Transfer of Training of Simulator Visual and Training Features for the Carrier Landing Task with Undergraduate Pilots

Dennis C. Wightman,
Naval Training Systems Center,
Orlando, Florida

Daniel P. Westra,
Essex Corporation
Orlando, Florida

Gavan Lintern
University of Illinois,
Urbana-Champaign, Illinois

Abstract

A transfer-of-training experiment was conducted this past year as the culmination of the carrier landing behavioral research program at the Visual Technology Research Simulator (VTRS) at the Naval Training Systems Center (NAVTRASYSCEN) in Orlando, Florida. The results of this experiment provide guidance on the design and use of simulators for the Navy's new undergraduate pilot training airplane, which together with the simulators and other training aids, will comprise the T-45 Training System (TS). Two visual display variables and two simulator training variables were selected for inclusion in this experiment: scene detail (day contrasted with night); field of view (wide versus narrow); task type (circling, straight-in or segmented); and number of simulator trials (20, 40, or 60). A total of 72 student pilots were trained on the VTRS prior to going through the Field Carrier Landing Practice (FCLP) phase of their pilot training program. The performance of these students at FCLP was contrasted with that of a group of 54 students who did not receive simulator training. Results show that students trained in the simulator performed better at FCLP than students in the control group. There was no transfer advantage for those trained with a daytime high-detail scene compared to those trained with a lower cost nighttime low-detail scene. There was also no transfer advantage for those trained with a wide field of view compared to those trained with the lower cost narrow field-of-view scene. Transfer performance was better for the students who had 40 or 60 simulator trials than for the students who had 20 simulator trials. The pilots who trained with a segmented approach schedule did as well or better on transfer to FCLP than those training with the modified straight-in approach schedule or all circling approaches. The fields of view and scene detail results apply only to the carrier landing task.

Introduction

The goals of the behavioral research program at the Visual Technology Research Simulator (VTRS) are to determine simulator design requirements and instructional features for teaching Navy flight tasks. The overall research plan is to examine selected tasks in a series of within-simulator studies which culminate with a study that involves transfer to the airplane. The research reported here is the final transfer-of-training experiment that followed this series of within-simulator studies of the carrier landing task. It was aimed at identifying optimum design and instructional features for a simulator to teach carrier landings.

During the evolution of the VTRS carrier landing research program, a specific need for the results of VTRS experimentation became apparent. The Navy began to ask questions about the value and application of visual display devices for the T-45 training system (T-45TS). The T-45TS will ultimately replace the T-2C and TA4J aircraft currently used in the Jet Undergraduate Training Program (JUPT). The plan for the T-45TS includes the extensive use of simulators in the training of certain contact flying tasks. One very important task is aircraft carrier landing.

Chambers and Riley described the set of experiments which were conducted at the VTRS to support the T-45 program.[1] This presentation will focus on the carrier landing transfer-of-training experiment, detail the rationale for the experiment, describe the results, and describe their implications for both simulator design and use for teaching the carrier landing task.

A sequential research plan, progressing from within-simulator to field studies, was developed because a simulator-to-airplane transfer study is both expensive and difficult to conduct properly. Our first major step was a nontraining or performance study. In this experiment, Westra, Simon, Collyer, and Chambers investigated the effects of simulator-design factors on the performance of experienced pilots.[2]

The major effect on critical measures of task outcome quality came from a comparison of two methods of modelling the Fresnel Lens Optical Landing System (FLOLS), which is the primary guidance cue for carrier landing. Glideslope tracking performance with a computer-generated FLOLS was better than with an optical projection from a light-source model. In addition, approach lineup was better with the day scene than with the night scene, and shorter visual system lags resulted in less roll variability during the approach. The other factors had negligible effects. The display and simulator factors had been varied over a range of interest that was wide and that represented the realistic range of expensive to inexpensive simulator options.

Skilled pilots were used as subjects in this study so that the results do have some implications for simulators that are used for skill maintenance and transition training. Conditions shown to help pilot performance in the simulator may be considered desirable for skill maintenance simulators, although data from this type of study do not indicate whether there will be any subsequent enhancement of flight performance. Thus, the small to null effects resulting from variation of equipment factors in this experiment suggests that the simulator performance of experienced pilots on the carrier landing task is not enhanced substantially by expensive options.

