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Author(s)	O'Connor, Paul
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STRESS TRAINING ENHANCES NOVICE PILOT PERFORMANCE IN A

STRESSFUL OPERATIONAL FLIGHT

Objective: This study investigated whether stress training introduced during the acquisition of simulator- based flight skills enhances pilot performance during subsequent stressful flight operations in an actual aircraft. **Background**: Despite knowledge that preconditions to aircraft accidents can be strongly influenced by pilot stress, little is known about the effectiveness of stress training and how it transfers to operational flight settings. **Method**: For this study, 30 participants with no flying experience were assigned at random to a stress-trained treatment group or a control group. Stress training consisted of systematic pairing of skill acquisition in a flight simulator with stress coping mechanisms in the presence of a cold pressor. Control participants received identical flight skill acquisition training but without stress training. Participants then performed a stressful flying task in a Piper Archer aircraft. **Results**: Stress-trained research participants flew the aircraft more smoothly, as recorded by aircraft telemetry data, and generally better, as recorded by flight instructor evaluations, than did control participants. **Conclusions**: Introducing stress coping mechanisms during flight training improved performance in a stressful flying task. **Application**: The results of this study indicate that stress training during the acquisition of flight skills may serve to enhance pilot performance in stressful operational flight and, therefore, might mitigate the contribution of pilot stress to aircraft mishaps.

INTRODUCTION

Salas, Driskell, and Hughes (1996) define stress as the process by which certain environmental demands evoke an appraisal process in which perceived demand exceeds resources and the result is undesirable psychological, physiological, or behavioral outcomes. Stress is thought to act by restricting attention and distracting from the primary task (Eysenck, Derakshan, Santos, & Calvo, 2007; Hancock & Warm, 1989). An ability to cope with the effects of stress, particularly on cognitive performance, is clearly important to personnel in high-risk environments, such as aviation. To illustrate, stress-related failures of decision making have been attributed to nearly half of fatal aviation accidents (Wiegmann & Shappell, 1997), and stress has been found to have negative effects on flying skills involving psychomotor, working memory, and attentional components (Satchell, 1993; Stokes & Kite, 1997). Given the relation between stress and pilot performance, it is surprising, as Burian, Dismukes, and Barshi (2003) point out, that there is a dearth of training guidelines for aiding pilots to cope with stress.

With respect to training, experimental evidence suggests that effective experience-based expertise may have stress neutralizing benefits in aviation (Stokes & Kite, 1997). Although appropriate experience undoubtedly plays a role in aiding pilots to combat flight stress, it takes considerable time, and associated cost, to evolve (McClernon, 2009a; Stokes & Kite, 1997). Consequently, it would seem advisable to supplement the role of costly direct flight experience by providing pilots, particularly, novice pilots, with training in handling stress while engaged in flight-related tasks. Driskell, Salas, and Johnson (2001) state that an integrated model of stress training should incorporate two critical components: preexposure to the high-stress condition that will be faced by the trainee and the inclusion of specialized training in the skills necessary to maintain performance in the high-stress environment.

The specific integrated stress training approach taken in this investigation introduced pilots to "stress exposure training" (SET), a program designed to provide trainees with the abilities and tools to maintain effective performance when operating in stressful environments (Driskell & Johnson, 1998; Salas, Wilson, Priest, & Guthrie, 2006). There are three elements to be considered in SET training.

First, training theories suggest that a transfer task must share stimulus and response elements with a training task for the training to be effective (Ellis, 1965; Osgood, 1949; Roscoe, 1971; Swezey & Andrews, 2001; Thorndike & Woodworth, 1901). The military often refers to this idea as "train how you fight." Second, stress training relies on state-dependent learning theory, whereby retention and retrieval are dependent on a person's emotional, physiological, and mental states during both training and recall (Overton, 1964). Therefore, to train for a stressful flying task, a stressful flight training environment may be appropriate. Third, stress training is also contingent on providing trainees with resources so that they perceive themselves to be well prepared for a given situation (Lazarus & Folkman, 1984; Salas et al., 2006). These elements were key dimensions in the SET program employed in this study.

