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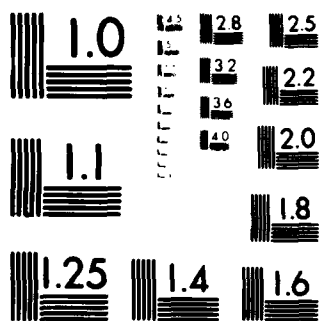
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**EFFECTS OF CRITERIA ON FLIGHT SIMULATION:
STUDY II - MULTIPLE CRITERIA**

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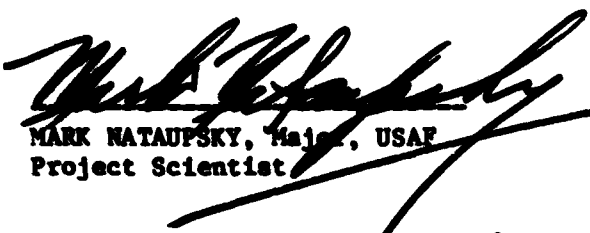
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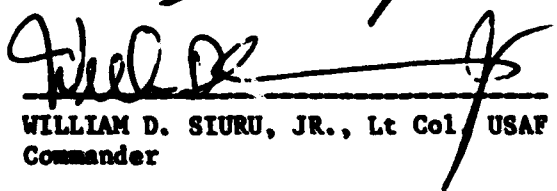
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Recent studies have shown that criterion levels established in training directly affect later performance of subjects on experimental tasks. Approximately 20% of variance can be explained by these criteria. The purpose of this study was to determine if a similar relationship can be found in transfer of training situations. Twenty male Air Force Academy cadets were trained to one of two multiple criteria levels on a difficult flight maneuver in a GAT-1 simulator. There was an easy criterion set and a more difficult criterion set. These two sets consisted of holding pre-			

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scribed performance parameters in heading, vertical velocity, and altitude. After achieving their assigned criterion, all cadets in each of the two groups were then tested on the same task in a GAT-1 simulator, but this time the maneuver had to be performed under turbulent wind conditions. This wind condition served as the transfer task. Half of the cadets in each group had the same criterion in both the training and the transfer task. The other cadets had different criteria in the training and transfer tasks. Thus there were four experimental groups: easy-easy, easy-difficult, difficult-easy, difficult-difficult. One control group had the easy criterion while the other control group had the difficult criterion. There were five cadets in each control group. The dependent measure was the Transfer Effectiveness Ratio (TER), derived from trials of this criterion data. This index is an estimate of the amount of time saved in learning a transfer task when performance is adjusted to that of a control group. Several analyses of various tasks of derived scores yielded significant results, confirming that criterion levels established in training carry over to transfer of training situations. Moreover, the data showed consistency with previous studies in accounting for 20% or more of the variance.

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PREFACE

The authors would like to express their appreciation to Capt. William G. Buchta, Lt. Craig M. Seeber, and Lt. James J. Colabufo, who also participated in this study. SSgt Ken D. Fortenberry and TSgt Frank C. Derry provided the technical support to maintain the simulator in an operational status. Mrs. Helen Wilson provided typing and administrative support.

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TABLE OF CONTENTS

	Page
INTRODUCTION.....	1
METHOD.....	3
Subjects.....	3
Apparatus.....	3
Procedure.....	4
Data Collection.....	7
Scoring.....	7
RESULTS.....	7
DISCUSSION.....	9
REFERENCES.....	12

LIST OF ILLUSTRATIONS

Figure

1. Attitude Indicator.....	5
2. Vertical S-Alpha.....	6
3. Score Sheet.....	8

LIST OF TABLES

Table

1. Means and Standard Deviations of Training Trials, Transfer Trials, and Transfer Effectiveness Ratios....	9
2. Analysis of Variance on Transfer Effectiveness Ratios.	9

INTRODUCTION

Despite the growing number of studies that contribute to the literature of flight simulation, studies which involve training criteria as independent variables are a relative rarity (Nataupsky, Schwank, Griggs, McKay & Schmidt, 1979; Nataupsky, Bermudez & Tirman, 1980). We earlier demonstrated that the criterion level established for subjects in training directly affected their later performance level on experimental tasks. One result of these training carry-over effects is to bias the research conclusions reached by the investigator. If carry-over effects are not controlled, they become confounded with the effects of the experimental variables and act to lower the internal validity of the research (Campbell & Stanley, 1966). Training criterion effects are therefore important factors for two related reasons. First, they directly influence the specific subject behaviors that will be tested in the research design. Second, the conclusions of researchers are influenced by what appear to be either more or less effective treatments, but which are, in fact, spurious effects.

