ON THE USE OF A FLIGHT SIMULATOR'S FREEZE FEATURE

DURING ACQUISITION OF A CARRIER LANDING TASK

Ronald G. Hughes
Air Force Human Resources Laboratory
Williams Air Force Base, Arizona

Gavan Lintern
Canyon Research Group
Orlando, Florida

Dennis C. Wightman
Naval Training Equipment Center
Orlando, Florida

Rebecca B. Brooks
Air Force Human Resources Laboratory
Williams Air Force Base, Arizona

ABSTRACT

Performance errors committed during the acquisition of a carrier landing task in the simulator resulted in the occurrence of a freeze. Pilot subjects exposed to the freeze developed control strategies which were distinguishable from those of a no-freeze control group in terms of throttle, rudder, aileron, and elevator activity. Neither rate of learning nor level of performance was affected. Use of the freeze, however, was reported as initially "frustrating" and as adding to the overall difficulty of acquiring the task. With certain applications, the freeze appears to be aversive, altering pilot motivation for learning the task. Methodologically, the study's use of a probe trial technique represents a departure from the traditional transfer of training methodology for the assessment of alternative instructional treatments.

INTRODUCTION

Error-free and trial-and-error approaches represent extreme positions with respect to the treatment of errors during learning. (6,13,14) The traditional approach to flying training lies somewhere between these extremes. Not until the recent widespread use of flight simulators did the instructor even have a choice with respect to how errors could be dealt with instructionally. Now that instructional options are available, one question that arises is the extent to which errors should be permitted to freely occur during training and the extent to which errors actually affect subsequent performance. (13)

The specific role of errors in skill acquisition is unknown. Holding has expressed the concern that frequently committed errors may be learned, or if not actually learned in the sense of being committed more frequently, that they may become embedded in the student's response repertoire. (6) This outcome appears possible in the case of the carrier landing task studied here since errors often seem to be reinforced. For example, a marginal approach, although being severely criticized by the Landing Signal Officer (LSO), can result in a safe touchdown. Although Navy pilots are consciously and explicitly concerned with technique in making carrier approaches, successful completion of a dangerous task by any means is, in a strict sense, reinforcing. Undoubtedly, the natural consequences of errors has a powerful self-correcting influence in perceptual motor learning, but the natural consequences of errors in carrier approaches may not be sufficiently negative with the required frequency to give full force to this effect.

The present study sought to address those instructional approaches to teaching the carrier approach task that are possible given the instructional environment of the flight simulator. The carrier landing task was considered ideal for the present study. Control behavior is strictly constrained by the demands of the task, and errors can be clearly specified. Navy pilots and instructors almost unanimously agree that error detection and correction are fundamental to safe and consistent carrier landings.

Specifically, the study addresses the use of the simulator's FREEZE feature to interrupt an otherwise continuous performance whenever an error is detected. The simulator environment also makes it possible following an error to either allow the errorful performance to continue or to make some correction (e.g., putting the aircraft back on course) prior to continuing the task. A potential instructional advantage of using the FREEZE is that of allowing the student to attend to instructional feedback without at the same time having to continue to fly the aircraft. A potentially negative aspect, however, is that the FREEZE may function like

a Time Out (TO), a behavior modification method frequently used to suppress inappropriate or undesirable behavior.

An important methodological issue is also addressed by the present study, that of how to assess the differential effectiveness of alternative experimental treatments (in this case, instructional conditions) upon subsequent ability to perform the criterion task: the familiar transfer of training problem. One important issue in transfer of training research is related to the selection of an appropriate training period. Training to a proficiency criterion has often been used, but in a study of differential transfer, the average time for various groups to attain proficiency almost invariably differs. Thus training time tends to be confounded with the experimental effects of interest. Fixed training times resolve that problem but selection of an appropriate period can be critical, and necessarily relies heavily on the judgement and experience of the experimenter. Training times could be too short to allow differences to emerge. Alternatively, they could be so long that worthwhile training differences are worked out by subjects attaining a high level of proficiency with even the poorest training conditions. Thus training times should be extended into, but not beyond, that period in training that shows worthwhile learning differences between instructional methods.

