FAA-AM-80-14

STRESS, ANXIETY, AND THE AIR TRAFFIC CONTROL SPECIALIST:

SOME CONCLUSIONS FROM A DECADE OF RESEARCH

SEPTEMBER 1980

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
MIKE MONRONEY AERONAUTICAL CENTER
OFFICE OF AVIATION MEDICINE

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Roger C. Smith
Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma

September 1980

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Springfield, Virginia 22161

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Office of Aviation Medicine
Washington, D.C. 20591

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM-80-14		

4. Title and Subtitle	5. Report Date
Stress, Anxiety, and the Air Traffic Control Specialist: Some Conclusions From a Decade of Research	September 1980
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Roger C. Smith	
9. Performing Organization Name and Address FAA Civil Aeromedical Institute P.O. Box 25082 Oklahoma City, Oklahoma 73125	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, SW. Washington, D.C. 20591	14. Sponsoring Agency Code

15. Supplementary Notes

This report was prepared under tasks AM-C-80-PSY-74 and AM-C-80-PSY-79.

16. Abstract

It is often assumed that air traffic control specialists (ATCSs) endure a high degree of work-related stress and that they may be near the limits of their ability to cope with such stress. This paper summarizes a decade of research evaluating possible stress effects of work on ATCSs. Studies were conducted at a variety of large and small air traffic facilities. A visit of several days to each facility was part of an interdisciplinary research effort involving physiological and biochemical, as well as psychological, assessments. The principal psychological measure was the State-Trait Anxiety Inventory (STAI). The STAI and other questionnaires were administered at the beginning and end of three to five different work shifts scheduled at a facility. The findings showed that controller groups scored significantly below college student norms on both the A-state (current anxiety level) and A-trait (anxiety proneness) measures of the STAI. Results with mood adjective checklists were similar. The findings also showed that anxiety levels (i) increased across an 8-hr work shift and (ii) were higher on shifts rated "difficult" than they were on "easy" shifts.

The establishment of adult norms for the STAI was undertaken to provide a better comparison for ATCS data. Results of those efforts indicated that ATCSs had lower anxiety scores than the normal adult population. Moreover, A-state scores increased from the beginning to end of work shifts for employees in a variety of non-air-traffic jobs (e.g., engineers), just as they did for ATCSs. Thus, ATCSs are well within normal limits on every indicator of psychological states used in these studies and appear to experience less anxiety than is the average in other work settings.

17. Key Words	18. Distribution Statement
Anxiety Air Traffic Controllers Stress Workload Shift Work	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

STRESS, ANXIETY, AND THE AIR TRAFFIC CONTROL SPECIALIST: SOME CONCLUSIONS FROM A DECADE OF RESEARCH

I. Introduction.

When stressful occupations are discussed, particularly in the popular press, it is common for the air traffic control specialist (ATCS) to be identified as belonging to a professional group under intense stress (9,23). As one author put it: "The job of juggling airliners and making snap decisions on which lives depend exacts a steep toll in stress-related diseases, nightmares, and acute anxiety" (26). In a recent book on occupational stress, Kasl (22) notes that air traffic control work is one of those vocations that seems intuitively to be stressful.

This paper reviews a series of field studies conducted with ATCSs to assess possible stress effects in their work. The studies are presented in chronological order to provide some indication of how results from one investigation influenced the conduct of the next one. The presentation is also designed to show the development of the perspectives needed to assess most properly the presence or absence of work stress in this occupation.

Attempts to document the presence of unusual stress in the air traffic setting date from the middle 1960's (10,11,17); however, concerted efforts to study this issue did not get underway until the last part of that decade. The Civil Aeromedical Institute (CAMI) began its program of stress research in 1968, an effort which continued throughout the 1970's.

II. Procedure.

Most of the CAMI studies were multidisciplinary in scope and involved psychological, physiological, and biochemical assessments of the state of the ATCS. The format of these studies followed the same general pattern in each investigation. Volunteers were solicited from the crews working at each facility with the understanding that they would be involved with the project for up to 10 days. For the psychological portion of the studies, each participant filled out one or more assessment questionnaires at the beginning and again at the end of each work shift under consideration. The questionnaires varied across studies and each will be discussed in the context of the specific study in which it was used. The major physiological measure, heart rate, was recorded throughout the work shifts under investigation by the use of miniature tape recorders. These instruments permitted the participants to remain ambulatory throughout the work shift while providing continuous electrocardiographic (ECG) recordings. On occasion, blood pressure and the galvanic skin response were also measured. The biochemical measures were derived primarily from urine samples collected before, during, and after the work shifts under consideration. In some of the earlier CAMI studies there was also collection of blood samples after at least one work shift. Since the concern of the author in these studies was with the psychological domain, that will be the main focus of this paper; however, the physiological findings from the studies will be highlighted as well.

