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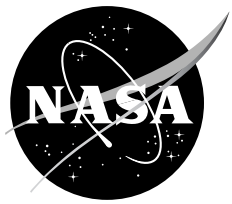

The Effects of Life-Stress on Pilot Performance

James A. Young
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December 2008

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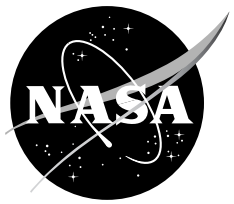

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TABLE OF CONTENTS

LIST OF TABLES

THE EFFECTS OF LIFE-STRESS ON PILOT PERFORMANCE

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INTRODUCTION

The fact that pilots are often reluctant to report physical complaints or illnesses for fear of being temporarily grounded or having their flying careers adversely affected is a common challenge to aviation safety. For the typical pilot there is no greater fear than losing flying status. Aviators understand that even when medical issues are not likely to be exacerbated by flight, medical personnel are required to consider the degree to which the pilot's performance may be compromised by the symptoms of the particular ailment (e.g., through spatial disorientation from labrynthitis).

Now let's consider the aviator who struggles with psychological or emotional issues. To what degree might these life-stressors impair aviation safety? Are life-stressors as dangerous as the acute stress arising from immediate threat? Might they be more dangerous because aviators are very reluctant to seek help for these problems? For the purpose of this paper, life-stress is defined as physical and psychological symptoms (e.g., muscle tension, worry or preoccupation, disrupted sleep/fatigue, change in appetite, or alterations in social interactions such as withdrawal, irritability, or difficulty concentrating) that are often a product of difficult life circumstances. Among those circumstances are relationship difficulties, financial worries, health concerns, bereavement issues, work related problems, and separation from family. Is there any evidence to suggest that life-stress might be an issue in our aviation community? Bowles, Ursin, and Picano (2000) stated that stress researchers have recognized that the pilot has one of the most stressful jobs. In a recent publication (Burke, 2007), the executive chairman of the Air Line Pilot Association's (ALPA) human performance structure stated that, "Our representatives have seen an uptick across the board in stress-related issues, manifested in medical or professional standards issues and in general malaise…no other industry in the United States has been under more direct stress and pressure since 9/11 and we know that our members are carrying that stress (p. 24)."

One might assume that higher levels of life-stress substantially increase vulnerability to error, but many aviators claim that they can compartmentalize (i.e., to keep personal issues/feelings/thoughts outside the cockpit) to protect performance. What does the research literature tell us about this issue? If life-stress impairs performance, how common is it? What aspects of performance are affected and by what mechanisms? This paper attempts to answer these questions. Even though the primary focus of this paper is on aircrew performance the results equally apply to any skilled performer (e.g., astronauts, military personnel, air traffic controllers, maintenance personnel, medical personnel such as emergency room physicians or surgeons, corporate executives, firefighters, police officers).

A review of the stress-performance literature reveals a substantial body of research demonstrating that acute stress (i.e., that which arises in the context of high task demand/potentially threatening situations) can impair task performance (Bourne & Yaroush, 2003; Driskell, Mullen, Johnson, Hughes, & Batchelor, 1992; Driskell & Salas, 1996; Staal, 2004; Stokes & Kite, 1994). This research suggests that impairment from acute stress results from altered cognitive processes (e.g., "tunneling" of attention, decreased working memory, and degraded judgment and decision-making). Might life-stressors impair performance in a similar fashion?

Only limited research has examined the effects of life stress on skilled performance. The paucity of research in this area may be a consequence of methodological and ethical limitations inherent in the experimental manipulation of life-stress. This is not a subject easily studied in the laboratory or the field. Simmel, Cerkovnik, and McCarty (1989) suggest at least three specific reasons to explain why strong evidence for a connection between life-stress and performance has been elusive: (1) difficulties in the measurement of life-stress; (2) individual differences in reactions to stressors; and (3) luck—they suggest that most often the influence of life-stress will go undetected because it only infrequently joins with other circumstances (e.g., emergency situations) to cause a mishap.

The fact that pilots are unlikely to report stress symptoms makes the life-stress–performance relationship even more difficult to investigate. This under-reporting occurs for at least two reasons: it is possible that pilots are not fully aware of the effect that stress has on them; and even when they are aware of these effects, a variety of internal and external pressures make it less likely that a pilot will report or seek help for symptoms (e.g., fear of losing face in the eyes of other pilots, of being perceived as less reliable, or of being removed from flight status—they are often counseled by colleagues to avoid mental health care at all costs). Bor, Field, and Scragg (2002) add that, in general, pilots do not like being interviewed by mental health professionals. Capturing the extent of perceived risk some pilots have about seeking help, a senior fighter pilot (Hamilton, 2005) recently commented "…aviators are notorious for avoiding flight surgeons and would disavow the very existence of mental health professionals if given the opportunity. Both occupations (flight surgeons and mental health professionals) represent a threat to a pilot's flying status (p. 43)."

LIFE-STRESS AND AIRCREW PERFORMANCE

Several authors suggest a relationship between life-stress and pilot performance (Aitken, 1969; Alkov, Gaynor, & Borowsky, 1985; Bor, et al., 2002; Green, 1985; Haakonson, 1980; Neubauer, 1999; Raymond & Moser, 1995; Shuckburgh, 1975; Simmel, et al., 1989; Loewenthal, Eysenck, Harris, Lubitsh, Gorton, & Bicknell, 2000; Ursano, 1980; Voge, 1989). For example, Green (1985) speculates that those experiencing life-stressors may be more likely to commit errors because they are likely to be thinking about the stressor rather than devoting all of their cognitive resources to the task at hand. A senior U.S. Air Force flight surgeon (Neubauer, 1999) suggests that, while pilots may have some ability to keep life-stressors from entering the cockpit and interfering with performance, each also has a level of stress or a specific stressor that is likely to significantly interfere with this ability to compartmentalize. Christy (1975) contends that even high functioning pilots "under some combination of stresses—intrapersonal or interpersonal—may develop personality reactions,

anxiety, somatic symptoms, with reduced effectiveness and inadequate functioning (p. 310)." Loewenthal, et al. (2000) hypothesize that stress indirectly impairs performance by disrupting sleep and impairing one's ability to pay attention. Finally, Bor, et al. (2002) suggest that various aspects of the pilot's job (e.g., disrupted relationships, odd routines, jet lag) may cause significant levels of stress.

There have been a number of attempts to empirically study the possible causal relationship between life-stress and performance. These studies can be divided into at least three types: those examining pilots' perception and reporting of stress, those that look for a correlation between life-stressors and aviation accidents, and those examining reported effects of life-stress on cognitive aspects of task performance. This last category may prove to be the most promising area of study for understanding the underlying mechanisms by which life-stress may interfere with performance.