Pre-experimental work could ascertain the most appropriate training period but it would require expenditure of a large portion of the experimental resources to obtain a reliable answer. Furthermore, in a study of more than two training conditions, the selected training time may be appropriate for only some of the comparisons. A range of times could be used, but to do so would only reduce the power of the experiment (i.e., its capability to reveal differences between conditions) to the extent that some of the selected training periods are inappropriate.

The alternative addressed in the present study is that of a "probe" technique. A probe technique in which learning trials are interspersed with test (criterion) trials could avoid the problems discussed above. This technique, which appears to have been used only once in applied transfer of training research (15), might effectively map the course of learning and thus allow an estimate of the optimum training period for each instructional method. Smith et al. (15) used a single trial probe strategy in which they alternated training and probe trials; a strategy that was probably not optimum. Presumably, an experimental session should be weighted heavily with training versus probe trials to limit dilution of the training effects. Nevertheless, probes should be frequent enough to ensure that critical differences are not missed, and sufficient data would be required at each probe to achieve worthwhile stability. Probe methodology would seem to offer distinct advantages for the initial investigation of a novel training method. However, for evaluating its savings in relation to a standard instructional paradigm, the traditional transfer of training paradigm would still be preferred.

Summary of Primary Objectives

1. To assess the relative effectiveness of three instructional methods differing in the degree to which each alters the instructional environment following an error.

2. To determine the effects of displacement-only versus displacement-displacement-plus-rate error criteria on acquisition of the approach to landing task.

3. To assess the extent to which criterion performance sampled periodically on probe trials is sensitive to what is being learned on training trials.

METHOD

Subjects

Five groups of experienced Air Force pilots were taught carrier landings in a flight simulator at the Naval Training and Equipment Center under a control or one of four experimental training conditions. Pilot subjects averaged 35 years of age, had approximately 2400 flying hours, 300 simulator hours, and approximately 20 hours in their assigned aircraft (F-4 or F-16) in the 30 days preceeding the study.

Apparatus

The Visual Technology Research Simulator (VTRS) consists of a fully instrumented T-2C Navy jet trainer cockpit, a six degree-of-freedom synergistic motion platform, a 32-element G-seat, a wide angle visual system that can project both computer generated and model board images, and an Experimenter/Operator Control Station. (5) The motion system, G-seat and model board were not used in this experiment.

Visual System

The background subtended 59° above to 39° below the pilots' eye level, and 80° to either side of the cockpit. The carrier image, which was a representation of the Forrestal (CVA 59) was generated by computer and projected onto the background through a 1025-line video system. A carrier wake and FLOLS were also generated by this method. Both day and night carrier images could be displayed.

Average delay between control inputs and generation of the corresponding visual scene was approximately 116 msec. Calculation of new aircraft coordinates required 50 msec while calculation of the coordinates for the visual scene corresponding to the viewpoint

from the new aircraft coordinates required approximately 50 msec. Generation of the new scene required 16 msec. An updated visual scene was 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 brightness area of the day carrier was 4.0 fL. Except for the horizon, there were no features represented in either the sky or sea. The night background luminance was 0.04 fL and the horizon and seascape were not visible. The night carrier appeared as light points of 0.8 fL brightness outlining the landing deck and other features.

Fresnel Lens Optical Landing System (FLOLS)

In contrast to a carrier FLOLS, which is generated by incandescent lights, and can therefore be much brighter than other parts of the carrier, the simulated FLOLS was generated by the same system as the carrier image. It was, therefore, only as bright as the brightest areas of the ship (e.g., the white lines on the landing deck). To compensate for its lower relative brightness, the FLOLS was enlarged by a factor of three when the distance behind the ramp was greater than 2250 ft. From 2250 ft the size of the FLOLS was linearly reduced until it attained its normal size at 750 feet. The FLOLS was centered 414 ft down the landing deck and 61 ft to the left of the centerline. It was set at a nominal 3.5^0 glideslope and with a lateral viewing wedge of 52^0.