(again biomedical observers) contributed both psychological and physiological/ biochemical measurements.

A total of 16 ATCSs and 4 biomedical observers completed the research tasks. The data from the CMACL indicated that, as a group, the Houston ATCSs showed the same general pattern as the O'Hare controllers. Scores related to fatigue were higher at the end of shifts than at the beginning and were higher for night than day shifts. The trend for anxiety indicators in the CMACL to be higher at the end of work shifts than at the beginning was also found but was not as pronounced as in the O'Hare study.

Compared to the control subjects who had observed them, Houston ATCSs were less fatigued, more vigorous, and less anxious. The comparisons with ATCSs at Chicago's O'Hare International Airport showed the overall degree of positive affect to be somewhat higher in Houston. However, most of this effect was due to the difference in scores between the day shift measures at Houston and the evening shift measures at O'Hare, especially on scales related to fatigue. On the night shifts, the situation was reversed, with the O'Hare ATCSs showing the lesser feelings of fatigue even though they were considerably busier during this shift than were the Houston ATCSs.

The STAI scores followed the trend of the CMACL data in that scores on the A-state scale increased significantly from before to after work on both day and night shifts. The use of the STAI also permitted comparison to normative groups, whereas this was not possible with the CMACL. The normative group most closely matching the air traffic sample was that of college undergraduates who had the lowest mean score of any of the available normative groups (high school students, surgical patients, prisoners). According to the college student norms, the mean A-state score for the Houston ATCSs was at the 42nd percentile. The A-trait scale (anxiety proneness) was at the 24th percentile. These findings tended to affirm the CMACL results that the expressed levels of anxiety reported by ATCSs were certainly within normal limits and were at relatively low levels. These data are inconsistent with the presence of any unusual emotional stressors.

Physiological measures showed that heart rates were generally higher during the day shift than during the night shift for the Houston ATCSs. The heart rates of Houston ATCSs during the day shift were lower than the heart rates obtained from evening shifts at O'Hare. The night shifts did not differ. Preshift measures of heart rate also showed that the ATCSs at O'Hare had the higher mean rate. This suggests that some of the differences observed between these two facilities may relate to different baseline levels of physiological arousal rather than to differences in the work situation itself.

The urine analyses for Houston ATCSs showed epinephrine and norepinephrine to be higher during day shifts than during night shifts. The comparison with O'Hare ATCSs showed that the two facilities differed primarily on night shift measures where the greater workload at O'Hare is reflected in the higher level of catecholamine excretion. Plasma phosolipids were also found to be higher for O'Hare than for Houston ATCSs.

Study VI. Air Traffic Work Demands and STAI Scores: A Sensitive Measure. At this point the psychological data seemed clearly to contradict the notion that significant psychological or emotional stress was a factor in air traffic work. However, limitations in the design of the previous studies, often due to real-world situational and administrative constraints, left many questions unanswered. One of these was the question of the sensitivity of the measures, particularly the STAI, to stress in the air traffic situation. To answer this question comparisons were made of the STAI data from the Houston ATCSs with data from a total of 62 additional ATCSs from (i) an extremely busy general aviation tower (Opa Locka, Florida, a nonradar tower primarily serving light and business aircraft) and (ii) an air route traffic control center (ARTCC), a radar facility controlling high-altitude cross-country traffic (48). Ratings of the difficulty of each day or night of work were also obtained. The A-state score was found to increase over twice as much across shifts rated "difficult" as for shifts rated "easy." Thus, it appears that the STAI was in fact sensitive to variations in arousal associated with perceived changes in demand or difficulty.

The physiological and biochemical measures showed personnel at the general aviation tower to be under greater physiological arousal during work than were personnel at the ARTCC or the Houston tower, and at about an equal level of arousal with the O'Hare ATCSs (35).

Study VII. Validation of Findings From Houston. The next study was designed to replicate and clarify findings from the two studies comparing shift rotation schedules at the Houston tower (31). The earlier comparisons of the two schedules, the 5-day and 2-2-1, at the Houston facility had been hampered by a variety of problems, including the fact that no assessment of evening shifts was available for the 5-day schedule. This new study was conducted at two large ARTCCs, one on the 5-day and the other on the 2-2-1 schedule, and covered all shifts at each facility.