Pilot's Report of Stress Symptoms

Sloan and Cooper (1986), in a study of British commercial airline pilots, offer information about the typical pilot's experience of stress. Using a modified version of Alkov, Borowsky, and Gaynor's (1982) questionnaire, they randomly surveyed 1,000 pilots who were also members of the British Airline Pilots Association (BALPA). They received a response of 442 usable surveys. While there were many interesting findings, some appear particularly relevant to the discussion of pilot's perception of the stress–performance relationship. For example, 16.2% of the pilots said they could tell when they experienced stress because at work they "usually" or "almost always" felt tired, 13.1% said they experienced recurring thoughts during periods of low workload, 9.1% experienced a tendency to not listen as intently, 8.4% had a tendency to worry, 8.4% reported decreased concentration, and 7.2% reported becoming detached from tasks at hand. When the pilots who reported these symptoms occurring "sometimes" are included, the percentages increase substantially. For example, using this less conservative approach, over 45% indicated that they experienced decreased concentration at least sometimes as a result of stress. Nearly 93% indicated that they thought negative life events could affect pilot performance. The authors suggest that many of the noted effects are cognitive in nature.

The data for this study was based on the pilots' perceptions and therefore depends on how accurately the pilots were able to recall past experiences and determine causal relationships between the variables (e.g., between stress and not listening intently). Regardless of how accurate perceptions of causality are, the descriptive data regarding the frequency of experiencing the various problems is noteworthy.

Parsa and Kapadia (1997) attempted to document the occurrence of symptoms of excessive stress by surveying a group of U.S. Air Force fighter pilots from five squadrons, four of which were stationed at bases out of which combat operations were being conducted. The fifth squadron was a composite of pilots from two stateside bases who were not involved in combat missions at the time of the survey. The impetus for this study was that while stationed overseas, one of the authors noted that pilots were complaining about excessive stress. Although the use of a well known depression inventory (the Beck Depression Inventory, or BDI) to assess levels of stress is problematic because it was not

designed to assess stress, the study reveals some rather unexpected findings. For example, looking at BDI responses for the entire group of 57 fighter pilots, 89% reported insomnia, 86% reported irritability, 63% reported dissatisfaction, 61% fatigue, 58% self-accusation, 47% work difficulty, 38% pessimism, 38% guilt, and 35% loss of libido. Somewhat surprisingly, over 50% of two squadrons and 33% of another squadron scored above 9 on the BDI (scores range from 0-63). Although when taken out of context these scores are difficult to interpret accurately, in a clinical setting, scores in this range would suggest at least low levels of depression.

When they compared mean BDI scores between pilots stationed overseas and those stationed in the U.S. (i.e., the composite squadron not involved in combat missions), they found no significant differences, suggesting that pilots exposed to combat operations are not necessarily at higher risk for psychological issues than those who are not. The authors believe the overall findings are particularly surprising when one considers that pilots are known for denying these types of symptoms and have undergone a rigorous selection process which demands high levels of stress tolerance. They also suggest that this level of symptom endorsement certainly raises issues of safety and further state "aircrew that may have had the most rigorous combat training may experience a lowered stress resistance than what may be expected (p. 1091)." Although these findings are interesting and somewhat surprising, unfortunately, one is left to speculate about the effects of these symptoms on pilot performance since there was no attempt to correlate the degree to which pilots experienced symptoms with measures of performance (e.g., mishaps, accidents, or removal from flying status).

In another study (Fiedler, Della Rocco, Schroeder, & Nguyen, 2000), using Sloan and Cooper's (1986) modification of the Alkov, et al. (1982) questionnaire, researchers asked aviators directly about their perception of the relationships between self-reported home–stress, work–stress, and perceived performance. Results from this study indicated that pilots believed their flying performance was impaired when home–stress carried over to the work environment. Pilot's perceptions of tendencies to worry at work, not listen as intently, and feeling slowed down at work were significantly correlated with their perception of poorer flying performance. How much home–stress was carried over to the work environment was significantly and negatively related to specific flying performance items such as being ahead of the game, smoothness and accuracy of landings, degree of airmanship exhibited, and the ability to divide attention. Pilots reported that fatigue and rumination about the home–stressor were the most common ways home–stress intruded while they were at work. The authors suggest that their findings support Sloan and Cooper's conclusion that the primary effect of home–stress at work is in the cognitive domain (worry/rumination/intrusive thoughts). As with Sloan and Cooper's study, all of the findings reflect pilots' retroactive perceptions and are therefore dependent on the accuracy of these perceptions. Additionally, while the pilots believed certain stressors negatively impacted their work performance, the frequency with which this occurs is unclear. Perhaps it occurs so infrequently that the risk of error while flying is minimal.

A study of U.S. civilian pilots (Little, Gaffney, Rosen, & Bender, 1990) offers another indication of the types of stress-related symptoms that pilots might experience. These authors examined the effects of corporate instability on commercial pilots by contrasting pilots from stable airlines with pilots from unstable airlines, speculating that pilots working in unstable work environments would be more likely to experience symptoms of stress. The stability of airlines was based on the previous 12-month history (e.g., sale, merger, and takeover; gains/losses reported for the previous two earning

periods; and employee wage/work rule concessions in the past contracts with management). They surveyed a random sample of 839 pilots who were members of the Air Line Pilot's Association (ALPA) and received 432 returned surveys—212 from the unstable airline and 220 from the stable airlines combined. These pilots completed the Symptoms of Stress Scale which assessed the extent to which respondents experienced each of 18 symptoms over the "past few weeks."

The authors noted substantial and statistically significant differences between the two groups. Pilots from unstable airlines were far more likely to report symptoms such as feeling hopeless about the future, irritability, inability to concentrate, decreased attention, excessive anger, "feeling like a pressure cooker about to explode," having "no feeling" in emotional situations, procrastination, general dissatisfaction, crying easily or feeling like crying, and having a pessimistic attitude, as can be seen in table 1.

While we are unable to determine how often the individual pilots experienced these symptoms, once again we are left with the impression that some of the symptoms are related to fundamental cognitive processes: attention and concentration. On amethodological note, the investigators took what could be perceived as a relatively conservative approach in determining what constituted symptom endorsement. Each item was marked on a 5-point Likert scale: "almost always", "frequently", "sometimes", "once in a while", and "never." The researchers counted only "almost always" and "frequently" as symptom endorsement. For example, a pilot experiencing a particular symptom "sometimes" in the past few weeks would not have been counted as having endorsed that particular symptom. This cautious interpretation leads one to believe that the actual frequency of these symptoms may have been greater than reported. The underlying mechanisms by which these symptoms might impair performance will be discussed later in this paper.

TABLE 1. CORRELATIONS BETWEEN PILOTS FROM STABLE AND UNSTABLE AIRLINES ON SYMPTOMS OF STRESS SCALE[†]

	Airline Variables	
Stress Variables	**Stable**	**Unstable**
Feeling hopeless about the future	2.3%	17.9%*
Irritability	7.3%	14.6%*
Inability to concentrate	3.2%	9.4%*
Decreased attention	4.1%	9.9%*
Excessive anger	1.4%	5.2%*

[†] Little, Gaffney, Rosen, & Bender, 1990.

*$p \leq .05$.