Simulator Configuration

The simulator was initialized with the aircraft at 9000 ft from the ramp, on the glideslope and centerline, and in the approach attitude and configuration (hook and wheels down, speed brake out, 15 units AOA, and power at 83%). The T-2C is normally landed with full flaps, but flaps were set at half extension for this experiment to more closely simulate approach speeds of typical fleet aircraft. Fuel was set at 1320 lbs to give 10,000 lbs gross weight. A landing trial was flown from the initial condition to wire arrestment or, in the case of a bolter, to 1000 ft past the carrier. The carrier was set on a heading of 360^0 at 5 knots. Enviromental wind was set at 349.0^0 with a velocity of 20.1 knots. This combination of carrier speed and environment wind produced a relative wind component of 25 knots directly down the landing deck. Turbulence was used to increase the difficulty of the task. The turbulence model buffetted the simulator with a random forcing fuction.

PROCEDURE

Two subjects arrived at the simulation facility each day, Monday through Thursday, during the experiment. They viewed a video tape on carrier landings which described the FLOLS and carrier landings. They were then given detailed instructions by a Navy LSO on carrier landing techniques. This instructional period lasted approximately 45 minutes. Where convenient, subjects were given their preliminary instruction in pairs, but the remaining experimental work was undertaken with only one subject in attendance except that subjects were occasionally permitted to monitor the performance of others from outside the simulator if they had entirely completed their experimental work. Subjects were assigned to training conditions as they arrived at the simulator facility in accordance to a predetermined sequence.

Training Conditions

Two experimental training procudures in addition to a control (CONVENTIONAL) procedure were used in the experiment. For both experimental procedures, the subject pilots were frozen during the approach if their vertical deviations from the glideslope broke specific criteria. Under one procedure, known as FREEZE/RESET, when the pilots were frozen they were instructed on how they had incurred their vertical error and were then reset to the glideslope with the simulator in its optimum approach attitude. Longitudinal distance from the carrier and lateral distance from the extended centerline of the landing deck were not changed. Pilots continued their approach from the reset position. Under the other experimental procedure, known as FREEZE/FLYOUT, pilots were instructed on how they had incurred their vertical error and how to correct it once they were released. They then continued their approach from the position and attitude in which they had been frozen.

Two different experimental training conditions were derived from each FREEZE procedure by applying two different freeze criteria. The first froze the system if $|\theta_i| \geq |\theta_c|$ where

θ_i = angular displacement of the aircraft from the 3.5 degree glideslope,

$\theta_c = 0.5625 - (.3125 \times 10^{-4})$, and where

r = range in feet from the carrier ramp

This algorithm linearly increased the criterion in meatball units from 1.0 at 6000 ft from the ramp to 1.5 at the ramp. Freezes did not occur beyond 6000 ft or past the ramp.

The second criterion would result in a freeze if vertical deviation from the 3.5^0 glideslope, or decent rate error, or some combination of the two was excessive. Freezes would occur if $|M_i| \geq \theta_c$ for

$M_i = \theta_i + 0.5625 \ \dot\theta_i \dot\theta_c$

$\dot\theta_i$ = angular rate of displacement in degrees/second from the glideslope

$\dot\theta_c = 0.405 - (.49 \times 10^{-4})(r + r_k)$

$r_k = 524$ feet, the distance of the carrier from the FLOLS origin.

This algorithm established a criterion that was a weighted sum of the previously described displacement criterion and a descent rate error limit that decreased linearly from 600 fpm at 6000 ft from the ramp to 200 fpm at the ramp.

None of the experimental training conditions permitted a freeze within 10 seconds of restarting the approach after a freeze. In adddition, a freeze would not occur if, at the end of this 10-second period, the subject was outside of the performance criterion but was descreasing his error.

In a fifth training condition, designated as CONVENTIONAL, subjects were not frozen during the approach but were given their error feedback, equivalent in nature to that given the FREEZE/FLYOUT group, during and at the end of each trial.