In our experience, training carry-over effects are frequently overlooked by investigators in applied research and particularly in flying training research. Perhaps the subject is given insufficient attention because of the inherent problems in working out effective controls. For example, if subjects are given a fixed number of training trials, there is the problem of the more able subjects becoming more highly trained than the less able subjects, since they begin from different ability levels. A fixed number of trials also presents a problem when subjects learn at different acquisition rates. On the other hand, if subjects are trained to a fixed criterion level, there is the problem that the subjects with lower initial capability and those with lower acquisition rates receive more trials than the other subjects. Either approach could result in under or over-estimating the treatment effects, depending on the ratio of high to low ability subjects. This problem is particularly troublesome in flying training research, because the

typical small samples of subjects make it difficult to employ the desired controls, such as blocking on ability. In addition, it is difficult to assess initial ability.

One resolution of this problem is to train subjects to fixed criteria, and adjust their performance scores to that of both controls and their own initial acquisition rate to account for differences in achieving the criteria. The Transfer Effectiveness Ratio (Payne, 1980; Roscoe, 1971, 1972) incorporates this concept, and this ratio can be used to determine the effectiveness of the training task in preparing subjects to later apply the training. In the present case, this ratio provides an index of the relative strength of training carry-over effects for the different training criterion levels. This ratio accounts for both initial capabilities and acquisition rates.

Conceptually, the Transfer Effectiveness Ratio (TER) is an estimate of how much in time or trials to complete the transfer task is saved by the training task. For example, if the TER = .75, then one trial in training saves .75 trials in the transfer task. The higher the ratio, the more effective the transfer of training. The numbers take on added significance when the training is in a simulator and the transfer task is in an aircraft. Dollar savings can be projected from estimated costs to operate both the simulator and the aircraft. The TER is usually computed as follows:

$$\frac{\bar{C} - \bar{X}}{\bar{S}_x} = \text{TER}$$

Where: $\bar{C}$ = the control group mean for trials to criterion in the aircraft.

$\bar{X}$ = the experimental group mean for trials to criterion in the aircraft.

$\bar{S}_x$ = the experimental group mean for trials to training criterion in the simulator.

In the present study:

$\bar{C}$ = control group mean for trials to criterion in the transfer task.

$\bar{X}$ = each subject's trials to criterion in the transfer task.

$\bar{S}_x$ = each subject's trials to criterion in training.

Focusing on the problem of training carry-over effects, we wondered whether or not training criteria influence performance in transfer-of-training tasks in a manner similar to the way criteria effect experimental task performance. This question is of interest because there are many occasions in flying when the effect of prior learning on later application could be hazardous. The usual simulator training is accomplished in "smooth" air; transfer is then made to an aircraft in air with some turbulence.

Following our earlier study, we would expect to find a dependent relationship between eventual outcomes in transfer performance and training criterion levels. In our previous study, an average of 20 percent of the experimental variance could be accounted for through training criterion effects. Estimated values of Omega squared were used to estimate these effects. It appears that the TER can also be used to estimate the strength of relationship between training criterion and task performance. With the TER, it is possible to directly measure the relationship using a transfer paradigm.

METHOD

Subjects

Thirty male senior cadets at the United States Air Force Academy served as volunteer subjects. All subjects had completed a minimum of 15 flying hours in a T-41C aircraft (Cessna 172). The median number of hours was 25. Some cadets had had some experience in other light aircraft. Each cadet was randomly assigned either to one of four experimental or to one of two control groups.

Apparatus

A Link Group General Precisions Systems, Inc., General Aviation Trainer 1 (GAT-1) was used to train all pilots to selected criterion levels. The GAT-1 approximates the flight characteristics of the T-41C. This same trainer, using the turbulent air mode, was used for the transfer task.