As described by Salas et al. (2006) and by Wickens and Hollands (2000), there is a wide variety of training strategies designed to enhance learning in a domain of interest. One such strategy is the three-phase approach to stress training proposed by Friedland and Keinan (1992), which has shown promise for alleviating stress while ensuring the acquisition of task-related skills. Similar to the variable priorities approach advocated by Gopher and Kramer in training for executive control functions (Gopher, 2007; Kramer, Hahn, & Gopher, 1999; Kramer, Larish, & Strayer, 1995), the Friedland and Keinan procedure focuses on the interplay between three elementary phases of training.

During task acquisition (TA), a trainee is first taught the requisite knowledge and skills required for a task until a desired level of proficiency is achieved. Next, stress exposure (SE) teaches stress coping mechanisms in the presence of a stressor but in isolation from the training task. During that phase, trainees are provided with knowledge of typical stress reactions and develop the know-how for dealing with stressors. Finally, the task and stressor are combined in a practice-under-stress (PUS) phase, when the task is practiced in the presence of a stressor. Friedland and Keinan point out that in training for skilled performance under stress, the complete compartmentalization of stress exposure and skill acquisition (e.g., exclusion of the PUS phase) is insufficient—both task learning and stress exposure must be integrated into a total training plan.

In support of Friedland and Keinan's (1992) arguments favoring a three-phase approach, Johnston and Cannon-Bowers (1996) reviewed 37 studies addressing the effectiveness of that approach to stress training. Of the studies in their analysis, 67% demonstrated significant performance improvement in a stressful transfer task following three-phase stress training. In another review, Saunders, Driskell, Hall, and Salas (1996) determined that stress training was effective in reducing performance anxiety, reducing state anxiety, and enhancing performance under stress.

Recently, McClernon (2009b) conducted an initial experimental effort to test the efficacy of a three-phase stress training regimen in an aviation context. Toward that end, he employed the cold pressor technique as a source of acutepassive stress. The reason for the choice of the cold pressor was the need to introduce a source of stress that did not directly interfere with the primary task. The cold pressor has been employed extensively in the stress literature as a means of effectively introducing physiological stress without harming participants (e.g., Ishizuka, Hiller, & Beversdorf, 2007; Rosenbaum, 1980). The cold pressor technique has been used in the study of cognitive performance (Duncko, Johnson, Merikangas, & Grillon, 2009), and it was also used to induce stress in Friedland and Keinan's (1992) initial investigation of their three-phase approach to coping with stress.

Because hand dexterity was required for the flying task employed in the study, the cold pressor technique consisted of submerging a participant's foot in a bucket of ice water kept at a constant 9 °C. An experimental group experienced the stressor during flight simulator training and then during a flight simulator criterion task. A control group underwent flight simulator training in the absence of the pressor and subsequent testing in the flight simulator criterion task while exposed to the pressor. McClernon (2009b) found that the stress training regime decreased participants' subjective appraisal of their personal stress levels during the stressful criterion task, and more to the point, it measurably improved performance efficiency.

The McClernon (2009b) study provides promising initial evidence that a three-phase approach to stress training may be of significant value in improving pilot performance under stress. However, the study is limited in two potentially critical ways. One of these is the fact that it was conducted completely in a flight simulator. Although the

extent to which flying skills transfer from a flight simulator to actual flight is well understood (e.g., Bell & Waag, 1998; Carretta & Dunlap, 1998; Hays, Jacobs, Prince, & Salas, 1992), the extent to which stress training in a flight simulator improves performance in a stressful real-world flying task remains undetermined. The working hypothesis is that simulator-based stress training will be effective in improving stressful operational flight performance. One goal for the present study was to test that hypothesis.

The second limitation in the McClernon (2009b) study concerns the relation between the stressors experienced during training and transfer. In that study, the stressor experienced in the transfer task (cold pressor) was the same as the stressor applied in training. An immediate question that arises from this procedure is whether three-phase training with one form of stressor transfers to performance with another form of stressor. A study by Driskell, Johnston, and Salas (2001) involving the use of a computer-based task found that training in the context of one form of stressor facilitated subsequent performance with another form of stressor. In an aviation setting, their results suggest that a pilot will benefit from stress training even if the context in which stress training is received (a low-fidelity flight simulator) is different from the stressful operational task (an aircraft). A second goal for this study was to test that hypothesis.

METHOD

Participants

For this study, 30 participants (26 males, 4 females) were recruited from the Naval Postgraduate School and the Defense Language Institute in Monterey, California. They were all U.S. military personnel. None of the participants had any previous flying experience.