The bulk of research at the VTRS has been in the form of quasi-transfer studies. In these studies, a variety of simulator conditions were used to train independent groups of subjects. After predetermined periods of training, subjects were transferred to another simulator condition (the criterion condition) that was as similar to the aircraft as possible. A control group, trained and tested on the criterion condition, was also included. This procedure can be contrasted to a true *transfer study in which subjects* transfer from simulator training to the aircraft. Quasi transfer refers to a situation in which subjects are tested in the training device, but on a criterion configuration.

Quasi transfer studies were used to examine variables that may affect training. Those that survived the performance studies, and others that pre-experimental work or other research had suggested would have a worthwhile effect, were tested in this phase. In general, if a factor effect in the performance experiment was considered practically negligible, the factor was either not studied further or it was combined with others. Thus, the model-board image-generation system was not used again, and the g seat, TV-line rate, and engine lag factors were not tested further. Elements of scene brightness and seascape detail were incorporated with ship detail into a new scene detail factor. The optical FLOLS was also dropped from further study since it had resulted in poorer performance, even though it was the more expensive of the FLOLS display methods. However, FLOLS size, which was believed to be primarily responsible for the effect, was studied in a later quasi-transfer experiment.[3]

In Westra's quasi-transfer experiment, field of view, approach type (straight-in or circling), platform motion, and FLOLS rate cuing were included as factors.[4] Since the experiment had as one of its goals the training of aircraft carrier landings, pilots without previous carrier landing experience were employed as subjects.

There were glideslope tracking and lineup advantages in transfer from training with the wide field-of-view and high scene detail conditions, while platform motion and FLOLS rate cuing had no differential transfer effects. Approach type did have a substantial effect with better transfer performance resulting from training with the straight in approach. These findings indicated that only field of view, scene detail, and approach type should be tested in a subsequent simulator-to-airplane transfer study.

Data from other laboratories on FOV and scene detail effects have been mixed. A wide FOV appears to help simulator performance during turns to final and during glideslope tracking.[5] A quasi-transfer study by Collyer, Ricard, Anderson, Westra, and Perry showed strong FOV performance effects during carrier landing training, but no effect of these training differences on transfer to a criterion simulator condition.[6]

In the Kraft et al. study, and *another by Buckland, Monroe, and* Mehrer[7], scene detail affected landing performances in the simulator. In contrast, Martin and Cataneo found no effects of simulator training with different levels of scene detail on conventional landing performance in an airplane.[8] The scene detail issue is thrown into further confusion by the work of Brictson and Burger.[9] They showed that prior training with a night carrier display helped night landings but not day landings. Taken as a whole, these results indicate that further research on the transfer effects of variations in FOV and scene detail is warranted.

Other quasi-transfer experiments were undertaken at the VTRS to examine instructional features. The most promising result was obtained by *Wightman in a test of a backward-chaining* procedure for teaching simulated carrier landings.[10] His experimental subjects were taught carrier approaches in a series in which early trials were started at 2000 feet behind the carrier, and later trials at 4000 feet, and then 6000 feet behind the carrier. This procedure was more effective than whole-task training in which subjects flew all their trials from the 6000-foot mark. The result was consistent with the advantage shown for straight-in approaches in the Westra quasi-transfer study.[4] Thus, an approach-type factor combining features of the manipulations tested in both of these studies was developed for the transfer study.

In summary, two equipment factors, those being field of view and ship detail, were included in the transfer experiment on the basis of the results from the within-simulator research at the VTRS. That research also supported the inclusion of a backward-chaining type of instructional factor, referred to here as approach type. In addition, training time was included as an experimental factor so that incremental transfer effectiveness ([11], [12], [13],[14]) could be estimated.

Performance Measurement

Our experience with the carrier landing task has helped us establish a viable performance measurement approach for the simulator and that same approach seemed preferable in the field. A substantial effort *to develop a field* performance measurement system was carried out by McCauley and Cotton for the transfer experiment.[15] As a result of their work, a laser tracking system, developed by the Naval Weapons Center, China Lake, California (designated the Hybrid Terminal Assist *Landing or HYTAL), was tested, modified,* and made available for the experiment. HYTAL can measure altitude and lineup errors in the final approach to touchdown. Since measures of altitude and lineup error had dominated the analyses of simulator data, the HYTAL was considered a suitable data collection device.