Procedure

Each subject participated in two sessions, each one lasting not more than one hour. The first session was a training session and the second was the transfer task session. After a review of the cockpit instrumentation, a maneuver called the vertical S-alpha was described to the subjects using diagrams (See Figs. 1 and 2) and a narrative explanation. The cadets were told to alternately climb and descend at 80 mph (35.75 m/sec), 500 ft/min (2.54 m/sec), and to maintain a heading of 270 degrees during the entire maneuver. After establishing a baseline altitude at 2000 ft (609.6m) the cadets were instructed to alternately climb and descend 500 ft (152.4m) from the baseline altitude. All subjects were told to fly as closely as they could to the desired parameters. One-half of the subjects (Easy Criterion Group) met the criterion when they completed three successive trials where they (a) kept their heading within 10 degrees of the desired heading of 270 degrees, (b) kept maximum and minimum altitude within 60 feet (18.3m), and (c) kept the vertical velocity within 300 feet/min (1.52m/sec). The remaining one-half (Difficult Criterion Group) reached the criterion when, for three successive trials they kept within five degrees of the desired heading, kept within forty (40) feet (12.2m) of maximum and minimum altitude, and kept within 200 feet/min (1.02m/sec) of vertical velocity. The cadets were thus grouped into either the Easy or Difficult training criterion groups. All subjects from each of these two criterion groups were assigned to one of two transfer task conditions (Easy versus Difficult). Half of the subjects experienced a change in criteria in the transfer task. The transfer task incorporated turbulent air. In this manner, four experimental groups were formed with five subjects in each group. These four groups were as follows: Easy Criterion-Easy Task (EE); Easy Criterion-Difficult Task(ED); Difficult Criterion-Easy Task (DE); and Difficult Criterion-Difficult Task (DD). Two control groups were formed, each consisting of five additional subjects. One group performed under the easy criterion, and the other performed using the difficult criterion. Both control groups received only the transfer task.

ATTITUDE INDICATOR

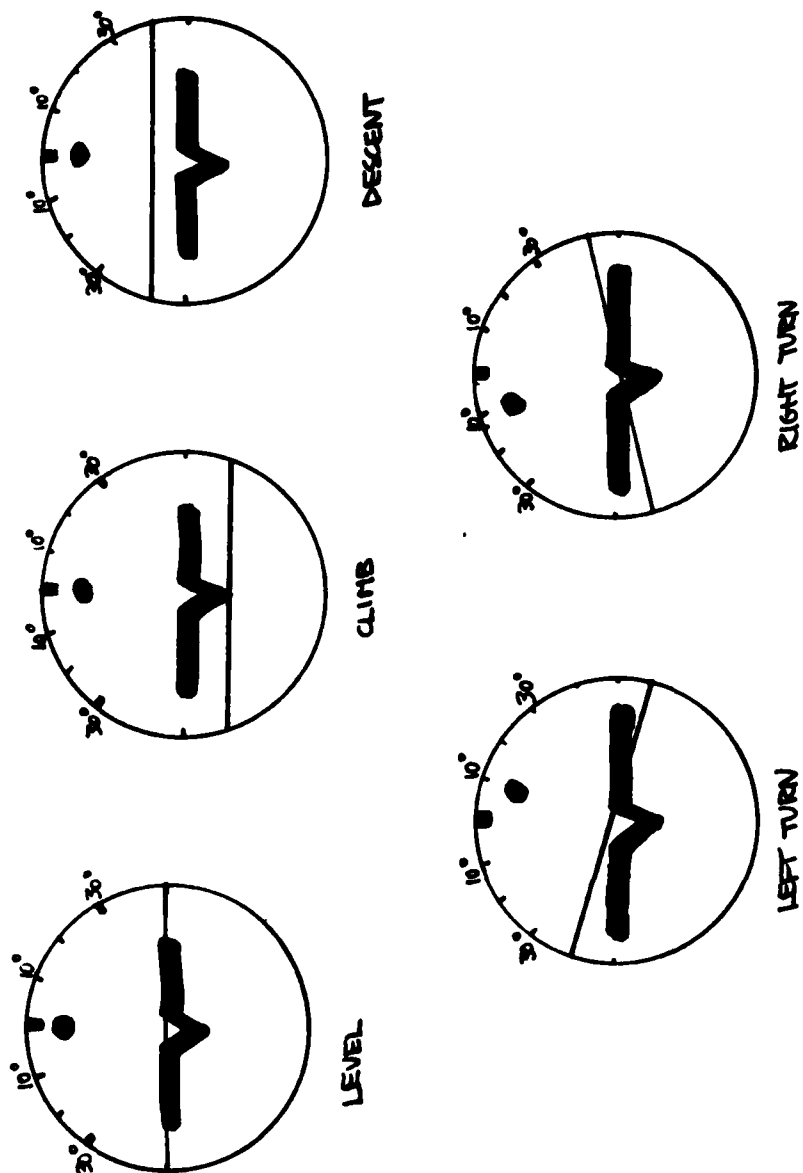
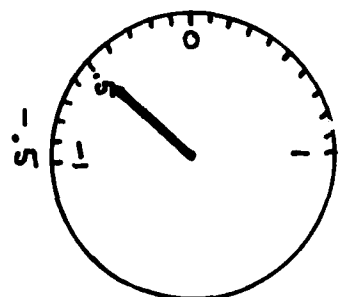
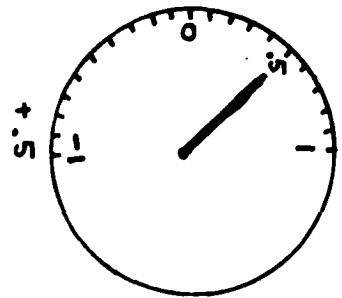
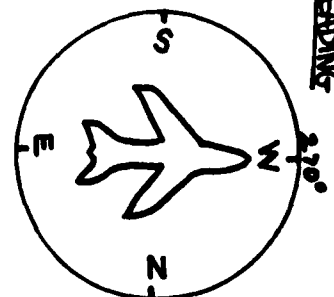