Design

Participants were assigned at random to either a stress-trained treatment group or a control group, and the order in which each participant was run was also randomized. Each condition contained an equal number of males (n = 13) and females (n = 2). The mean ages of participants in the treatment (M = 27.1, SD = 6.0) and control (M = 27.3, SD = 5.8) groups were essentially identical. Participants were given a 1-hr flight

simulator training protocol that was followed by a 1-hr flight in an aircraft. Flight performance measures were obtained from aircraft telemetry data and certified flight instructor (CFI) performance evaluations. Stress was measured using subjective stress ratings.

Procedure

Stressor. Similar to McClernon (2009b), the stressor used in training consisted of a cold pressor applied to the left foot at 9 °C. The stressor used in the subsequent flying task was the real-world stress associated with piloting an aircraft for the first time in simulated instrument meteorological conditions.

Simulator. The flight simulator (X-Plane® by Laminar Research) was fitted with a display that replicated the transfer aircraft's primary flight display (PFD): a 10.4-in. full-color, flat-panel liquid crystal display, shown in Figure 1. All simulator sessions were performed in instrument meteorological conditions (i.e., no outside view was provided), and aircraft maneuvers were performed by reference to the PFD only.

Task training. Participants were first familiarized with the flying task to be used in the study. The familiarization phase featured (a) verbal descriptions of the control yoke and the PFD, (b) a 5-min instructional video on the PFD, and (c) a 10-min simulator session. The navigation elements consisted of "turns-to-heading" assignments, which were read by a simulated air traffic controller. After a new heading was given (e.g., "Turn left to a heading of one-two-zero") the participant was required to turn the aircraft to the new heading. During familiarization and prior to each simulator session, participants were instructed to maintain a constant altitude (7,000 ft) throughout each phase of training. In addition, they were instructed to maintain their assigned heading, $\pm 5°$, during level flight and 20° bank angle, ± 5, during turns. The familiarization phase concluded with a short quiz to ensure that participants understood the flying task and the required performance parameters.

Figure 1. The Avidyne primary flight display (PFD). The same display was used for training in the flight simulator and in the transfer aircraft.

Participants then experienced a 10-min TA session consisting of the same simulator flying task in the presence of background "chatter" and light turbulence. These elements were included to make the TA session more representative of a real flying task.

Stress training. Following TA, the treatment group received SE training in the absence of the simulator task. Prior to application of the cold pressor, participants in this group were read the following three stress mitigation techniques, which were also featured in the McClernon (2009b) study: "During exposure to the cold pressor, or any stress, it is important to first maintain your normal breathing as best as possible. This will help calm and relax you. Next, attempt to focus on the task at hand and ignore the distractions of the stressor. Finally, pay especially close attention to the performance parameters that you are asked to fly".

Participants in the treatment group were then asked to submerge their left foot in the cold pressor. During the 5-min SE, they were read the three stress mitigation techniques again. The PFD was paused but remained in view, and participants were encouraged to mentally rehearse the flying task they had been taught. During the SE period of the experimental session, the control group remained in the flight simulator in the absence of the cold pressor. Control participants were instructed about the importance of mentally rehearsing the flying task during this time in the presence of the paused PFD. To prevent confounding from any potential motivation effects, both groups were blind to what condition they were in and what other participants did during the experiment.

Following SE, participants in the treatment group performed a 10-min flight simulator session with their foot in the cold pressor (PUS). Instead of PUS, control group participants performed the same flying task as those in the treatment group but void of the presence of the cold pressor (practice without stress [PWS]). The PWS session controlled for the amount of time both groups received in the simulator. Both groups were given a short break (approximately 10 min) before proceeding to the aircraft for the transfer task.

Transfer task. The transfer task took place in a 2006 Piper Archer aircraft with the same Avidyne PFD as provided in the simulator (see Figure 2). A CFI sat in the front right seat and flew the aircraft to a designated practice area. It was important to control for weather conditions throughout the experiment. Consequently, all of the flights took place in generally good weather (calm wind, no turbulence, etc.) and visual meteorological conditions, an aviation flight category in which pilots have sufficient visibility to fly the aircraft and maintain visual separation from terrain and other aircraft. The aircraft and all instruments were inspected prior to each flight to avoid the likelihood that troublesome technical problems would appear during flight. In transit to the practice area, the participant sat in the front left seat and wore a pair of blinders, which obscured the view of the controls and instruments. These blinders prevented the participant from gaining any further knowledge about the aircraft controls and displays while en route to the training area. However, the outside view was still visible to prevent motion sickness and undue discomfort.