In a somewhat similar study, Girodo (1988) examined the effects of stress resulting from an ongoing labor dispute between airline pilots and management. Investigators administered four instruments: (1) Eysenck Personality Questionnaire (EPQ), a personality inventory, (2) Health Opinion Survey (HOS), an instrument used to assess mental health, (3) Symptom Checklist 90 (SCL-90), an instrument assessing a variety of psychological symptoms, and (4) semi-structured clinical interviews that assessed things such as pilot's status (i.e., fired, demoted, layed-off), pilot's perception of the impact of being involved with such labor disputes, any noted changes in behavior or performance as well as anything the pilot may have done to cope with the dispute. Because the subjects (N=24) were solicited at a pilot's association meeting, the researchers sought a sample of pilots who normally would not attend these meetings to act as a control group (N=12). Results indicated that these two groups did not differ significantly on any of the scales and were therefore combined for the remainder of the statistical analysis.

Results revealed that nine pilots, (>24%), scored at levels indicating clinical significance on the HOS. One would predict only 11% scoring in this range using age–equivalent male population norms. In other words, these pilots admitted to symptoms in a manner that would indicate they might benefit from psychological/psychiatric assistance. On the SCL-90, as a group, these pilots scored in a range that was more similar to psychiatric outpatients than to normal controls on scales that assessed anger and paranoia. Also, some pilots reported experiencing some memory difficulty, having their mind go blank, and having to slow down and double check their work to ensure they did not make mistakes. Of the 24 pilots who completed the clinical interview, 14 were actively flying and 10 were not (and had not flown for 2 to 4.5 months). One of the pilots who was still flying was described as "experiencing major sleep disturbances, migraines, somatic complaints, weight loss and heavy drinking (p. 508)." He also reported that his major concern was the fact that he knew he wasn't fit for flying, but feared being fired if he called in sick. In interpreting these findings, one wonders to what degree a motivation to appear distressed contributed to the overall symptom presentation, although it seems fairly unlikely that these subjects would create an entirely false presentation.

Gerbert and Kemmler (1986) surveyed 1,448 German Air Force pilots, using an extensive (315-item) questionnaire. Pilots were asked to recall the circumstances surrounding recent aircraft incidents and the researchers gathered information on "(a) flying background of the pilot; (b) date and time of the incident; (c) flight order, phase of flight, type of task and flight parameters at the time the critical situation occurred; (d) extent and sequence of preflight preparation; (e) physical and psychological condition of the pilot prior to flight; (f) pilot's assessment of his persisting behaviour characteristics; (g) environmental, organizational and aircraft subsystem conditions during flight; (h) psychological and physiological state of the pilot immediately prior to and during the incident; (i) type of restriction of functional abilities or type of performance error, respectively; (j) hazardous situation encountered; (k) resolution of critical situation (p. 1441)." Some of the most frequent errors reported by these pilots were a delay in taking necessary actions and various forms of misjudgment (e.g., of weather conditions, distance, altitude and clearance, airspeed). Some of the most common "internal conditions" associated with these errors were channelized attention, lack of awareness of risk, task oversaturation, overconfidence, distraction of attention, and lack of motivation.

These authors suggest that flying performance can be best understood by considering the "psycho-physiological fitness" of the pilot in combination with the fluid performance demands (task requirements) of the flight. As the fitness of the pilots worsens and the demands of a particular flight increase, one would expect an increase in the probability of an incident which may or may not lead to an aircraft accident. On a methodological note, the reliance on the pilot's ability to not only accurately recall the details of particular flights but also to remember details of their psychological and physiological state prior to flight limits interpretation of the data.

Correlation Between Life-stressors and Accidents

Alkov and Borowsky (1980) surveyed 155 medical members of mishap investigation boards in an attempt to explore the influence of personality and life changes on the likelihood of having an accident. A questionnaire focused on recent personality and life changes was sent to squadrons reporting major aircraft accidents from June 1977 to May 1978. The flight surgeons assigned to the accident boards were asked to complete the questionnaire by acquiring information about the person's personality and professionalism from his commanding officer, and information about recent life events from the aviator or friends/relatives if the aviator died as a result of the mishap.

Of the 155 original questionnaires, 129 were returned. Aviators were divided into two groups, those who were deemed causally involved in the mishap and those who were not. In an attempt to cross-validate the results, the researchers sent a modified version of the survey to all squadrons reporting major aviation accidents during calendar year 1979. This new version of the survey was, in part, a result of using items that appeared to discriminate between the two groups (causal vs. non-causal) in the first survey. They received 150 returned questionnaires. Results from the combined surveys indicated that certain items discriminated between those who were causally involved in aircrew error accidents and those who were not. As can be seen in table 2-A, five items were more likely to be causal: (1) recently became engaged, (2) made any recent decisions regarding the future, (3) have difficulty with interpersonal relationships, (4) recently have a death in the family or recently lose a close friend through death, (5) recently have trouble with superiors or recently have trouble with peers or subordinates. Four items were less likely to be causal: (1) exhibit the characteristics of maturity and stability, (2) exhibit professionalism in his approach to flying, (3) have a sense of humor and humility concerning himself, (4) exhibit the ability to quickly assess potentially troublesome situations.

The researchers acknowledge an obvious problem with this retrospective analysis: the commanders and flight surgeons' knowledge of the aviator's contribution to the mishap may have colored their later assessment. In other words, those who were believed to play a causal role in the accidents may have been characterized in a less positive manner. Another criticism of the study (Stokes & Kite, 1994) is that the authors interpret as important some findings with weak statistical significance.

TABLE 2–A. ITEMS DISCRIMINATING PILOTS CAUSALLY INVOLVED IN ACCIDENT†

Survey Item	Statistical Significance
Exhibit the characteristics of maturity and stability (less likely to be causal)	p = .054
Recently became engaged (more likely to be causal)	p = .072
Made any recent decision regarding the future (more likely to be causal)	p = .002*
Exhibit professionalism in his approach to flying (less likely to be causal)	p = .069
Have difficulty with interpersonal relationships (more likely to be causal)	p = .066
Have a sense of humor and humility concerning himself (less likely to be causal)	p = .012*
Exhibit the ability to quickly assess potentially troublesome situations (less likely to be causal)	p = .048*
Recently have a death in the family or recently lose a close friend through death (more likely to be causal)	p = .058
Recently have trouble with superiors or recently have trouble with peers or subordinate (more likely to be causal)	p = .033*

†Alkov & Borowsky, 1980.

*$p \leq .05$.

In a follow up study, Alkov, et al., (1982) explored whether the causally involved aviator was more likely to demonstrate symptoms of poor stress coping. Previously only anecdotal evidence (clinical case histories) existed for a relationship between poor coping and accident involvement. The authors also suggest that depression or self-destructiveness may be a result of poor stress coping. As in the previous study, they sent a survey to Naval flight surgeons who were members of mishap investigation boards for accidents reported during calendar years 1979 and 1980. As shown in table 2–B, the findings suggest that pilots causally involved in mishaps were more likely to have marital problems, to show signs of immaturity and instability, to have recently become engaged to be married and to be making a major career decision, such as getting out of the service. Pilots were less likely to be professional in their approach to flying and less likely to be able to quickly assess potentially troublesome situations.

