The contrasts are presented in Table 14 and the means are presented in Table 15.

Table 14.

Descent with AFCS deactivated (iteration effects at AUIB).

Contrast	F	p
Roll		
Itr 1 vs Itr 3	6.92	0.0302
Itr 2 vs Itr 3	6.42	0.0350
Rate of descent		
Itr 1 vs Itr 2	6.60	0.0331
Itr 1 vs Itr 3	5.94	0.0408

Table 15.

Descent with AFCS deactivated (iteration means).

	Roll		Rate of descent	
	AUIB	UH-1	AUIB	UH-1
Itr 1	1.0570	1.0006	4.9593	4.9669
Itr 2	1.0766	1.1015	4.8049	4.9719
Itr 3	0.9210	1.1210	4.6985	5.0201

In addition, there was a main effect on the flight factor for rate of descent ($F(3,45)=6.40$, $p=0.0011$). Contrasts showed this was because performance was poorer on the first flight than on the third, fourth, or fifth (see Table 16). There was also a group main effect on heading control ($F(1,15)=6.31$, $p=0.0240$) which was due to better performance in the UH-1 group (0.7683 degrees transformed RMSE) than the AUIB group (0.9816).

Table 16.

Descent with AFCS deactivated (flight effect-rate of descent).

Contrast	F	p
Flt 1 vs Flt 3	13.70	0.0021
Flt 1 vs Flt 4	26.66	0.0001
Flt 1 vs Flt 5	14.21	0.0019

In summary, significant effects were found on every maneuver with the exception of the left standard-rate turn which was flown without the AFCS engaged. The noteworthy effects included group by flight interactions on the straight and level with no AFCS and the left standard-rate turn with AFCS. In both cases, there were no differences among the flights in the UH-1 group, but the AUIB group evidenced varying degrees of improvements from the first flight to the last. There were also group-by-iteration interactions on the descent (with no AFCS) and the straight and level (with AFCS). With regard to the descent, there were no differences among iterations within the UH-1 group, but there were differences within the AUIB group. Performance on the descent indicated an improvement from the first iteration to the last. With regard to the straight and level, there were iteration effects within both groups, and in this case, performance declined from the first iteration to the last. There were group (UH-1 versus AUIB) effects on the left and right standard-rate turns, the climbs, and the straight and levels (all with AFCS), and there were group effects on the right standard-rate turn and the left descending turn (with AFCS off). In every case, the performance in the UH-1 group was better than performance in the AUIB (or UH-60 pilot) group.

Discussion

These preliminary results tend to support the hypothesis that basic pilotage skills for rotary-wing flight operations are essentially the same regardless of aircraft. This statement may be considered true if basic pilotage skills are defined as minimal level qualifications for instrument flight requirements. Initial results indicated the UH-1 group performed better than the UH-60 group on basic pilotage skills such as roll, airspeed, heading, and slip control. The initial results may be compared to the results from Farrell and Fineberg (1976) that indicated no significant difference in overall simulator performance between highly skilled pilots (2,000 hours flight time) versus recent graduates (200 hours flight time). This study along with the current results may indicate that some level of flight training prior to data collection may match the benefits of experience in limited circumstances. However, there are two alternative explanations about the relative performance of the two groups.

The first is that the UH-60 pilots used for this comparison were distinctly different from the UH-1 group in terms of basic piloting skills. In fact, after consulting with staff members who were knowledgeable about the individual subjects used in the AUIB study, concerns were raised that these pilots simply were not performing up to the highest standards (for some unspecified reason). Therefore, this comparison group (UH-60 pilots) might not be representative of typical Army UH-60 pilots, and such a difference may partially explain their poorer performance compared to the UH-1 pilots. However, given that these UH-60 pilots were recruited from an operational aviation unit, we cannot negate the fact that they were at least performing to an acceptable level, and thus, they can be considered representative of at least some segment of the UH-60 pilot population.

The second is that the UH-60 subjects had a greater amount of "real world" flight experience than the UH-1 subjects. Such differences in experience levels could have impacted performance in the following ways: (1) Aviators in operational units typically do not spend a great deal of time flying precision instrument "upper airwork" of the type flown in this protocol unless they are completing annual checkrides; however, aviators who are more recent graduates from flight school have very recent experience in executing precise standard-rate turns, climbs, descents, etc. Thus, in some circumstances, one might expect the lower experience group to perform better than the higher experience group. (2) Aviators who have been flying a particular aircraft for many hours have more of a tendency to become bored with a flight profile than aviators who are newly transitioning into an aircraft. Thus, the experienced UH-60 pilots may have tended to lose interest in precisely controlling the simulator after 1-2 flights, whereas the relatively inexperienced UH-1 pilots viewed flying the simulator as a demanding challenge which they only had 1 week to master.

The relative importance of these alternative explanations is difficult to estimate since all of the factors discussed could seriously impact the outcome of any aviator performance study.

However, these issues can be more fully explored in a larger controlled study.

These data provide some degree of preliminary evidence that non-UH-60 pilots (preferably recent flight school graduates), who are far more numerous and easy to recruit than rated UH-60 pilots, may be suitable research subjects if only basic instrument pilotage skills are required.

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Appendix A.

List of manufacturers

Concurrent Computer Corporation (CCC)
2 Crescent Place
Oceanport, NJ 07757

Digital Equipment Corporation
5401 Corporate Woods Drive
Suite 850
Pensacola, FL 32504

Appendix B.

List of abbreviations

AFCS-	Automatic flight constrol system.
CLIMB-	Straight standard rate climb.
DESC-	Straight standard rate descent.
fpm-	Feet per minute.
kias-	Knots of indicated airspeed.
LDT-	Left descending turn.
LSRT-	Left standard rate turn.
RSRT-	Right standard rate turn.