Figure 2. The transfer task aircraft on the ground (top) and in flight showing a participant during a transfer task session (bottom).

After arrival at the training area, the participant donned a second set of blinders that shielded the outside view and all instruments other than the PFD. These blinders ensured that only the skills learned in training (instrument flying) were used during the transfer task. An experimenter (the first author) sat in the backseat of the aircraft to make certain that the only communications that took place were those necessary for the experimental procedures. In addition, the aircraft was fitted with audio equipment that allowed the CFI to communicate verbally with air traffic controllers in isolation from the participant and the experimenter. Following an approximately 10-min flight to the practice area, the CFI aligned the aircraft with the starting heading and altitude. Session instructions were read by the experimenter, and aircraft control was

transferred to the participant. The experimenter then provided 10 turn-to-heading assignments during a 15-min period using the same procedures as in the flight simulator sessions. The experiment officially concluded after all maneuvers were accomplished. At this point, the CFI resumed control and flew the aircraft back to the airport Aircraft telemetry data. Aircraft telemetry data were recorded by the PFD at five samples per second and were used to provide accurate measures of pilot-aircraft system performance in regard to seven flight dimensions. The dimensions included the aircraft's angle of pitch and angle of roll (measured in degrees from straight ahead), the rotational rates attributable to pitch and roll (measured in degrees per second), and directional acceleration in the lateral (side-to-side), longitudinal (forward-to-back), and normal (up-and-down) aircraft axes (measured in m/s2). These measures are direct, objective indices of how smoothly the aircraft was flying.

CFI performance evaluation. We employed two CFIs in this study. They were Federal Aviation Administration–licensed flight instructors with instrument instructor ratings. Combined, the two CFIs had more than 19,000 flight hours and more than 50 years of flying experience. In addition, both were instrument instructors and experts in evaluating a student's flying performance during instrument maneuvers. CFIs were asked to evaluate the participants' performance on a scale from 1 (very poor) to 10 (very good). Instructions and training were provided to the CFIs on using this scale. At five times during the transfer task (during every other turn-to-heading assignment), the CFIs scored participant performance, writing their scores on an evaluation form that was out of the view of the participants.

The CFIs were instructed to limit their interaction with the participants both before and during the transfer task and not to let the participants know that they were being evaluated. The CFIs also were blind to which experimental condition a participant was assigned. Because of scheduling limitations, CFIs were not assigned at random to the experimental conditions—one CFI flew 11 sorties (control = 6, treatment = 5) and the other flew 19 sorties (control = 9, treatment = 10).

Subjective stress queries. Subjective measurement provides insight about a participant's appraisal of a situation, given his or her available resources (Welford, 1973). Toward that end, a 10-point subjective stress scale was employed to assess

participants' stress appraisal. This scale was originally developed by McClernon (2009a) to assess subjective stress in real time with a query approach and was found sensitive to manipulations in stress (McClernon, 2009b).

Prior to flight simulator training, the following introduction to the subjective stress scale was read to each participant: "During the following sessions, you will be asked to rate your stress levels during sessions using a 10-point scale. "One" is not stressed at all, similar to a peaceful, relaxing afternoon. "Ten" is the most possible stress you can withstand; for this experiment, that would be the stress you can withstand before asking to terminate the experiment. The queries will refer to the most recent maneuver that you flew. Please now answer the following sample query for your current stress level: 'Rate your stress on a scale from1 to 10.' Do you have any questions concerning the stress queries?"

The query was used as a baseline for each participant's subjective stress level. At five times during each phase of training and during the transfer task (during every other maneuver), participants were asked the same stress query, and they reported their responses verbally. The score for each query was computed as a proportion of each participant's baseline. The subjective stress queries were also the cue for the CFIs to provide performance evaluations during the transfer task, which prevented any conversation regarding the CFI evaluations.

RESULTS

Pretest Comparison of the Two Groups

Preliminary analyses were carried out to determine whether there were any significant differences between the experimental and control groups' flight simulator performance and baseline subjective stress scores. Toward that end, flight simulator telemetry data collected during the TA session and the baseline subjective stress queries were used to compare the two groups. No group differences emerged. Consequently, any performance or stress differences between the groups during actual flight cannot be attributed to initial sampling artifacts.