The authors suggest that these results support the hypothesis that aircrew members identified as causal in aircraft mishaps are more likely to show symptoms of inadequate stress-coping. They do not speculate as to the specific ways in which life-stressors or symptoms of stress might be causally related to performance decrements. Regarding methodology, the flight surgeon's impression of the particular aviators may have been influenced by their knowledge of the pilot's role in the particular accident. For example, the knowledge of a particular pilot's causal role in an accident may have influenced their judgment about that pilot's ability to quickly judge a potentially problematic situa-

tion or their level of professionalism in their approach to flying. However, some items are less worrisome in this regard (e.g., marital problems, recently engaged, difficulty with others) as they seem more objective and less likely to be influenced by hindsight bias.

In another study, Alkov, et al., (1985) attempted to validate the hypothesis that poor stress coping may increase the chances of causing a mishap. They hypothesized that for aggressive, young, military aviators the typical reaction to heightened levels of stress would be "acting out" behavior in which frustrations and the aggressive feelings they produce are directed at other people or objects rather than turning inward to become self-destructive or depressive. "Acting out" behavior might be more likely to result in problems in interpersonal relationships as suggested by the previous study in which aviators who played a contributory role in their mishaps exhibited more difficulties with superiors, peers, and spouses, than those who did not play a contributory role. Alkov, et al., suggested that those who exhibited "acting out" behavior, irrespective of the cumulative total amount of life-stress encountered, would be more likely to be identified as having contributed to their mishap.

The methodology was similar to the previous studies, however, four items were added to the questionnaire: (1) drink to excess or recently change alcohol intake; (2) exhibit a sense of his own strengths and limitations; (3) undergo a recent personality change; and (4) take unnecessary risks. The questionnaire was sent to U.S. Navy flight surgeons who sat on mishap boards during 1981 and 1982. Results were compared with previous studies and because there were no major differences except for marital problems, the researchers combined data for all four years (i.e., 1979-1982). The data reveal that aviators who played a contributory role in their mishaps were more likely to be

TABLE 2–B. ITEMS DISCRIMINATING PILOTS CAUSALLY INVOLVED IN ACCIDENT[†]

Survey Item	Statistical Significance
Have marital problems (more likely to be causal)	p = .0202*
Show signs of immaturity and instability (more likely to be causal)	p = .0324*
Have recently become engaged to be married (more likely to be causal)	p = .0411*
Be making a major career decision (more likely to be causal)	p = .0017*
Not be professional in their approach to flying (more likely to be causal)	p = .0007*
Be having difficulty with interpersonal relationships (more likely to be causal)	p = .0047*
Have recently had trouble with superiors or received disciplinary action (more likely to be causal)	p = .0029*
Not be able to quickly assess potentially troublesome situations (more likely to be causal)	p = .0047*
Recently have had trouble with peers or others (more likely to be causal)	p = .0279*

[†]Alkov, Borowsky, & Gaynor, 1982.

*$p \leq .05$.

viewed as poor leaders, lack maturity and stability, have financial problems, be recently engaged to be married, have made a recent major career decision, be viewed as not professional in flying, have had difficulty with interpersonal relationships, have trouble with superiors, be incapable of quickly assessing potential trouble, have trouble with peers, drink excessively or to have recently changed alcohol intake, have no sense of own limitations and to have had a recent change in personality (see table 2–C).

The authors argue that these results support the idea that some mishaps are caused by aviators with poor stress–coping ability. Of course, this study is subject to the same methodological concerns as the previous studies. Also, although the authors view many of these symptoms as evidence of inadequate stress coping, one can formulate other explanations. For example, because a pilot has difficulty with peers or superiors does not necessarily prove that they are inadequately coping with stress. These types of difficulties are not uncommon, and adequate coping may be more accurately determined by assessing how pilots respond to these difficulties rather than merely their occurrence. Also, a change in drinking pattern could result from many factors, such as a change in social group or activities, and one should not automatically assume that it is a result of poor coping.

TABLE 2–C. ITEMS DISCRIMINATING PILOTS CAUSALLY INVOLVED IN ACCIDENT[†]

Survey Item	Statistical Significance
Be viewed as poor leader (more likely to be causal)	p = .0065*
Lacks maturity and stability (more likely to be causal)	p = .0425*
Have financial problems (more likely to be causal)	p = .0418*
Be making a major career decision (more likely to be causal)	p = .0001*
Not be professional in their approach to flying (more likely to be causal)	p = .0000*
Be having difficulty with interpersonal relationships (more likely to be causal)	p = .0385*
Have recently had trouble with superiors (more likely to be causal)	p = .0001*
Be incapable of quickly assessing potential trouble (more likely to be causal)	p = .0000*
Recently have had trouble with peers (more likely to be causal)	p = .0203*
Drink excessively or recently changed alcohol intake (more likely to be causal)	p = .0047*
Have no sense of own limitations (more likely to be causal)	p = .0131*
Have a recent change in personality (more likely to be causal)	p = .0304*
Recently engaged to be married (more likely to be causal)	p = .0118*

[†]Alkov, Gaynor, & Borowsky, 1985.

*$p \leq .05$.

Platenius and Wilde (1989) surveyed civilian pilots in an attempt to establish a link between certain life events, pilot characteristics, and accidents. They used a lengthy questionnaire (302 items) and surveyed over 8,800 Canadian airline transport, commercial and senior commercial, helicopter and private pilots. The pilots were asked if they had an aircraft accident in the last 10 years. They were also asked about a variety of life events, their propensity to take risks, their preferred hobbies, medical/psychiatric symptoms, comfort in social settings, and use of alcohol. The researchers then analyzed the items to determine whether any differentiated between accident and non-accident pilots. While the analysis revealed many "accident markers," preoccupations about separation, divorce or business decisions appeared most frequently. While it's impossible to determine the direction of the relationship (Did accidents prompt preoccupation with a business decision or vice versa?), it is noteworthy that many of these background stressors and accidents are frequently correlated. Unfortunately, we do not know whether the reported preoccupations occurred concomitantly with the accident—it is possible that a pilot experienced both preoccupation and an accident, but not at the same time.

Aitken (1969) examined the relationship between prevalence of worry in normal aircrew and aircraft accidents. He surveyed British military pilots from eight squadrons, one of which had a particularly high rate of mishaps in the preceding year. He simply asked pilots if they had "'experienced personal worry or emotional stress during the previous year'; those who indicated that they had were invited to mark one or more appropriate causes from a selection of 10 offered (p. 283)". Of those surveyed, 71% admitted to experiencing personal worry or emotional stress during this year. Topics of worry included housing, wife, finances, children, examinations, flying, love-life, parents, and bereavement. Accident rates were correlated with worry about one's wife, $r = .140$, $p = .05$ and bereavement, $r = .196$, $p = .01$. Because the researcher did not reveal more specific information, we are left with only general categories of worry and must speculate about the specific concerns these pilots had. For example, with regard to worries about a spouse, is the concern about the relationship itself, the spouse's health, or something else? Also, it is possible that higher accident rates in a particular squadron might make pilots more sensitive to other worries or more likely to report worries in general. Although the researcher makes no claims about the causal role of worry or stress on accidents, he does establish that many pilots are willing to admit to worrying about various issues.