Method

Experimental Design

A transfer-of-training design was used to study the effects of two simulator design factors (field of view and ship detail), and two instructional factors (approach type and simulator training time) on carrier landing training. These variables, together with some experimental constants, are described in Table 1. Navy undergraduate pilots visited VTRS for simulator training prior to their normally scheduled field carrier landing practice (FCLP), which is used as a workup for initial carrier landing qualification. Seventy-two pilots were trained at VTRS under various conditions described by combinations of the factor levels shown in Table 1. The experimental design for the training phase of the experiment was a fully-crossed 2X2X3X3 factorial of the four factors. Field and carrier data were collected on an additional 43 control subjects who did not visit VTRS and 11 who did but were randomly assigned to the control conditions.

Apparatus

Simulator. The Visual Technology Research Simulator (VTRS), described elsewhere by Collyer and Chambers, has a fully-instrumented T-2C Navy jet trainer

TABLE 1. SIMULATOR VARIABLES AND CONSTANTS

VARIABLES		LEVELS	
Field of View			
Vertical	-27 to + 9°	-30 to +50°	
Horizontal	± 24°	± 80°	
Ship detail	Night point light	Day solid surface	
Approach Type	Segmented: 25% of trials straight-in from 3000 ft, 25% straight-in from 6000 ft, 25% with 13° lineup off-set from 8100 ft, 25% circling	Modified straight-in: 75% of trials with 13° lineup offset from 8100 ft, 25% Circling	Circling: 100% circling trials
Simulator Trials	20	40	60

cockpit, T-2C flight dynamics, a six-degree-of-freedom synergistic motion platform, a 32-element g-seat, a wide-angle visual system that can project computer-generated color images, and an experimenter/operator control station.[16] The motion system and g-seat were not used in this experiment.

Visual System. The background scene was displayed by a 1025-line raster system, subtending 50 degrees above to 30 degrees below the pilot's eye level, and 80 degrees to the left and right sides of the cockpit's longitudinal axis. The carrier image, which was a representation of the USS Forrestal, was overlaid on the background with a 1025-line target projector. A carrier wake and FLOLS were also displayed with the target projector. Both daytime and nighttime carrier images are available.

Average delay between control inputs and generation of the corresponding visual scene was approximately 117 msec. Calculation of new aircraft coordinates required 50 msec, while calculation of the coordinates for the visual scene corresponding to the viewpoint for the new aircraft coordinates required approximately 50 msec. Generation of the new scene required 17 msec. An updated visual scene could be displayed every 33 msec.

The sky brightness for the day scene was 0.85 fL (foot-Lambert) and the seascape brightness was 0.6 fL. The brightest area of the day carrier was 4.0 fL. Except for the horizon, there were no background features represented in either the sky or sea. The night background luminance was 0.04 fL. The horizon was visible but the seascape was not. The night carrier appeared as lights of 0.8 fL brightness outlining the landing deck and other features.

Fresnel Lens Optical Landing System. The FLOLS is the primary glideslope reference used in carrier landings. The simulated FLOLS is shown with the simulated carrier in Figures 1 and 2. To prevent some of its smaller elements from shimmering and disappearing temporarily as they crossed raster lines, the simulated FLOLS was enlarged by a factor of 4.5 when the distance behind the ramp was greater than 2250 feet. From 2250 feet its size was linearly reduced until it attained 1.5 times its normal size of 750 feet. It remained that size throughout the remainder of the approach. The FLOLS was set for a 3.25-degree glideslope.

Field. Flight trials with the T-2C jet trainer were undertaken first at Goliad Field, Texas, and then on the USS Lexington during operations in the Gulf of Mexico. These flights were a normal component of the Navy basic jet training program which culminates with Carrier Qualification (CQ) aboard the USS Lexington. A FLOLS of the type simulated in the VTRS is available both at FCLP and at the USS Lexington.

The HYTAL laser tracking system was placed near the active runway during FCLP. This system recorded altitude and lateral deviations from glideslope in the final approach to touchdown.[15] An optical glass retroflector was mounted in the landing-light housing of each aircraft participating in the experiment to return the laser signal.