After preliminary instruction, subjects were familiarized with the controls of the simulator. They were then given a brief flight of approximately two minutes before they commenced their carrier landing training. The training sequence consisted of 24 approaches to the day carrier on the afternoon of their first day at the simulator facility, and 24 approaches to the night carrier on the morning of their second day. The two 24-trial blocks were divided into 6-trial sub-blocks, the first 4 trials of which were flown under the appropriate training condition. The last 2 trials of each sub-block were used as probe trials to assess the progress of learning, and were flown under the control condition. The LSO gave no instructions during or following probe trials. Subjects were given a 10-minute rest after the twelfth trial of each 24-trial block.

Performance Measurement

Parameters of aircraft position and attitude were sampled at 30 Hz and 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 that mean were calculated for these three dependent variables or four equal segments of the final 6000 ft of the approach.

Glideslope and lineup errors at 4500, 3000, 2000, 1000, and 0 ft from the ramp were used to derive means and standard deviations at these five points in the approach. Distance from the deck, distance from the centerline, and descent rate were measured at touchdown, and the Landing Performance Score (LPS) was calculated. (3) The LPS is a score assigned to each pass, ranging from 1.0 (technique wave off) to 6.0 (#3 wire trap).

Lateral stick, longitudinal stick, rudder pedal, and throttle positions were sampled at 30 Hz. The distance of control movement from one sampling point to the next was accumulated over one second periods and averaged over four equal segments of the final 6000 ft of the approach.

RESULTS

Day Versus Night Performance

The data showed little evidence for significant improvements in student pilot performances during the night carrier approaches. Isolated effects during the night trials included a significant reduction in aileron movement in the area of 6000-4000 ft to the ramp; a reduction in glideslope variability from 1000 ft to the ramp; and a reduction in throttle movement from 3000-1000 ft to the ramp. Since performance appears to have stabilized during the day carrier trials, results are discussed for the day trials only except as where noted otherwise (specifically, the correlational results on the probe vs. training trial performances and the discriminant function analysis).

Use of Displacement Versus Displacement-Plus-Rate Error Criteria

Neither rate of learning nor level of performance was significantly affected by the particular error criterion in effect; that is to say, whether the freeze was occasioned by deviations in vertical displacement or deviations in vertical displacement from glidepath plus rate of descent. Although Kaul et al. (8) found significant differences for experienced Navy pilots using displacement-plus-rate information displayed on the FLOLS, the Kaul study and the present study were different in several respects. (8) First, the displacement-plus-rate information in the Kaul study was presented to the pilot continuously via a modified FLOLS display. In the present study, the conventional FLOLS was displayed regardless of which error criterion was in effect. Second, the present study contained no condition which exactly paralled the displacement-plus-rate condition in the Kaul study. In the present study, there was no condition where subjects performed under the CONVENTIONAL (i.e., no freeze) criterion with feedback provided in terms of displacement plus rate. Although the subject population (experienced, carrier qualified Navy pilots versus experienced, but not carrier qualified Air Force pilots) also differed, the similarity of the glideslope maintenance portion of the task was highly similar for both groups of pilots.

Relationship Between Performance on Training Trials and Subsequent Probe Trials

Pearson product moment correlation coefficients were computed between measures of performance on training trials and subsequent probe trials for subjects in both the FREEZE/FLYOUT and CONVENTIONAL conditions. Data were combined across both day and night

landing trials. No correlations are reported for the FREEZE/RESET condition since use of the RESET feature precludes use of variability data. Correlational data are not presented here due to limitations on published presentation length. Nevertheless, the following observations can be made from these data.

1. During the approach portion of the task, a high degree of consistency was observed between pilot control movements (i.e. pilot inputs to aileron, pedal, and elevator) on training trials and subsequent probe trials. This was true to a lesser extent for throttle control. This suggests that for subjects within a given instructional condition the same or similar control strategies used during training were also used during probe trials.