Chappelow (1989) discussed results from 149 British military flying accident investigations. These investigations were conducted by psychologists and utilized data from several sources of information: interviews with survivors and others, personal records, eyewitness reports, flight data recordings, and examination of cockpit equipment, regulations, manuals and other documents. These investigating psychologists classified the human factors contributions as "possible," "minor," or "major." The author reports that "life-stress," defined as "any personal or domestic events believed to have a worrying, anxiety provoking or exciting effect on an individual" was a possible contributing factor in 11% of the accidents. They reported a direct link between a stressful life event and accidents in two cases. Additionally they reported that "cognitive failure" or distraction was involved in 33% of the cases and provided the following definition for cognitive failure: "A type of error in which actions fail to match intentions, usually because an intended action is omitted or

because an unintended action is committed." The most common result of cognitive failure was a wheels-up landing. Of the 26 accidents in which cognitive failure was viewed as a primary or contributing cause, nine involved errors of omission—usually items that were very familiar to the crew, and 19 accidents were a result of performing one action when intending to perform another.

Summary of Correlational and Anecdotal Findings

Even though the above studies, taken together, appear to make a reasonable case for the view that life-stress affects performance, all suffer from methodological problems that limit confidence in their interpretation and conclusions. The most rigorous studies provide us with only correlational data which does not allow us to infer causality. Also, these studies do not attempt to provide a theoretical explanation of the purported changes—how does the presence of life-stress lead to impaired performance? Of course, the lack of strong empirical support does not mean that life-stress does not impair performance, and a causal relationship might be revealed with other methods.

In several of the studies (e.g., Sloan & Cooper, 1986; Fiedler, et al., 2000) pilots acknowledged that life-stress was significant, negatively affecting their task performance. If this is true, by what mechanisms might life-stress impair performance? We can begin to explore this question by considering the common symptoms associated with life-stress. Several authors (Little, et al., 1990; Sloan & Cooper, 1986) noted the following symptoms: irritability, fatigue, inability to concentrate, decreased attention, worry, memory difficulty, and a tendency to not listen carefully. Parsa and Kapadia (1997) found that some U.S. Air Force fighter pilots admitted to the following symptoms: insomnia, irritability, dissatisfaction, fatigue, self-accusation/blaming/guilt, and pessimism. All of these symptoms are highly consistent with the common clinical notion of the effects of stress. It is very common for a clinical population to experience stress–related symptoms, such as difficulty sleeping, fatigue, increased irritability, inability to focus or concentrate, increased levels of worry and anxiety, and interpersonal difficulty.

These findings suggest several potential routes by which life-stress may directly or indirectly impair performance:

1. It may lead to decreased quantity and quality of sleep, leading to a state of fatigue, which is known to impair performance in specific ways.
2. It may undercut motivation to perform one's job well. While one's approach to tasks perceived to be critical may not change, tasks viewed as less significant (e.g., following checklist procedures) may receive less attention than is appropriate.
3. It may negatively influence one's affective state, leading to higher levels of frustration, irritability/anger, anxiety, or depression. Mood states such as irritability, anxiety, or depression can negatively influence the interpersonal atmosphere in the cockpit, potentially leading to ineffective crew resource management. To the degree that life-stress creates a sense of dissatisfaction, pessimism, and depression, one's motivation and task engagement may decrease. A crewmember may become more hostile or withdrawn, creating an interpersonal environment that might lead to a less than optimal exchange of important task–related information.

4. Life-stressors may increase levels of off-task thinking or worry, which acts to divide finite attentional resources necessary for acquiring new information (e.g., change of runway from air traffic control) and effectively managing tasks.
5. Efforts to suppress unwanted (stressful) thoughts consume a portion of finite cognitive resources, thereby impairing task performance.
6. Emotionally draining events, such as arguments with a spouse or boss, may cause fatigue or demotivation.

Anything that interferes with efficient information processing might significantly impair skilled performance. Extensive research indicates that this is how acute stress effects performance. For example, acute stress causes a narrowing of attention, which could lead to overlooking important cues to effectively resolve an emergency. Also, working memory is impaired, which impairs problem–solving and decision–making.

There are hints in the studies described above that cognitive processes may also be affected by life-stress. Several researchers found that pilots report concentration and attention management issues when under life–stress (Little, et al., 1990; Fiedler, et al., 2000). Pilots admit to increased levels of worry or rumination during stressful times (Aitken, 1969; Sloan & Cooper, 1986; Fiedler, et al., 2000). Furthermore, Fiedler reported that many of their pilots experienced intrusive thoughts during times of low workload when stressed.

In the following section, I explore ways that life–stress may affect cognitive processes and, in turn, pilot performance.

EFFECTS OF LIFE-STRESS ON UNDERLYING COGNITIVE PROCESSES

Memory

In a series of three studies, Klein and Boals (2001) explored the effect of stressful life events on working memory and hypothesized that thoughts about stressful events or the active suppression of these thoughts would compete for the finite pool of mental resources needed by the task at hand. According to Shah and Miyake (1999), working memory refers to "the system or mechanism underlying the maintenance of task-relevant information during the performance of a cognitive task (p. 1)."

The first study attempted to establish a connection between working memory and life-stress. Researchers administered the 10-question short form of the State-Trait Personality Inventory, which is used to assess state-anxiety levels at the time of the experiment (state-anxiety is short-lived and related to a particular situation/circumstance, while trait anxiety reflects the existence of a stable characteristic level of anxiety); the Life Experiences Scale, which assesses level of life-stress; and a working memory task[1] Findings revealed a negative correlation between life-stress and working

[1] Subjects read an arithmetic equation followed by a single-syllable word on a computer screen (1 x 9 – 8 = 1, dog) and stated whether the answer given was true or false. After 2-7 problems subjects attempted to recall the associated words.

memory ($r = -0.46$, $p<01$). Additionally, working memory deficits increased as the demands on working memory increased. No relationship was found between state-anxiety levels and working memory performance, suggesting that changes in transient anxiety levels did not mediate the relationship between life-stress and working memory performance.

In a separate study, the researchers attempted to replicate their initial findings and to test whether those who reported higher levels of life-stress committed more intrusion errors (failure to inhibit irrelevant or no-longer relevant information from interfering with task performance). They also tested whether positive life events might negatively affect working memory. The authors suggested that it is possible that thoughts of positive events might also draw attention away from the task at hand, negatively affecting working memory processes. The researchers used the Life Experiences Scale and a modified working memory task. A significant positive correlation was found between degree of negative life-stress and number of intrusion errors, $r(64) = 0.33$ (numbers recalled from previous sets no longer relevant). There was a significant negative correlation between working memory and negative stress (-0.36). No correlation was found between intrusion errors and positive life events. However, the authors suggest that it is possible that those who perceived that they did poorly on the working memory task may have reported more life-stressors as a way of explaining or excusing their poor performance. The final study explored this possibility.