Procedure

Approximately 60% of the students from each intermediate class of training squadron VT-26 at Naval Air Station (NAS) Chase Field, Texas, were selected to visit Orlando. The Orlando visit was made generally on the weekend before the scheduled commencement of FCLP. Eight to 12 student pilots visited VTRS every

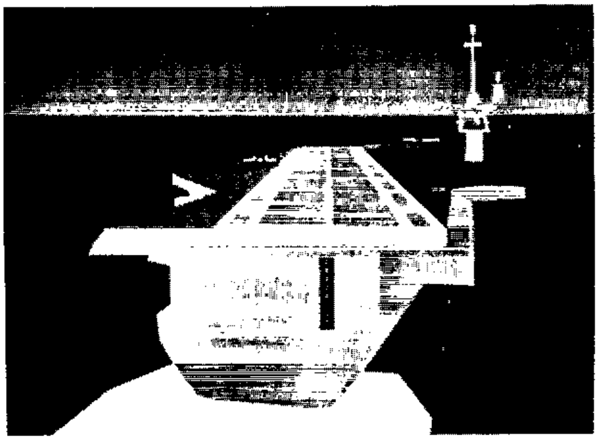

Fig. 1 Simulated Day Carrier Scene

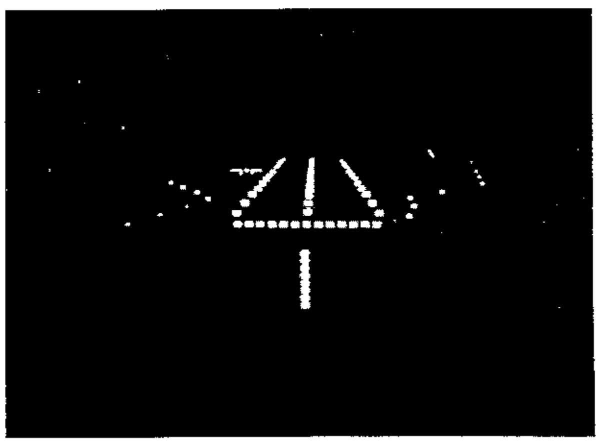

Fig. 2 Simulated Night Carrier Scene

six weeks. Data collection extended from October 1983 to August 1984.

The students who did not visit VTRS were classified as Texas-control subjects. Some members of each class to visit Orlando (generally two) were randomly selected as additional control subjects and did not fly the simulator. They were classified as VTRS-control subjects, and their FCLP scores were compared to those of the Texas controls to ensure that there had been no bias in the selection of students to visit Orlando.

The remaining students, who were to be trained with one of the experimental simulator conditions, were briefed on the simulator by VTRS experimenters. They were then briefed on the task requirements and on their simulator training condition by VT-26 Landing Signal Officers (LSOs) who had accompanied them to Orlando. Experimental students were cycled through their training to complete a number of simulated carrier landings. Each was assigned a VT-26 LSO who monitored their simulator trials throughout and gave instructional advice during and after a trial much as is done at FCLP and at CQ.

All approaches were initialized with the simulator in its landing configuration. Approaches from 3000 to 6000 feet were initialized with the simulated aircraft on glideslope and lineup: 349.5 degrees heading, 103 knots airspeed, 83% power, and a 500 fpm descent rate. The modified straight-in approaches were initialized with the simulated aircraft in straight-and-level flight, 13 degrees to the port (left) of centerline (Figure 3), heading 18.5 degrees, 400 feet altitude, 104 knots airspeed, and 86% power. From this position, students were required to fly forward, maintaining altitude and heading to intercept the centerline and glide- slope, and then to commence their landing approach. The circling approaches were initialized with the simulated aircraft in straight-and-level flight and 4,421 feet off the port beam of the simulated ship, heading 170 degrees, and at 606 feet altitude, 96 knots airspeed, and 86% power. From this position students were to undertake a descending left turn to intercept the centerline and glidelsope for their landing approach. Figure 3 gives an overhead view of circling and modified straight-in approaches.