2. Even though control inputs appear to have been consistent across training and probe trials, the consistency of training and probe trial touchdown performances differed as a function of instructional method. The correlation between the wire caught on probe and training trials was highly correlated for the CONVENTIONAL group (r=0.60) but not for the FREEZE/FLYOUT group (r=0.17). Likewise, pitch, vertical velocity at touchdown, and angle of attack at touchdown were significantly correlated for the CONVENTIONAL group (correlations of 0.64, 0.78, and 0.53, respectively) but not for the FREEZE/FLYOUT group (correlations of -0.11, 0.32, and -0.10, respectively). The extent to which performances acquired during training transfered to the criterion conditions of the probe trial is also expressed in terms of the correlations between Landing Performance Scores (LPS) on training and probe trials. For the Conventional group this correlation was 0.35; for the Freeze/Flyout group, 0.18.

Did Learning Occur

The data showed a small but statistically significant reduction in freezes (errors) across successive blocks of probe trials, $F(3,60)=3.62$, $p=0.018$, indicating that learning did occur. Comparisons by instructional condition, however, revealed no significant differences due to group assignment, $F(4,20)=0.94$, $p=0.46$. The learning effects are small when considered from an operational standpoint. The opportunity for measured errors to occur was bounded by the 10-second limitation imposed on the freeze as well as by not freezing when a rate error was in effect but the pilot was correcting. Neither can the effect of subjects' experience be overlooked. Based on their experience with constant airspeed, angle of attack approaches, one might expect that the carrier task differed only in close to the ship (e.g., 3000 ft to the ramp). This is supported by the data which show significant practice effects occurring most often in the 1000 ft to the ramp segment of the task. Only in the case of aileron movement did significant learning effects occur

consistently in all segments of the task from 6000 ft to the ramp.

Process Versus Product Measures of Performance

A step-wise discriminant function analysis (BMPO7M) was performed on the performance measures. As the data set did not conform to rules normally required for a discriminant analysis (e.g., the size of the smallest group should exceed the number of variables), its use here should be considered as purely exploratory. (16) The cumulative proportion of total dispersion accounted for by the discriminant function was 48%, and the variables that contributed most to separation of the groups were those of control movements (pedal movement from 4500-3000 feet from the ramp, throttle movement from 1500 feet from the ramp to touchdown, and aileron movement from 4500 to 3000 feet from the ramp). The discriminant function tended to distinguish the control (CONVENTIONAL) group from the experimental groups, and in all cases the trends in the data were towards smoother control inputs for pilots in the CONVENTIONAL (no freeze) condition.

The results of the discriminant analysis agree with those of the correlational analysis in so much as they point to pilot control responses as being the dimension most significantly affected by variations in instructional approach. It appears from the data that those pilots exposed to the freeze adopted control strategies that were different than those adopted by pilots in the CONVENTIONAL instructional condition. It is hypothesized that these differences were acquired during training as part of the task of "coming-off-freeze." The probe trial procedure was sensitive to the transfer of variations in control inputs from training trials to probe trials even though customary training outcome measures of performances on probe trials were not found to differ as a function of instructional condition.

Questionnaire Responses

Following participation in the study, each pilot subject in the FREEZE/FLYOUT and FREEZE/RESET groups completed a questionnaire (see Appendix). The results are summarized below.

On the General Role of Errors in Training

Pilots generally disagreed that "errors served little purpose" as well as with the notion that "students may actually learn the errors they commit" (Item 12). Pilots also disagreed with the contention that "instructional methods that allow errors to occur are inefficient" (Item 14). Instead, pilots in the study pointed to error recognition as a basis for the development of correct performance (Item 18). Errors were seen as helping the student to focus on the critical elements of task performance (Item 13), as well as exposing the student to out-of-tolerance situations which may under

later conditions result from factors such as adverse weather, visibility/ceiling limitations, etc. (Item 15). On the issue of whether correct performance is best thought of as resulting from a process of eliminating errors or from a process of shaping desired responses, pilots were undecided (Item 17).