Aircraft Telemetry Data

For all participants, the variance of their scores across the 15-min transfer task was determined for each of the seven aircraft telemetry measures. Although root mean square error is a common approach for indexing operator performance (Gawron, 2000), a variance index has been used effectively as a preferred measure of performance in a driving context (e.g., Mackie & Miller, 1978; Marcotte et al., 2003), and McClernon and Miller (in press) have recently found that the variance of aircraft performance measures is a precise, efficient, and effective index of flight control that describes how smoothly the aircraft is traveling through the air. Accordingly, a variance measure was employed in this investigation. To compare the data from the seven telemetry scale we standardized participants' variability scores on each scale by converting them to z scores using the formula:

$$Z = (Vp - \text{Mean } Vs) / SDVs, \quad (1)$$

where Vp is a participant's variability score on a given dimension. Mean Vs is the mean variability score on that dimension across all participants, and SDVs is the standard deviation of the distribution of scores on that dimension across all participants.

Mean variability scores for all combinations of seven flight dimensions and two treatment groups (experimental stress training and control) are plotted as a function of successive 3-min intervals in Figure 3. Higher scores reflect more variance and poorer performance. It is evident in the figure that for all seven flight dimensions, the variance in performance was greater in the control than in the experimental group. This impression was confirmed by a 2 (group) × 7 (flight dimension) × 5 (interval) mixed ANOVA of the Figure 3 data, which revealed a significant main effect for groups, $F(1, 28) = 6.61$, $p < .05$, $\eta 2 = .19$. None of the remaining sources of variance in the analysis was significant ($p > .05$).
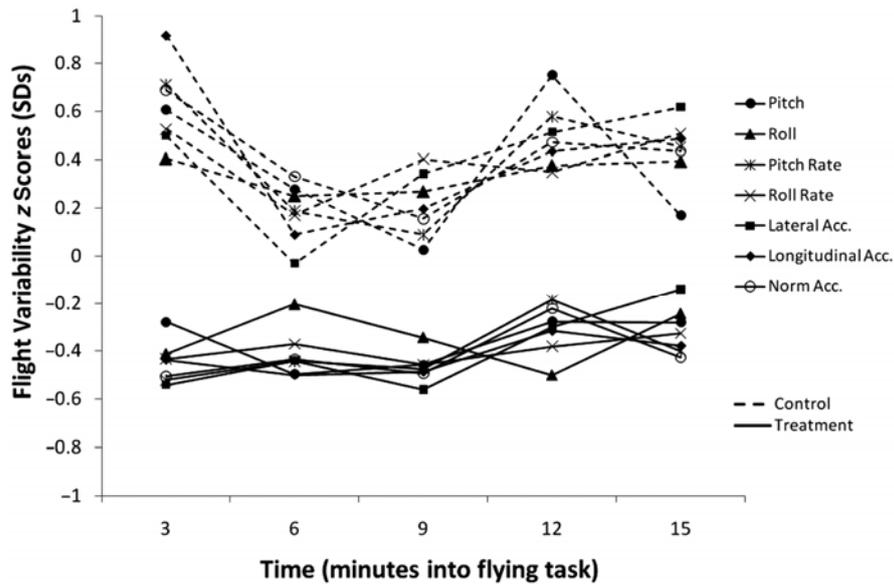
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Figure 3. Mean flight variability scores as a function of time. Flight dimensions and experimental groups are the parameters. Error bars are omitted to reduce excessive noise in the figure.

CFI Performance Evaluations

For each of the two raters, an overall CFI rating was determined for each participant. These overall ratings were used to determine any difference in the two CFIs' evaluations. A t test of the mean ratings determined no significant difference between the two CFIs' evaluations ($p > .05$), implying that the CFIs rated the performance of the participants in a consistent manner. Consequently, the ratings of the two CFIs were combined in a subsequent analysis of the CFI performance evaluations.