Following their simulator training, the experimental subjects and the Orlando controls rejoined their classmates at NAS Chase Field to continue their undergraduate flight training. The FCLP portion of the course was generally scheduled over 10 consecutive weekdays at Goliad Field,

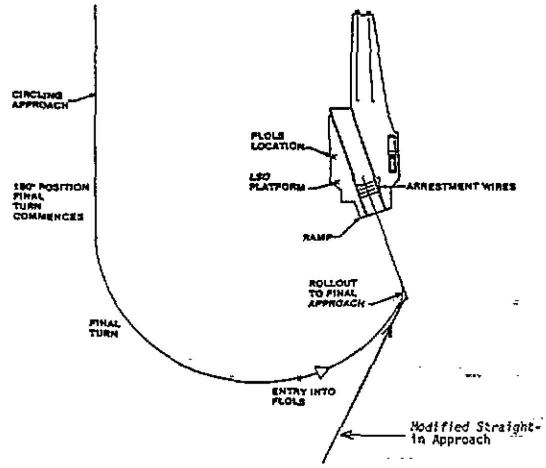

Fig. 3. Overhead View of Circling and Modified Straight-in Approaches.

which is near NAS Chase. Students generally flew one each day, and made 8-10 FLOLS approaches to a runway that was marked near the approach end to represent a carrier landing deck. Instructors accompanied the students on their first two flights and often took control of the aircraft. Students were solo on their remaining eight FCLP flights.

<u>Data Collection</u>

<u>Simulator Performance Measurement</u>. Parameters of aircraft position and attitude were sampled within the simulator and were used to derive altitude and lineup error scores from the desired approach path and deviations from desired AOA (15 units). Root Mean Square (RMS) error, mean algebraic error, and variability around those means were calculated for these three dependent variables over four equal segments of the final 6000 feet of the approach. Distance down the deck, distance from the centerline, and descent rate were measured at touchdown, and the Landing Performance Score (LPS) was calculated. The LPS is a score assigned to each pass, ranging from 1.0 (technique wave-off) to 6.0 (3 wire trap).[17]

<u>Field Performance Measurement</u>. Glideslope tracking scores for FCLP were measured by the HYTAL system at Goliad Field. Data from a student's first two flights were not analyzed because of the likelihood that instructors had assisted with many of these approaches. In addition to tracking data, touchdown scores and LSO grades were collected for FCLP.

<u>Results</u>

Table 2 presents mean values for two important measures of approach

TABLE 2. MEAN VALUES FOR APPROACH (3100 - 100 ft) MEASURES OF PERFORMANCE FOR FCLP HOPS 3 to 6.

Experimental Condition	No. In Group	Within-Trial Glideslope Variability (ft)	Percent Time on Target for Lineup (+/- .75°)
Day Scene	18	7.3	76
Night Scene	19	6.5	83
Wide FOV	19	6.9	79
Narrow FOV	18	6.8	82
20 Trials	11	7.7*	77
40 Trials	15	6.7	82
60 Trials	11	6.3	80
Segmented Approaches	15	6.7	82
Modified Straight-in Approaches	11	7.2	79
Circling Approaches	11	6.8	79
All VTRS Pilots	37	6.9†	80†
Control Group	46	7.8	74

* Mean for number of training trials significantly different from each other, $p < .05$.

† Mean for all pilots trained at VTRS significantly different from control group mean, $p < .05$.

performance at field carrier landing practice (FCLP) for pilots who went through VTRS training prior to FCLP and for the control group. A number of VTRS-trained pilots experienced considerable delays (up to 12 weeks) between VTRS training and FCLP and these pilots have been excluded from the analyses. Only those pilots who commenced FCLP within one week after their VTRS training have been included in the data given in Table 2. Separate analyses for the pilots who had a long delay between VTRS and FCLP showed that they generally did no better than the control group.

The data in Table 2 give the average scores for FCLP sessions (flights) three through six. A flight consists of 8 to 10 trials (approaches) so that the means given in Table 2 are the averages of between 32 and 40 approaches per pilot. Usually, there was one flight per day so the means represent about four days of work at FCLP. Pilots have a total of 10 FCLP flights and then go to carrier qualification at the USS Lexington, assuming they are not required to recycle. In the first two flights at FCLP an instructor pilot is in the plane. The third flight is the first solo one by the student pilot and is the first pure indication of the ability of the pilot. Thus, the third flight is the first one considered "clean" for performance measurement purposes. For the measures shown in Table 2, there was no evidence of any main effect-by-flights interaction across flights three to six. Therefore, the flights were averaged as shown in Table 2 with little loss of information.