On the Instructional Use of the Freeze Feature

Pilots agreed that it was significantly easier to attend to the LSO's feedback while the simulator was frozen than while trying to listen and fly the aircraft simultaneously (Item 3). Pilots also agreed that use of the the freeze aided in the development of error recognition (Item 5). Pilots, however, were undecided as to whether the use of the freeze might be used to significantly decrease the overall training time required to learn the landing task. On the negative side, pilots indicated that the occurrence of the freeze early in training was "frustrating" (Item 8). In fact, pilots in the FREEZE/RESET condition indicated that they were more motivated by "trying to avoid the freeze than by trying to fly the task correctly" (Item 7). Reponses of pilots in the FREEZE/FLYOUT condition to the same item did not reflect this implied aversive aspect. Regardless of the freeze condition to which subjects were assigned, all indicated that regaining control of the simulator following a freeze significantly added to the difficulty of the flying task (Item 2), and that the difficulty increased the closer the freeze occurred to actual touchdown (Item 2).

In general then the questionnaire data indicated that pilots perceived errors as contributing positively to training; that the present use of the freeze was in some instances aversive and that it served to add to the difficulty of learning the task in the simulator despite the fact that the freeze made it easier to attend to the feedback from the LSO instructor. So far as being able to potentially reduce the time needed to learn the task, pilots perceived the present applications of the freeze to have little value in this regard.

SUMMARY AND CONCLUSIONS

The view of the freeze as an opportunity to review past events and to plan for the future is consistent with an information processing approach to learning. (9) Under this view, competing information processing activities can interfere and retard acquisition of perceptual-motor skills. There was no evidence that this was the case in the present study, even though pilots indicated that it was easier to attend to the LSO's instructional feedback while frozen than to do so while continuing to perform the task simultaneously. Subjects in the present study were, however, experienced Air Force pilots even though naive with respect to the carrier landing task. Those studies which suggest that experienced pilots are better able to

time share than less experienced pilots or non-pilots would suggest that differences might have emerged had subjects come from a less experienced subject population.

The specific relevance of the information processing notion to flight instruction has not been fully established. Other psychological processes may play a role in mediating the effect of the freeze. For example, the freeze could well be aversive, functioning in the same manner as a "time-out from positive reinforcement" (usually referred to simply as T.O.) has been shown to function in the control of undesirable or inappropriate behavior. (2) Pilot comments in the present study support the view that the freeze may be viewed as aversive and that some applications of the freeze (e.g., the FREEZE/RESET) may even significantly alter the nature of the student's motivation to learn the task. All agreed that use of the freeze was "frustrating" early in training. That one or more of these processes can affect the acquisition of a psychomotor task is also indicated by the work of Payne and his associates. (10, 11,12)

Furthermore, there can be no certainty that the freeze effect will facilitate learning. The interruption caused by the freeze may disrupt the integrity of the task in a manner reminiscent of part-task learning. It was clear in the present study that the use of the freeze produced differences in how pilots' performed the landing task even though analyses of customary performance measures failed to clearly discriminate between instructional treatments. Pilots were in general agreement that the freeze added to the difficulty of the task and suggested that this difficulty is, in part, traced to the task of "coming-off-freeze," a task that becomes more difficult the closer the freeze occurs to touchdown. It thus appears that the effect of the freeze is more than that of simply halting the simulation. Instead, it seems to add a new task component and to contribute, as well, to the overall difficulty of the primary task being learned.

Lastly, from a methodological standpoint, the present study is significant in that it demonstrates the utility of the probe trial technique as an alternative to the more traditional transfer of training methodology for the preliminary investigation of instructional treatment effects. In the present case, the probe technique proved to be sensitive to learning effects as well as to subtle differences in criterion performance acquired as the result of the use of the freeze.

Recommendations

1. Avoid use of the flight simulator's FREEZE feature during the performance of a continuous control task such as that involved in the approach to landing task. Other tasks to which this advice might also apply are aerial

refueling training and weapons delivery training.