In the third study intrusive thinking (involuntary thoughts) and avoidant thinking (exerting effort to not think about certain things/events/issues, "I tried not to think about it") were measured by administering Horowitz's Impact of Events Scale (IES) and a working memory task. The IES measures both intrusive thoughts and avoidant. Positive and negative events were found to be similar in terms of intrusiveness; however, negative events created more avoidant thinking, which is assumed to make greater demands on limited cognitive resources. More important, the self-reported intrusive and avoidant thinking predicted performance on the working memory task. The size of this effect varied with task load. Klein and Boals (2001) conclude that, because the act of suppressing thoughts competes for working memory resources, it can impair cognitive processes, such as problem solving and decision-making.

The authors list several limitations of these studies. They acknowledge that it is not clear that thoughts about the stressful events were actually active during the working memory tasks. Also, it is possible that the stressed individuals may have been more fatigued by the stress and that this fatigue may better account for the results. The authors also underscore one of the significant weaknesses of the entire line of life-stress research: subjects cannot be randomly assigned to levels of life-stress; thus, other undetermined variables may co-vary with stress.

A study by Wilding, Andrews, and Hejdenberg (2007) offers additional support for the idea that life-stress interferes with working memory, thereby impairing cognitive performance. They utilized the Life Events and Difficulties Schedule, a semi-structured interview to assess life events and difficulties occurring in the previous 12 months and a memory span task to measure working memory capacity. The impact of life events was assessed by the investigators based on what they assumed an average person would experience in response to these stressors rather than basing it on the perception of the subjects. The investigators believed this was more objective than ratings given by the

subjects themselves. Subjects reporting at least one life difficulty had a smaller memory span (39.3) than subjects with no difficulties (44.5)[2]. Additional or more severe difficulties did not further reduce memory span.

In a review of research on math anxiety, Ashcraft (2002) suggests that this anxiety reduces mathematical ability because attention paid to anxiety-related intrusive thoughts acts as a secondary task and decreases overall processing efficiency. Consistent with the findings of Klein and Boals (2001), Ashcraft speculates that as math tasks increase in working memory demands they are more affected by anxiety than those that are relatively simple.

Rapee (1993) attempted to determine which of the subcomponents of working memory (phonological loop, visuo-spatial sketchpad, and central executive) are effected by worry by having subjects worry about a topic of importance to them while simultaneously performing various tasks selected to utilize different working memory resources. The subjects consisted of self-reported worriers and non-worriers randomly assigned to one of four task conditions, each condition attempting to target different aspects of working memory (e.g., worry alone, or worry combined with a task). In addition to working memory tasks, the subjects completed two common anxiety instruments, the trait form of the State–Trait Anxiety Inventory and the Penn State Worry Questionnaire. Subjects were asked to pick an issue about which they could worry, asked to worry about it and also asked to discuss the issue with the experimenter as a way of reminding the subject of the salient aspects of the issue. Following this, subjects were exposed to 10 experimental phases, five that consisted of the subject worrying and five that consisted of the subject worrying and performing the task that they had been assigned.

The experimenters were interested in the frequency of worry between the worry alone phases and the worry + task phases. Tasks relying on both the central executive and the phonological loop were most effective in reducing worry. Tasks using only the phonological loop reduced worry to a lesser degree, while those using the visuo-spatial sketchpad or the central executive seemed to have minimal influence. No differences were found between worriers and non-worriers. The authors suggested that this might be because subjects were non-clinical and that a difference might have been found if the worrier group had been selected from a clinical sample.

These findings suggest that worry most directly impairs the phonological loop and central executive components of working memory. According to Eysenck and Calvo (1992), the central executive is the most important subsystem as it is required for higher level tasks such as decision-making. A major implication for aviation is that – unless pilots are truly able to "compartmentalize" (suppress worrying while on the job) – their performance can be seriously impaired. This impairment might be most likely during periods of low workload, when worrying could more readily intrude.

In a study of the relationship between life events and anxiety/worry, Russell and Davey (1993) differentiate three levels of life events: (1) daily hassles (micro-level), such as bad weather, arguments, or misplacing things, (2) major life changes (meso-level), such as divorce or death of a spouse, and (3) societal stressors (macro-level), such as war or downturn in economy. They argue that "life events at all three levels contribute, in part, to either negative affect, stress, anxiety or

[2] $p = .002$

physical illness, and this has been substantiated in both retrospective and prospective studies" (p. 317). Using a population of college students (N=100), they administered several scales and examined the intercorrelations (Life Experience Survey; the Hassles and Uplifts Scale, a measure of the influence of world events; the Student Worry Scale, a measure of trait anxiety, a measure of tendency to view situations as threatening; and the Miller Behavioral Style Scale, a measure of stress coping).

Trait–anxiety and worry were positively correlated with measures of daily hassles but appeared to be unrelated to events at the meso- or macro-level. The tendency to interpret events as threatening and the tendency to seek out threat–relevant information were significantly related to micro stressors only. While not supporting the notion that major life events significantly increase levels of worry, this study suggests that common daily hassles contribute to trait–anxiety and worry. To the degree that these hassles distract us with worry, it is possible that processing of task-related information will be negatively affected. The authors raise the possibility that those who have a tendency to seek out threat-relevant information and to perceive situations as more threatening might have a higher propensity to view daily activities/events as hassles. This perceptual bias would of course increase levels of trait–anxiety – creating a vicious circle (i.e., anxiety shaping perceptions that increase anxiety). It is also possible in this study that daily hassles were more related to anxiety because they occurred more recently than meso- and macro-life events and were more in memory. It would be interesting to see how very recent meso-level stressors compare to daily hassles in their effect on anxiety. Also, it makes sense that the meso-level stressors would have more influence on state–anxiety as opposed to trait–anxiety, unless one was exposed to a series of these stressors – possibly influencing one's expectations about the possibility of future negative events and thereby increasing general levels of anxiety.

Information Processing/Decision-making

Kolich and Wong-Reiger (1999) explored the notion that emotional stress due specifically to non-work factors (e.g., family, financial, social), may impede one's information processing ability and therefore contribute to accidents. While the authors did not provide an operational definition of emotional stress, they listed anxiety, fatigue, and low motivation as emotional stress symptoms. They identified the tasks of operators of automated person-machine systems (e.g., aircraft) as monitoring, interpretation, and intervention, and suggest the underlying relationship between stress and information processing is important to accident prevention. At the time of the study, they reported that no previous research had been conducted in the area of emotional stress and information processing.

They list four following assumptions (p. 594):

Accidents are seldom random and can be traced to causes and contributing factors which, once isolated, can perhaps be eliminated or at least ameliorated.

The task to be performed in a person-machine system does not exceed human capabilities, given a mentally healthy individual who is not under the influence of stress.

Persons experiencing marked degrees of stress are more susceptible to accidents because stress has a spillover effect on information processing capacity.

Information processing deficiencies are precursors to accidents occurring in advanced person-machine systems.