The measures presented in Table 2 describe key findings but do not fully summarize the results. Other performance measures and the remaining flights were also analyzed (see Westra et al.). The first performance variable given in Table 2 is a measure of within-trial vertical variability about the mean glideslope for that trial (approach) from 3100 ft to 100 ft from touchdown. The actual measure used was the square root of this variability, or the standard deviation about the mean glideslope flown by a pilot for a particular approach. This measure gives an indication of pilot glideslope control with smaller values indicating better control.

As Table 2 indicates, the VTRS-trained pilots had an average value for this measure of 6.9 ft. The control pilots who did not receive VTRS training had an average value of 7.8 ft. This difference was significant at the .05 level. Perhaps even stronger evidence of a transfer benefit from the VTRS training is seen when examining the results for glideslope variability across the training trials factor. The difference in FCLP performance among the three groups receiving 20, 40, or 60 training trials is significant ($p < .05$). The 20-trial group did no better than the control group, while the 40-trial and 60-trial groups did better than the control group. The 60-trial group did slightly better than the 40-trial group, but this difference is not significant. Thus, it would appear that 40 simulator trials result in a significant transfer benefit. Sixty simulator training trials result in still more transfer, but beyond 40 trials there is a point of diminishing returns, at least under the schedule used in this experiment.

For the glideslope variability measure, transfer from the day scene was no better than transfer from the night scene, nor was transfer from the wide field of view better than a transfer from the narrow field of view. In fact, the night scene appears to have led to better FCLP performance than the day scene, although this difference is not significant. At present, there is no explanation for this. The type of approach schedule flown during training does not seem to have affected transfer performance. However, it must be noted that those flying the segmented schedule (25% from 3000 ft, 25% from 6000 ft, 25% modified straight-in approaches, and 25% circling approaches) spent considerably less time in the simulator than those flying an equal number of trials with all circling approaches. To illustrate, it took less than 30 seconds to complete a trial from 3000 ft, while it took over 2 minutes to complete a circling approach trial. Thus, this result strongly favors the segmented approach schedule since it involves much less simulator time.

The second measure shown in Table 2 is of percent time within .75 degree (horizontally) of the lineup centerline from 3100 to 100 feet from touchdown. The VTRS-trained group was within the tolerance limits 80% of the time on average, compared to 74% of the time for the control group. This difference was significant ($p < .05$). Thus, the VTRS-trained group performed better on transfer to FCLP than a control group on both glideslope and lineup control.

The groups receiving 40 and 60 VTRS training trials did slightly better than the group receiving 20 trials on the lineup time-on-target (TOT) measure, but this difference is not significant. Apparently, lineup control takes less time to learn than glideslope control, and in this sense is not as critical a performance dimension. As with the glideslope variability measure, there was no transfer advantage from the day scene compared to the night scene, or the wide field of view compared to the narrow field of view. Transfer from the night scene group also appears to be better than from the day scene, although the difference is not significant. There is no difference in FCLP performance on the lineup TOT measure among the groups receiving the different approach-type training schedules, and once again this result favors the segmented approach type since this method involves the least time in the simulator.

Discussion

Inevitably, there are problems with experimental control when conducting transfer experiments with data collected in the field, and this experiment was no exception. Researchers are subject to the vagaries of weather, unforeseen scheduling changes, and equipment breakdowns which may severely compromise the quality of transfer data. Although cooperation between the various commands involved in this experiment was excellent, there were two major problems which diluted results. First, about midway through the experiment, the training carrier Lexington was taken out of service for three months for repairs. Since pilots go immediately to the ship to carrier-qualify after FCLP, pilots in the pipeline who were ready for FCLP had their start dates delayed. Unfortunately, a number of these already had VTRS training and some of them experienced delays of up to three months before beginning FCLP. Since learning effects will generally decay with time, this effectively resulted in the "loss" of transfer data from 35 VTRS-trained pilots. Analysis of data from these pilots confirmed that they did not do as well as the VTRS-trained pilots who started FCLP within a week after VTRS training, and did no better than the control pilots.