Figure 1. Attitude Indicator

VERTICAL VELOCITY



HEADING



ALTITUDE

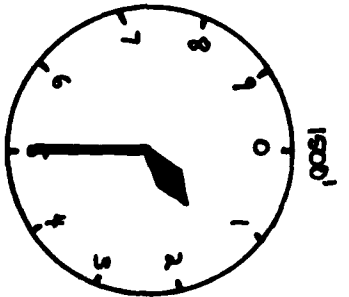
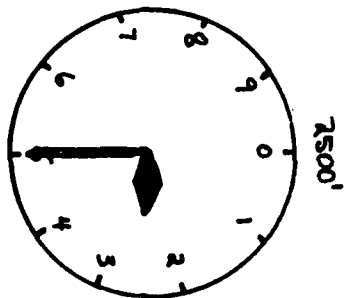
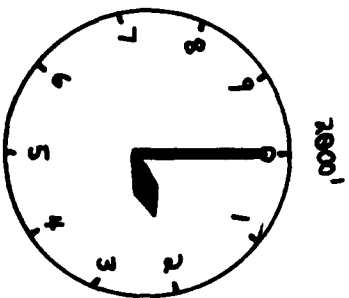


Figure 2. Vertical Velocity

Data Collection

Data collection was accomplished using a hand scoring method to record instrument readings on a specially constructed scoring sheet (See Fig. 3). Scoring was accomplished at selected portions of the vertical S-alpha maneuver. All instructors participated in the development of the scoring sheet and had several practice sessions prior to the data collection.

Scoring

There were five instructor pilots. Each of them recorded data from one subject in each experimental and control group. Thus, the scoring was counter-balanced across instructors and subjects. Variables scored included altitude, heading, vertical velocity, and trials taken to reach criterion during training and during the transfer task.

RESULTS

Table 1 presents the means and standard deviations of training trials, transfer trials, and TER's which were derived from the trials data. In computing the individual ratios for each subject, either the Easy Control Group mean (9.2 trials) or the Difficult Control Group mean (14.0 trials) was entered into the computation, as appropriate. Each individual's trials score was thus adjusted to that of his appropriate control group.

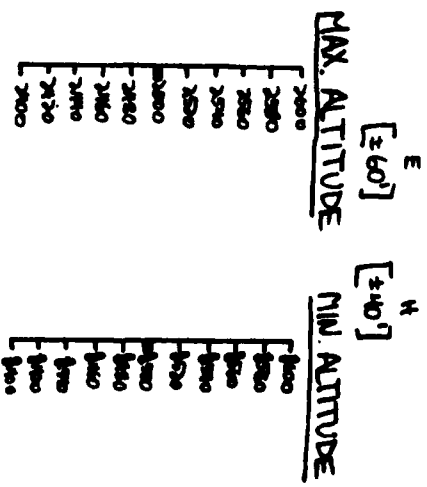
A 2x2 analysis of variance (Easy versus Difficult Training Criterion) X (Easy versus Difficult Transfer Task Criterion) conducted on the TER data yielded significant main effects for both training and transfer ($p < .02$ and $p < .04$, respectively). This information is summarized in Table 2.