The researchers collected stress data on 12 subjects. Subjects were reportedly chosen based on their availability, and most were college students. Using two separate instruments, subjects were asked to indicate how often they experienced particular stressors over the preceding 12 months (e.g., more upsets than usual with people who are important to you, a run of bad luck, greater financial difficulties, or bereavement). Also they were asked how often they experienced a variety of more subtle indicators of stress (e.g., feeling of having more than one's fair share of things to worry about, feeling that life is a strain, or being generally prone to worry). Each subject was given a total stress score by summing their responses to all questions. The subjects were then administered card-sorting tasks with varying degrees of information processing required (e.g., sort into red vs. black cards, sort into hearts/clubs/diamonds/spades). Level of information processing was determined by the amount of data the subject needed to consider in completing the card-sorting task. Reaction time was used as an indication of how effectively participants were able to perform the tasks. Results demonstrated that reaction time increased with stress level. The researchers concluded, "The most important finding of this research work is the fact that stress level has a statistically significant effect on information processing ability (p. 597)." This study is subject to several limitations, including reliance on self-report, using a fairly small pool of possible stressors, and using a small and non-random subject pool (i.e., selection based on availability/accessibility).

Baradell and Klein (1993) investigated the relationship between life-stress and performance on a decision-making task. These authors suggest that life-stressors are likely to increase autonomic reactions (e.g., heart rate, respiration rate) that are perceived as anxiety and speculate that to the extent that people focus their attention on these reactions, they will have less attentional capacity to focus on the task at hand. While they do not necessarily believe that everyone will be equally affected, they posit that those who are more sensitive to autonomic reactions stimuli are more likely to be distracted. "The model…has three basic assumptions: first, that life-stress results in autonomic reactions; second, that these reactions are attention demanding; third, that performance, including decision-making, is attention–limited (p. 267)."

Two weeks prior to the experiment, the Daily Hassles Scale (measuring difficulties that have occurred in the past month), the Life Experiences Questionnaire (assesses both "good" and "bad" experiences), and the Private Body Consciousness Scale (PBC – measures awareness of bodily changes) were administered to 138 introductory psychology students. Participants were categorized into high, medium, or low groups with respect to their daily hassles score. From each of these groups, a randomly selected subset was asked to participate in the next phase of the study, which included administration of the State–Anxiety Inventory (to assess levels of anxiety prior to the performance task. A computerized analogies task that allowed for an analysis of decisions as well as the scanning process used to reach each decision was given. The subjects were told that the analogies task must be completed in a limited amount of time, an 85% accuracy level must be accomplished, and that they would have to repeat the process if they did not meet these requirements, providing both time–pressure and accuracy demands.

The results suggest that life-stress (bad life events) is related to poorer decision-making and information processing for those who are more sensitive to or aware of bodily reactions. When private body consciousness was low, there was no relationship between life-stress and performance. However, high body consciousness subjects were more prone to (1) non–systematic scanning (i.e., using a disorganized non–systematic order for considering alternative solutions/deviating from a fixed order of viewing the 6 choices), $F = 8.16$, $p < .01$, (2) premature closure (the decision is made prior to considering all alternative solutions), $F = 5.42$, $p < .05$ and (3) perseveration (returning to reconsider alternatives already scanned), $F = 7.03$, $p < .01$. The authors point out that poor problem–solving skills may be the reason for the presence of such high levels of life-stress. In other words, individuals with low skill are less effective at tackling life's difficulties, which leads to higher levels of life-stress, rather than the higher levels of stress leading to poorer problem solving.

In a somewhat similar study, Klein and Barnes (1994) suggested that those higher in private body consciousness (more aware of bodily reactions) will be more likely to focus on physical sensations that stem from life-stressors and state anxiety. Because this focus will consume a portion of the limited attentional resources, these individuals should demonstrate impaired performance. The authors examined whether stress, PBC, and state–anxiety are related to problem solving on tasks varying in complexity and hypothesized that subjects high on PBC will do more poorly on the complex tasks that require more cognitive resources. As in the previous study, they were also interested in the use of non-optimal hypervigilant strategies (e.g., non-systematic scanning – a haphazard approach to considering alternatives, and premature closure – making a decision prior to viewing all alternatives).

Forty-five female introductory psychology students were given the Life Experiences Questionnaire (LEQ), the Private Body Conscious Scale (PBC), the State Anxiety Inventory and a computerized analogies task with varying degrees of complexity. Deviating somewhat from the methodology used in the previous study, subjects were told that there was no time limit and that speed was not necessary for success. Even without time pressure, higher life-stress was related to more non-systematic scanning on the complex problems, [$r(43) = .30$, $p<.05$]. As analogies increased in complexity, subjects higher in PBC, state–anxiety and life-stress performed more poorly.

In another study utilizing a limited capacity information processing framework, Klein (1995) suggested that performance would be impaired as thoughts of off-task issues deplete attentional resources that would have otherwise been focused on the task at hand. She explored whether off-task thinking mediates the relationship between performance and life-stress, and reported that a previous study found "on more complex problems, participants reporting high levels of off-task thinking made more errors, made fewer attempts to solve the analogies and spent less time evaluating the correct answer before responding (p 874)." Thirty-five subjects completed the PBC scale and a hassles measure of life-stress. They were also given the State-Trait Personality Inventory and an analogies task and instructed to take their time and told that speed was not required for success. Following the analogies task they were given the Cognitive Interference Questionnaire. Results indicated that off-task thinking did not mediate the performance-life-stress relationship. "Although

life stress is associated with off-task cognitions for problem solvers who are sensitive to their own autonomic reactions, and although these off-task cognitions are related to performance quality, the present results do not support the hypothesis that off-task thinking is responsible for the observed decrements" (p. 876).

Taken together, these studies offer some support for the notion that life-stress might impair performance by diverting attention from the task at hand or by pre-empting working memory. If we cautiously extend these findings to pilots performing real world tasks, it is possible that pilots may pay more attention to stress-related thoughts (e.g., thinking about relationship problems, a recent argument, problems on the job) or to increases in autonomic arousal. Acting as a secondary task, these preoccupations would divide attention and lead to deficits in working memory capacity, making it more probable that a pilot might fail to notice critical phenomena and forget to perform tasks that are not strongly cued by the environment.

Sleep

There is evidence that sleep loss/fatigue impair performance. Stokes and Kite (1994) point out that tasks requiring heightened vigilance and rapid reaction time are particularly sensitive to the effects of poor sleep. They also summarize evidence that inadequate sleep can lead to slower mental processing and short-term memory difficulties. Caldwell and Caldwell (2003) reviewed studies implicating pilot fatigue in a host of performance related issues such as decreased response accuracy and speed, acceptance of lower standards of performance, narrowing of attention, withdrawal from social interactions, and decreased ability to divide mental resources among multiple tasks. Howard, Rosekind, Katz, and Berry (2002) argue that performance of healthcare providers, including monitoring of important clinical variables (e.g., heart rate, blood pressure) is also impaired by fatigue. Dinges and Kribbs (1991) state "attentional deficits have long been recognized to be the common cognitive thread of sleep loss effects…we cannot conceive of a cognitive or perceptual task that does not involve attention as a fundamental component. To the extent that this is true, it seems reasonable to posit that all cognitive tasks eventually will show impairment during sleep loss (p. 120)." Carskadon and Roth (1991) make the case that these types of deficits are evident even with relatively short-term sleep reduction (e.g., five hours of sleep for two nights).