The second problem that compromised the assessment of transfer effectiveness was procedural in nature and was part of normal operations. Since our intent was to avoid disrupting normal procedure and only to interject VTRS training into the operational training schedule for carrier landing training, this problem was unavoidable. The procedure requires that the first two flights of FCLP be flown with an instructor pilot in the airplane for safety and instructional purposes. During the first flight, and the first-half of the second flight, approaches are flown under the control of the instructor pilot. The last approaches in the second flight are flown by the student under the control of the LSO, but with the instructor pilot still in the plane giving instruction. It is not until the third flight that the student goes solo and the first "clean" data is available. Not only does this result in a time delay between VTRS training and the first usable field data in the best case, but more importantly, the pilot is receiving additional, intense one-to-one instruction during this interval. It is reasonable to assume that this activity results in considerable dilution of the transfer effect. Taking this into account, the fact that a transfer advantage for the VTRS-trained pilots was found on measures of both glideslope and lineup control on flights 3 through 6 argues strongly for simulator training. The transfer advantage is clear and would seem to "prove" the value of simulator training for the carrier landing task. It is no longer a question of whether or not to use simulator training, but what design features to build into simulators and how to use them most effectively.

The cost-effectiveness of simulator training depends on the costs associated with the training devices and on the amount of transfer advantage achieved. The data show no benefit for a daytime scene or a wide field of view over the lower cost counterparts. Previous work indicates that there would be no transfer advantage for simulators with motion platforms over simulators without platform motion.[4] Thus, the data indicate relatively low-cost simulators could be built which would provide equal training to higher fidelity devices with very high costs. Note that this is not a question of accounting for a transfer differential and computing cost trade-offs. There is no transfer differential for the equipment design options discussed for training the carrier landing task with undergraduate pilots..

The issue that remains then is how to most effectively utilize simulator training. The data indicate that about 40 simulator approaches, spaced over two days in 10-trial sessions using the segmented approach-type schedule, will result in the most cost-effective transfer. Since instructional variables have accounted for more transfer variance than equipment features, further research in this area seems justified. For example, simulator training could be tailored for the individual, could be interspersed through FCLP, and could be given prior to carrier qualification using a moving model of the ship. (A fixed carrier was used in this experiment to correspond to FCLP.)

The question of how many FCLP approaches could be saved by simulator training is difficult to determine at this time. The data on glideslope and lineup control measures suggest at least one or two FCLP flights could be saved. On the other hand, analysis of LSO grades suggest that no more than one FCLP flight could be saved, although optimum use of the simulator should result in more savings. However, another criterion to consider is the number of pilots who must be recycled because they are not ready for carrier qualification after the usual 10 FCLP flights. In this experiment there were no recycles among the VTRS-trained pilots who started FCLP within a week after VTRS training. A total of 7 (7.9%) pilots from the control group and other VTRS-trained pilots were recycled.

Summary

Pilots who received additional carrier landing training at VTRS did significantly better at FCLP on measures of glideslope and lineup control than control pilots not receiving supplemental training. There was no transfer advantage for those trained with a daytime high-detail scene compared to those who trained with a lower cost nighttime low-detail scene. Similarly, there was no transfer advantage for those trained with a wide field of view compared to those trained with a lower cost narrow field-of-view scene. Those pilots who had 40 or 60 simulator trials did considerably better on transfer than the control group, while those who had 20 simulator trials did not. The 60-trial group was not significantly better than the 40-trial group, which suggests a point of diminishing returns after 40 simulator trials. The pilots who trained with a segmented approach schedule did as well or better than those training with either the modified straight-in approach schedule or all-circling approaches. Since the segmented approach schedule involved the least time in the simulator, this method has the advantage and is the recommended method.

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About the Authors

Dr. Dennis C. Wightman is a Research Psychologist responsible for the Behavioral Research Program on the Visual Technology Research Simulator at the Naval Training Systems Center in Orlando, Florida. He received a Ph.D. in Psychology from the University of South Florida in 1983. His primary interests are in the areas of part-task training, perceptual motor skill, and the application of simulators to the training process.

Dr. Daniel P. Westra earned his Ph.D. in Human Factors Psychology from the University of South Dakota in 1978. Since being employed at Essex Corporation, he has been at the Naval Training System Center's Visual Technology Research Simulator.

Dr. Gavan Lintern is an Assistant Professor at the University of Illinois, holding a joint appointment in the Department of Psychology and the Institute of Aviation. He holds a Ph.D. in Engineering Psychology from the University of Illinois. He has worked in aviation training research since 1974.