The findings from the STAI in this study again showed (i) no difference in shift schedules, (ii) low A-trait and A-state scores compared to scores of college students, and (iii) the significant increase in A-state from the beginning to the end of work. The biochemical assessment (only biochemical measures were taken in this study) appeared to favor the 2-2-1 schedule to some degree, although no impressive differences were found.

Study VIII. Some Effects of Automation on ATCS Stress Indicators. About this time, the middle 1970's, computer assistance for ATCSs was beginning to be a factor in the air traffic work situation. The system being brought on-line was designed to enhance radar targets and to handle information concerning aircraft that up until then was either committed to memory or noted by hand. The ATCS remained the decision maker but now possessed a rather sophisticated memory aid. In order to assess the impact of the introduction of the new computer systems on ATCSs, a CAMI research team visited two busy terminal radar facilities (Los Angeles and Oakland, California) on the west coast of the United States (30). Data were first collected before the installation of the new computer systems, then again some 5 months after the systems were in full operation. There were no differences in the psychological measures (STAI) taken before and after installation of the computers. Surprisingly, the biochemical indices showed several statistically significant increases after the installation of the computer systems, primarily in catecholamine excretion. However,

TABLE 1. STAI (Form Y) Means and Standard Deviations For Normal Adults

Age:	25 - 29		30 -34		35 - 39		40 - 44		45 - 49		50 - 54		55 - 59		60 - 69	
Sex:	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
A-trait																
Mean	36.6	39.4	34.8	35.7	35.2	34.8	34.9	36.0	35.3	33.7	34.2	32.4	34.0	32.0	33.0	30.7
SD	10.3	11.4	9.2	8.9	9.3	9.1	8.7	8.7	9.2	9.4	9.0	7.5	8.8	9.0	8.5	7.5
N	57	46	147	61	192	68	260	80	307	55	197	50	131	38	53	19
A-state																
Mean	36.8	39.5	36.1	35.0	36.2	36.4	35.6	36.3	36.5	35.9	34.6	32.6	35.0	31.5	32.1	32.4
SD	9.6	12.1	10.5	10.0	9.7	11.7	9.9	10.5	11.0	11.9	10.1	7.3	11.0	9.4	8.9	10.4
N	57	46	147	62	193	69	259	80	305	55	199	50	131	38	53	22

TABLE 2. STAI A-trait and A-state Scale Means and Standard Deviations (SD) for ATCSs, ATCS Instructors, Non-ATCS Adult Men, and Male College Undergraduates

Group	N	A-TRAIT Mean	A-TRAIT SD	A-STATE Mean	A-STATE SD
ATCSs	198	30.3	6.6	31.1	7.5
Instructors	92	32.8	8.9	33.8	10.1
Non-ATCSs	1,303	35.8	10.4	35.1	9.2
College Undergraduates[a]	253	37.7	9.7	36.4	9.7

[a]Taken from Spielberger et al. (51)

mood self-ratings were lower, at the end than at the beginning of work. Hibler (18) expanded upon CAMI studies of shift difficulty and anxiety (48) to include ratings by military ATCSs of difficulty and anxiety during shifts, and confirmed that A-state levels were higher for difficult shifts and that A-state scores generally increased across shifts. The mean A-trait and A-state scores for the military ATCSs were similar to those obtained in CAMI studies of civilian ATCSs. In another study, Caplan, Cobb, French, Harrison, and Pinneau (3) found anxiety levels among a group of midwestern ATCSs to be intermediate in comparison to 22 other occupations. Rose, Jenkins, and Hurst (38) reported that more than 80 percent of a group of ATCSs participating in an evaluation of health change scored low (over one standard deviation below the mean for college students) on the Tension/Anxiety Scale of the Profile of Mood States (28). Thus, those researchers who have made comparable measures of psychological states have obtained results highly consistent with CAMI findings.

Related work in the physiological area has been limited to two main studies. Schad, Gilgen, and Grandjean (39) found that six Swiss ATCSs excreted higher levels of catecholamines while doing air traffic work than when providing general supervision or doing clerical work. Rose et al. (38) considered heart rate and blood pressure in their health change study. The heart rate values they obtained from ATCSs in the northeastern region of the United States tended to be lower than the rates obtained from both the O'Hare (33) and Houston (29) studies. On the other hand, the mean blood pressures obtained by Rose et al. were considerably higher than those obtained at O'Hare. The meaning of these differences in physiological/biochemical findings is not readily apparent.