Mean CFI performance ratings for the experimental and control groups are plotted as a function of successive queries in Figure 4. It is evident in the figure that the performance ratings of the stresstrained treatment group were higher than those of the control group throughout the flying task and that the scores for both groups appeared to improve during the course of the flight. A two-way ANOVA with repeated measures on query confirmed that the treatment group performed better during the flying task than did the control group, $F(1, 28) = 7.20$, $p < .05$, $\eta 2 = .20$, and that there was a significant increase in the performance of both groups as the transfer flight progressed, $F(3.08, 86.16) = 5.45$, $p < .01$, $\eta 2 = .16$. The ANOVA did not indicate a significant Group $\times$ Query interaction ($p > .05$). The degrees of freedom for the

repeated measures in this analysis reflect the Box correction to compensate for violations of the sphericity assumption (Field, 2009).
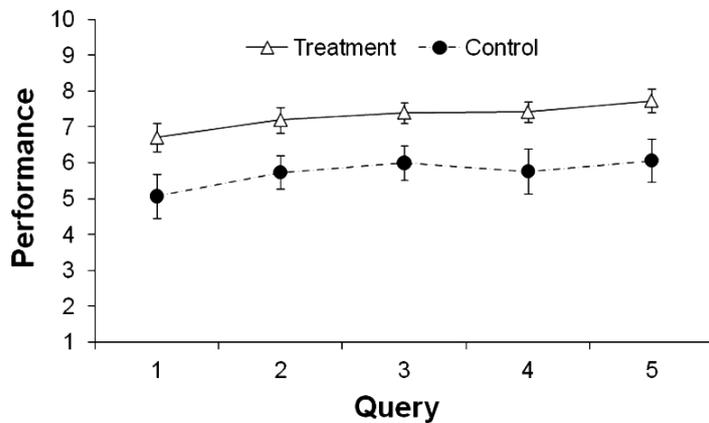

Figure 4. Mean flight instructor performance evaluations over time for the experimental and control groups in the flying task. Error bars are standard errors.

Subjective Stress Ratings

Mean stress scores for the experimental and control groups are presented as a function of successive queries in Figure 5. Perusal of the figure reveals that both groups found the task to be stressful—the mean stress scores during the initial portion of the flight were approximately 150% above baseline, and although the scores declined during the course of the flight, they were still approximately 120% above baseline at the point of the final query. A two-way ANOVA with repeated measures on query confirmed a significant decrease in reported stress levels during the course of the flight, $F(2.85, 79.79) = 5.21$, $p < 0.01$, $\eta 2 = .16$. No significant difference was found for the training manipulation or the Group × Query interaction ($p > .05$). Again, the Box correction was used to compensate for violations of the spericity assumption.
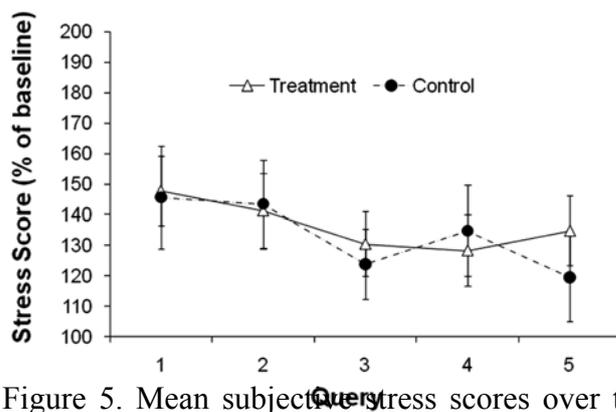

Figure 5. Mean subjective stress scores over time for the experimental and control groups during the flying task. Error bars are standard errors.

DISCUSSION

The results of this study confirm and extend McClernon's (2009b) initial finding that simulator-based stress training can benefit pilot performance. They do that by providing affirmative answers to two key questions: (a) Does simulator-based stress training enhance subsequent flight performance in an actual aircraft? and (b) Does such training generalize to a modification of the acquisition task and a novel stressor? With regard to the first question, participants in this study who were stress trained in a flight simulator subsequently flew an aircraft more smoothly, as recorded by telemetry data, and generally better, as recorded by CFI evaluations, than did control participants. With regard to the second question, the novice participants in this study benefited from the artificial, incongruent stressor (a cold pressor) experienced in training when later exposed to the real-world stress associated with flying an aircraft for the first time in simulated instrument conditions.

In providing positive answers to these questions, the results of this study support the efficacy of Friedland and Keinan's (1992) three-phase training method, which formed the foundation for the experimental approach employed here, and they validate Overton's (1964) state-dependent learning theory that employing the expected operational states in training may be beneficial to subsequent operational performance. In addition, the results of this study confirm Driskel et al.'s (2001) findings that the effects of stress training may generalize from one situation to another.