SUBJECT : _____
 INSTRUCTOR : _____
 # T-41 HOURS : _____
 DATE : _____
 TRIAL : _____
 # SUCCESSIVE TRIALS
 WITHIN CRITERION : _____
 (Attempts to reach criterion →)

CLIMB	401
DESCENT	1200
ROUGH AIR	100%
BARO. PRESS.	30.00
FLAPS	up
SWITCHES	on
ATT. IND.	adjust
TRIM	neutral

CRITERION: E H
 ROUGH AIR: YES NO
 MOTION: YES NO
 Training Transfer Control

HEADING- $\begin{matrix} E \\ \pm 10^\circ \end{matrix}$ $\begin{matrix} H \\ \pm 5^\circ \end{matrix}$



VERTICAL VELOCITY $\begin{matrix} E \\ \pm 3 \end{matrix}$ $\begin{matrix} H \\ \pm 2 \end{matrix}$

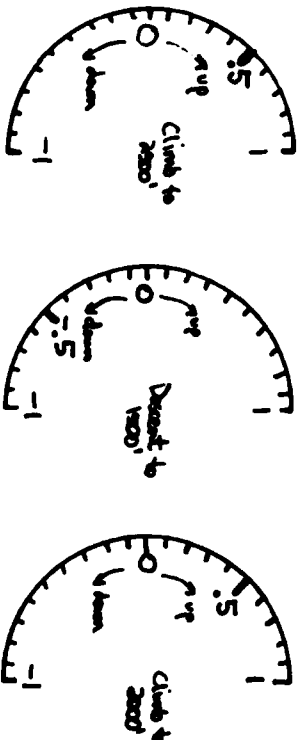


Figure 3. Score Sheet

TABLE 1
Means and Standard Deviations of Training Trials, Transfer Trials, and
Transfer Effectiveness Ratios

<u>Groups (n=5)</u>	<u>Training</u>	<u>Transfer</u>	<u>TER</u>
EE	7.6 (4.77)	6.0 (5.61)	.77 (1.13)
ED	5.8 (4.21)	10.4 (2.07)	-.29 (.37)
DE	9.8 (6.61)	3.8 (.84)	1.66 (1.34)
DD	6.8 (1.64)	8.4 (1.57)	.99 (.59)
Easy Control	—	9.2	—
Difficult Control	—	14.0	—

TABLE 2
Analysis of Variance on Transfer Effectiveness Ratios

<u>SOURCE</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
Training	1	5.312	6.437	.02
Transfer	1	4.232	5.128	.04
Training x Transfer	1	.094	.114	
Residual	16	.825		
	—	—		
	19	1.202		

DISCUSSION

Puig, Harris, and Ricard (1978) outlined a number of reasons to account for recurring inconsistencies in study results, replications, and interpretations with respect to the motion-no motion issue in flight simulation. Among these reasons they listed insufficient relationship of training objectives to criteria, and insufficient transfer of learning to criterion. No doubt many factors contribute, including hardware dependent factors. In the present study, we have focused on training factors, and particularly on the relationship of training criterion to treatment effects and to criterion task performance.

The main purpose of the present study was to investigate the effect of training criterion levels on later performance in a complex flight task. Because an earlier study had demonstrated that training criterion levels affected later performance levels, it seemed reasonable to expect similar carry-over effects to occur in transfer of training situations. Training criterion effects often get confounded with treatments causing spurious treatment effects and wrongful conclusions about treatments. It seemed possible that spurious effects might also surface in later transfer performance, and we were interested in estimating the extent of the influence. The TER was selected as the index to estimate the effects since the TER expresses the influence of the training situation in terms of savings of time or trials in the transfer situation. Additionally, when TER's are computed on an individual basis, subject's scores are adjusted to ability levels through comparison of subject mean scores to control group scores.

Based on the results of this study, it seems reasonable to conclude that the extent of influence of training criteria appears to depend as much or more on the sequence of criterion difficulty (easy-difficult or difficult-easy) than on the level of difficulty itself. This interpretation is based on a comparison of the TER means. In comparing these means, it should be remembered that the higher the ratio, the more effective the transfer, and, therefore, the greater the influence of the training criterion level on the transfer situation. However, this rule is true only in uncomplicated cases, e.g., as in the EE and DD groups, for whom the training and transfer criteria were the same. In complicated cases, e.g., as in the DE and ED groups, the situation is not straightforward because the training and transfer criteria are dissimilar.

It appears that both sequence and difficulty level produce large training criterion effects. For example, the best TER was produced by the DE group and the worst was by the ED group. The EE and DD group means represent only the influence of difficulty since these two groups were free of sequence effects. On the other hand, the DE and

ED group TER's reflect the combined influences of both sequence and difficulty.

The present data suggest that both criterion levels and sequence effects should be considered by the research worker in seriously accounting for experimental variance. Estimated omega squared values for the training and transfer main effects are .23 and .19 respectively. These values are consistent with findings in our previous study that showed training criterion effects accounted for an average of 20 percent of the variance. Consequently, it is likely that, to some extent, both difficulty and sequence effects are involved in producing some of the variance referred to by Puig et al (1978).

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