Though not directly comparable to CAMI research, there have been other investigations of the health consequences of air traffic work that have implications for the assessment of stress in ATCSs. The findings from these studies have been mixed. Two studies, by Cobb and Rose (8) and Rose et al. (38), suggest that ATCSs are at higher risk than men-in-general for hypertension; however, Booze (1) found hypertensive diagnoses to be well below expectancy in a review of health records for 25,000 ATCSs. Dougherty (10) found no difference between ATCSs and non-ATCSs in the prevalence of ECG abnormality. The evidence that the air traffic system is an "ulcer factory" (26) is also equivocal. Dougherty, Trites, and Dille (11) and Hauty, Trites, and Berkley (17) found a higher incidence of self-reported gastrointestinal symptoms by ATCSs than by non-ATCS personnel. The Cobb and Rose (8) and Rose et al. (38) studies both reported higher than expected incidence of ulcers in their samples of ATCSs. However, Singal, Smith, Hurrell, Bender, Kramkowski, and Salisbury (40) found no evidence that ulcers were above expectancy at the O'Hare facility, nor did Booze (1) in his survey of medical records from ATCSs. Neuropsychiatric problems were commonly reported in both the Rose et al. (38) and Booze (1) studies. However, it was not possible to determine (i) if the rates were above expectancy in the Rose et al. study because of the lack of comparable norms, or (ii) if the high rate in the survey by Booze occurred only after introduction of a special benefits program for ATCSs who were separated from their work for medical or administrative reasons. Reaching a general conclusion about these diverse results is difficult; perhaps they are best summarized as suggesting that some ATCSs at some air traffic facilities may be at higher risk for health change, particularly cardiovascular problems, but this is probably not true for the ATCS work force in general.

factors: intelligence, group-conformity, tough-mindedness, and compulsivity (21, 38,44). In comparison, airline pilots differ substantially from men-in-general on 11 of the 16PF scales. ATCSs score within the normal range on all scales of the California Personality Inventory with relative elevations on the factors associated with dominance and relatively lower scores on factors measuring mature socialization and respect for authority (38,54). On the Strong Vocational Inventory Blank (2), ATCSs score like men-in-general on all but a few scales mostly concerned with technical supervisors (45). These findings suggest that ATCSs form a unique occupational group only on a few personality dimensions. However, it is possible that those dimensions may be related to their psychological and physiological responses to air traffic work. Rose et al. (38) did find that ATCSs who were Type B personalities seemed at higher risk for hypertension than were those who were more competitive, an interesting reversal of the usual sort of findings (20). The problem is to discern to what extent the incidence of hypertension or other physical or psychological problems results from the work, not the person. In other words, it is quite possible that ATCSs who contract hypertension or other problems may be likely to do so in any work circumstance. Only the development of carefully matched control groups can resolve this question.

Although the problems just discussed require further research, it is clear from presently available evidence that the ATCSs appear remarkably free of emotional distress. According to Spielberger's (52) process theory of anxiety, this means that ATCSs perceive little, if any, threat in their work or the responsibilities associated with that work. The physiological data obtained in ATCS research suggest normal physiological responses to varied workloads. The extent to which high workloads are related to negative consequences for ATCSs is uncertain. There is some evidence (19) linking increased physiological responsiveness with cardiovascular and gastrointestinal problems; however, the extent to which this correlation is a function of the individual's response style as opposed to the effects of workload or other aspects of the work itself has not yet been determined. According to Rose et al. (38), the types of health change data that they obtained are suggestive of an interaction between individual predispositions to certain disorders and characteristics of the work setting. They suggest that it is not the work itself, but the context in which the work is conducted, that is the important factor interacting with predisposing factors in the individual ATCS.

In conclusion, there is little evidence to support the notion that ATCSs are engaged in an unusually stressful occupation. This is not to say that ATCSs never encounter unusual stress on the job; however, it does appear that this is the exception rather than the rule. ATCSs appear both well qualified and well suited for air traffic work. The demands of air traffic work do not appear to place unusual stress on ATCSs; this professional group appears quite capable of handling requirements of the job without distress. The notion that this occupational group is being pressed to the psychological and physiological limit is clearly unjustified.

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:: U.S. GOVERNMENT PRINTING OFFICE 1980 -341-428/378