2. *Consider as an alternative to use of the FREEZE the use of the simulator's IN-FLIGHT CONDITION STORE feature whereby events captured at discrete points in a maneuver can be stored and later recalled for student review. Consider also use of the simulator's RECORD/PLAYBACK feature. In doing so, however, remember that in some instances the training time consumed in using the PLAYBACK may be better used to provide the student additional practice time.* (7)

3. Response chaining as a training methodology is not ruled out by the findings of the present study. The data would simply suggest that once a response sequence is begun it is advisable to allow the sequence to proceed to completion. This is true whether chaining is conducted in a forward direction with termination of the sequence occurring as the result of an error, or whether chaining is conducted in a "backward" direction (2) where termination occurs with performance of the final link of the chain.

4. The probe methodology is strongly recommended as an alternative to the traditional transfer of training paradigm, especially for exploratory studies where training effectiveness may vary not only as a function of instructional approach but also as *a function of amount of training.*

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ABOUT THE AUTHORS

Dr. Ronald Hughes and Ms Rebecca Brooks are research psychologists with the Operations Training Division of the Air Force Human Resources Laboratory, Williams AFB, AZ. Mr. Dennis Wightman is a research psychologist in the Human Factors Laboratory of the Naval Training Equipment Center, Orlando, FL.

Dr. Gavan Lintern is a psychologist for Canyon Research Group and was under contract to NTEC at the time of this study.

Appendix

Student Pilot Questionnaire

INSTRUCTIONS: Circle the number on the scale that best describes your response to each of the following items.

1. Use of the freeze feature may be used to significantly decrease the overall training time required to learn to landing task.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

2. Regaining control of the simulator following a freeze signficantly added to the difficulty of the flying task in the simulator (when responding, consider each of the following phases of the maneuver separately):

(a) "In the Middle" (first 1/3)

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

(b) "In the Groove" (second 1/3)

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

(c) "In Close" (5-10 seconds from the ramp)

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

(d) "At the Ramp"

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

4. Improvements in performance were highly correlated with a decrease in the number of freezes.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

5. Using the freeze feature to explicitly identify pilot errors during the "training" trials made it easier to detect errors on "test" trials when no feedback was given and when no freezes were in effect.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

6. Compared with the usual practice of giving detailed feedback at the conclusion of a task, providing feedback immediately following an error is more effective.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

7. In learning the task, I was more motivated by trying to avoid a freeze than by trying the fly the task correctly.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

8. The occurrence of the freeze was "frustrating" early in training.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

9. A helpful feature would be to present a "warning" signal (such as an auditory tone) prior to freezing the visual system.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

10. Night approaches were more difficult to learn than the day approaches.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

11. Errors were more difficult to detect during the night approaches than during the day approaches.

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

12. "Errors serve little purpose, since students may actually learn the errors that they commit."

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

13. "Errors help the student to focus on the critical elements of task performance."

| 1 | 2 | 3 | 4 | 5 |

Strongly Disagree   Neutral   Strongly Agree

14. "Instructional methods that allow errors to freely occur are inefficient, since students spend valuable time practicing incorrect responses."

1	2	3	4	5

Strongly   Neutral   Strongly
Disagree   Agree

15. "In committing errors, students learn how to recover from situations which at some later time may be caused not by task-specific errors but by conditions beyond their control (for example, by adverse weather, visibility, turbulence, etc.")

1	2	3	4	5

Strongly   Neutral   Strongly
Disagree   Agree

16. "Pointing out 'errors' frustrates students, whereas pointing out what a student is doing 'right' is reinforcing."

1	2	3	4	5

Strongly   Neutral   Strongly
Disagree   Agree

17. "Correct performance results from a process of elimininating errors and not from a process of shaping desired performance."

1	2	3	4	5

Strongly   Neutral   Strongly
Disagree   Agree

18. "A student's recognition of what is considered correct is dependent upon his being able to recognize what is incorrrect (that is, an error)."

1	2	3	4	5

Strongly   Neutral   Strongly
Disagree   Agree