These findings are relevant to our discussion to the degree that life-stress negatively influences sleep. Linton (2004) states that stress is reported as the most common cause of sleep disturbance. Using a prospective methodology, he investigated the role that the psychosocial work environment played in contributing to the onset of sleep problems and suggested that those with poorer psychosocial work environments (more stress at work) will have a higher incidence of sleep problems. A questionnaire was mailed to 3,000 Swedish residents, aged 20-60, and returned by 2,066. Excluding those who did not have a self-reported sleeping problem and those who were not gainfully employed, 1,033 were included in the follow-up one year later, which yielded 816 responders. The questionnaire included items in areas such as background factors, sleep, health, and work. Items related to sleep were assessed using items from the Basic Nordic Sleep Questionnaire and the Uppsala Sleep Inventory. At follow-up, prevalence of sleeping problems during the preceding 3 months was 14.3%. This included getting too little sleep and waking up during the night. After controlling for age, gender, health and irregular working hours, results demonstrated a relationship between psychosocial

work environment and future incidents of sleep difficulty. The author suggests that more than 50% of these cases could have been prevented by reducing work-related stress through improvements in the psychosocial work environment.

Loewenthal, et al., (2000) provide some support for the notion that pilot performance may be impaired by stress-related sleep disturbance. They assessed levels of stress (life-events such as relationship problems, health problems, and financial difficulties), distress (symptoms such as depressed mood, poor appetite, sleep disturbance, loss of energy, loss of interest, guilt, loss of concentration, and suicidal thoughts), and performance (air-traffic incidents) with 105 civilian pilots (49 British and 56 Israeli pilots). In their analysis, they included only events and symptoms that were present prior to the reported incidents (in the previous 12 months) "which had lasted for more than two weeks, were of high intensity, interfered with other things, and were difficult to control (p. 6)". The assessment of flying performance was self-rated. Results revealed significant correlations between stress and incidents and between distress and incidents. Multiple regression analysis showed a significant effect of distress – pilots were significantly more likely to have an incident as the degree of stress symptomology increased. When pilots who denied previous incidents were compared with pilots that reported having past incidents, the variables of sleep disturbance and loss of energy/being tired differentiated the two groups. They conclude that stress-related sleep disturbance may be important in our understanding of flying accidents.

SUMMARY AND CONCLUSIONS

While research regarding the relationship between life-stress and pilot performance does not offer conclusive answers, the literature suggests that life stress can impair performance, and it points to possible mechanisms. For example, just as with non-pilot populations, a sizeable percentage of pilots (military and civilian) experience noteworthy stress symptoms when faced with difficult life circumstances. Furthermore, a portion of these pilots, themselves, believe that life-stress negatively affects their flying performance. Additionally, while the nature of this relationship is currently unclear, some correlational evidence suggests a relationship between life-stress and accidents.

With regard to mechanisms by which life-stress may impair performance, some evidence suggests that life-stress may negatively influence underlying cognitive processes such as information processing, working memory, problem solving and decision-making. To the degree that these important processes are affected, one might expect an associated decrement in performance. Additionally, there is evidence suggesting that life-stress disrupts sleep and leads to increased levels of fatigue, which in turn impairs cognitive and social performance (e.g., decreased response accuracy, narrowing of attention, social withdrawal).

My review of the research literature has several limitations. While attempting to include as much relevant research as possible, this review is not exhaustive. The interconnections of stress variables and their effects on flying performance are undoubtedly very complex. I have highlighted variables that seem especially worthy of further investigation.

Many questions remain regarding the relationship between life-stress and flying performance. Are some people more vulnerable to the effects of life-stress than others? If so, what are the differentiating factors and do they change over time? Do personality characteristics affect vulnerability? Are younger, less experienced aviators more or less vulnerable? Is it possible that many of these younger pilots have not yet had to deal with a significant number of life's difficulties and are therefore less prepared when they do occur? Is it the case that, as a group, they have fewer life-stressors to juggle (e.g., demands of family, childrearing, increased job demands/responsibilities), and that many of their most significant challenges are yet to come? Does vulnerability to the effects of life-stress decrease as expertise increases? What effect does the appraisal of life-stressors have, and to what degree does this appraisal influence variables such as off-task thinking and divided attention? Are some types of stressors more important than others? For example, do major life events have more of a negative impact than daily stressors? What are the additive effects of stress? At what point does something become a chronic stressor, and are the effects of this chronic stress different from a single, short-lived, yet significant, stressor? What are the effects of burnout (fatigue/diminished interest) on pilot performance? This may be especially important considering the current operational tempo for both military and civilian pilots. What are the most effective countermeasures to life-stress? Are there general stress management principles or techniques that are effective regardless of the stressor, or must the prescription be stressor-specific (e.g., marital therapy for marital issues, financial counseling for financial problems)? What are the individual and organizational barriers to implementing good countermeasure programs or seeking mental health care? To what degree are pilots and other human operators under-reporting the effects of stress? What changes, if any, are required to increase the comfort level of pilots who would like help but are hesitant to seek it? Is the ability to compartmentalize measurable? Does this ability change over time or with varying life circumstances?

Having a better appreciation of the effects of life-stress on skilled performance is underscored by the likelihood that the majority of skilled performers are prone to under-report such effects. The reasons for minimizing these symptoms are many (e.g., pilot personality, cultural pressures, lack of understanding of resources available, or a general distrust of these resources). I believe aviators will be much more likely to acknowledge the effects of life–stress to the degree that their organizations destigmatize emotional and psychological issues and improve the medical community's handling of these cases (e.g., improve mental health providers' understanding of the impact of their evaluations and associated recommendations, improve flow of communication between the mental health professional and the treating/referring physician).

Over a decade later, the author concurs with Stokes and Kite's (1994) conclusion that the best research in this area is still in the future. I hope this paper will renew interest in exploring this domain. I have highlighted one area, the effects of life-stress on cognitive processes, that can help explain when and how performance of real-world aviation tasks is affected. Even for the most expert or skilled performers, it is likely that cognitive processes, at one time or another, will be effected by life-stress in a way that impairs performance. We must continue to look for better methodologies and should not dismiss the potential influence of life-stress on performance because of the current lack of strong empirical data.

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14. ABSTRACT

The effects of acute stress, due to immediate threat, on skilled performance of pilots and other human operators are fairly well documented, but much less research has been conducted on the effects of stress from difficult life situations (life stress). Clinical research has focused more on the effects of life stressors on an individual's mood and coping than on skilled performance of demanding tasks such as military aviation. Pilots are reluctant to reveal information that might cause them to be removed from flight status, which makes study of this issue difficult. This paper reviews existing research on the effects of life stress on pilots' performance. Although this research has substantial methodological limitations, it does suggest that life stress can impair performance, and probably does so more than pilots realize. Performance may be impaired through mechanisms such as disturbed sleep, altered mood, decreased motivation, and preemption of attention and working memory by worry. A wide range of questions that require further research, carefully designed, is discussed.

15. SUBJECT TERMS

Acute stress, Cognition, Skilled performance, Pilot performance, Life-stress, Attention, Working memory

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