In addition to these findings, the performance results presented here provide further evidence for the efficacy of the variance-based approach to performance assessment in an aviation context suggested by McClernon and Miller (in press). Consistent with the CFI ratings, the telemetry-based variance measures were sensitive to differences produced by stress training. It is important to note, however, that there was a difference between the CFI ratings and the telemetry measures. The CFI ratings indicated that the flight performance of the participants improved over time, whereas such improvement was not mirrored in the telemetry data. Evidently, the performance portraits painted by these measures are not completely identical. One possibility for this outcome is that in addition to flying performance, the CFIs may also have been

evaluating behavioral indications of flying technique, such as excessive muscle tension and erratic control input, that may not be evident in the telemetry measures.

A critical assumption in this study was that the inexperienced participants would find the flight task to be stressful. This was indeed the case. In the initial stress query, the mean scores for both the experimental and control groups were approximately 150% above baseline, and although the participants' overall mean stress scores declined during the course of the flight, they were still approximately 120% above baseline at the end of the flight.

An important aspect of the present findings in regard to stress is the fact that they are both consistent and inconsistent with the results of McClernon's (2009b) initial investigation of the value of stress training in an aviation context. As in that earlier study, stress training enabled participants in the experimental group of this study to perform more efficiently during the transfer phase of the experiment than their control cohorts. However, unlike the case in the initial study, such training did not reduce the experimental participants' reported level of stress relative to the controls. In this study, the stress scores for both groups of participants during the transfer phase did not differ significantly on an overall level or in relation to time in flight. An outcome of this sort has potentially important implications for insight into the type of benefits acquired during training.

The stress inducer in the McClernon (2009b) study, the cold pressor, was the same during the training and transfer phases of the experiment. In the present case, the cold pressor was the stress inducer during the training phase, and the flight task itself was the origin of stress during transfer. Therefore, when the stressor was congruent between training and transfer, participants may have adapted to the physical stressor and, in that way, lowered its negative effect on performance efficiency. When the sources of stress were incongruent, the principal benefit of training may have been the development of cognitive coping skills that enabled performance in the transfer task even though the perceived level of stress remained high.

Although the development of appropriate cognitive coping skills was a desired aspect of training in this study, it is important to note that other, less desired elements can occur when participants are confronted with stress-inducing situations. More

specifically, as described by Endler and Parker (1990), there are three major strategies employed by individuals in coping with stress. One of these is task-focused coping, which refers to efforts to deal directly with the source of task or environmental demands. A second approach is emotion-focused coping, in which individuals attempt to confront a problem by changing their thoughts and feelings about it. The third approach is that of avoidance coping, wherein individuals do not confront the problem but instead avoid it.

Several studies have shown that task-focused coping often generates success in dealing with a stressful task, whereas the other two forms of coping often lead to failure (Matthews, 2001; Matthews, Davies, Westerman, & Stammers, 2000). The finding that stress training with the cold pressor led trained participants to enhance performance efficiency on the subsequent flight task but did not reduce their stress levels relative to the untrained control participants implies that the trained participants learned a task-focused approach to stress coping that transferred between tasks. That such an approach was acquired during training is a credit to the procedure employed as well as to the determination of the participants.

Although the present study was successful in linking simulator-based stress training to a real-world transfer task in an aviation context, it is only a beginning, and there are many research questions that merit attention. First, the transfer task occurred immediately after the stress training. Therefore, we do not know the retention characteristics of the stress coping training. Second, it is unknown what the impact of the stress training alone, in the absence of the cold pressor, may have had on performance of the transfer task. The cold pressor is an example of a passive physical stressor. An extension to the study would be to examine whether similar effects would be elicited to an active cognitive stressor that is relevant to a flight environment (e.g., the necessity to provide information in response to air traffic control calls).

Finally, operational considerations for implementing stress training and when and how often such training should be implemented also remain unanswered. The introduction of stress training into flight training certainly imposes additional time and costs; however, a comparison between these additional costs and cost savings

with traditional flight training paradigms (e.g., experiencebased expertise) warrant future investigation.

In sum, the results of this study indicate that by implementing stress in flight training, pilots may be more prepared to cope with various stressful flight environments and, therefore, avoid some of the preconditions to aircraft accidents that are susceptible to stress, as described by Wiegmann and Shappell (1997). The results help fill the critical void of research addressing training guidelines for aiding pilots to cope with stress (Burian et al., 2003) and point to a way to potentially improve training efficiency (i.e., reduced time to train, cost of training, etc.).

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