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16. Abstract

Three groups of subjects completed Composite Mood Adjective Check Lists (CMACL) before and after selected shifts at two air traffic control (ATC) facilities as part of a multi-discipline study of stress in ATC work. At one facility, a high traffic density tower (HDT), 22 air traffic control specialists (ATCS) were sampled before and after five evening (1500 to 2300) shifts and five night (0000 to 0800) shifts. At the second facility, a moderate traffic density tower (MDT), 16 ATCSs were assessed on three day (0800 to 1600) and three night (0000 to 0800) shifts. In addition, four non-ATC individuals involved in monitoring the MDT ATCSs for other aspects of the general stress study served as controls. It was found that all subjects, both ATCSs and controls, showed a considerable increase in feelings associated with fatigue and tiredness as a function of working an eight-hour shift. These effects were generally more pronounced for night shifts. There were no differences between subject groups on the variables predicted to be most sensitive to variations in stress. Findings are discussed in terms of expected work effects and the lack of significant stress variations.

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AFFECT ADJECTIVE CHECK LIST ASSESSMENT OE MOOD VARIATIONS IN AIR TRAFFIC CONTROLLERS

I. Introduction.

A number of investigators have attempted to measure the effects of stress through the use of mood adjective check lists. For example, Helmreich[7] found substantial differences between check list responses obtained from Navy recruits when undergoing chemical warfare training (high stress) and those obtained while the recruits were relaxing in barracks (low stress). In another study with military personnel, Bourne, Coli, and Datel,[2] found that check list measures of anxiety obtained from military air-ambulance medics were significantly higher on combat than on non-combat days. In general, these studies, and others of a similar nature [e.g.,3], have shown that at least some check list measures appear to be sensitive to variations in stress.

In view of the apparent utility of check lists for assessing mood changes as a function of stress, it was decided to apply this approach to the study of stress in air traffic control specialists (ATCSs). Assuming that stress in ATCSs is related to traffic density, it was the primary purpose of this study to compare responses to an affect adjective check list of personnel at a high traffic density tower (excess of 400,000 annual operations) with those of ATCSs at a moderate traffic density tower (200,000 to 400,000 annual operations).

There were two additional concerns of this study. One was to compare affect states associated with night shifts to those measured on day or evening shifts. The other was to assess the degree to which affect changes as a function of normal work activities by comparing adjective check list responses obtained prior to starting shifts with responses gathered at the completion of shifts.

The authors wish to acknowledge the contributions of Charles Abbott, Marlene Hoffmann, and J. T. Saldivar, Jr. in the acquisition and analysis of these data.

II. Method.

A. *Check List.* Malmstrom's[8] Composite Mood Adjective Check List (CMACL) was used to assess affective states. This device, which consists of 80 adjectives, includes items from the Clyde,[4] Zuckerman,[12] and Nowlis[9] check lists. Each adjective is rated by the respondent on a nine-point scale, with the lower end of the scale representing a judgment of "not at all" descriptive and the upper limit a judgment of "definitely" descriptive, of the respondent's current feelings. Each CMACL was scored for the 15 mood factors identified by Malmstrom (see Table 1 for the listings of factors and their adjective composition), and on an index indicating the overall degree of positive or negative affect expressed by the respondent. All records were also screened for dissimulation using a technique described by Smith.[10]

B. *Procedure.* The sample at the high-density tower (HDT) consisted of twenty-two ATCSs who had volunteered to participate in a physiological study of stress. Each ATCS was administered the CMACL before and after five evening (1500 to 2300) and five night (0000 to 0800) shifts. Insofar as possible the five evening shifts were consecutive, as were the five night shifts.

At the moderate-density tower (MDT), 16 ATCSs volunteered to participate in a multidiscipline study of stress. Although the study at this facility encompassed five day (0800 to 1600) and five night (0000 to 0800) shifts for each subject, the CMACL was administered only on the first, third, and fifth shifts of the day and night shift sequences. As at the HDT facility, CMACLs were completed before and after each of these selected shifts.

Four research assistants assigned to monitor the behavior and work load of the ATCSs at the MDT were used as control subjects. These individuals were required to work the same shifts

TABLE 1.—Adjective composition of the 15 mood factors in the CMACL.

Factor	Adjective Composition
Aggression [1]	angry, annoyed, defiant, fed-up, grouchy, rebellious
Anxiety [1]	ashamed, calm*, clutched-up, fearful, jittery, shocked, startled
Anxious	anxious
Concentration [1]	attentive, careful, concentrating, contemplative, earnest, intent, introspective, serious, throughtful
Depression [1]	blue, downhearted, frustrated, full of pity, insecure, lonely, optimistic*, regretful, sad, satisfied*, sorry, uncertain
Distrust [1]	dizzy, jittery, nauseous, shaky
Fatigue [1]	active*, bored, drowsy, dull, lazy, sleepy, sluggish, tired
Friendly [2]	kindly, pleasant, warmhearted
Nonchalance [1]	leisurely, nonchalant
Sleepy [2]	drowsy, fatigued, sleepy, tired
Social Affection [1]	affectionate, forgiving, kindly, warmhearted
Surgency [1]	carefree, lively, playful, talkative, witty
Vigor [1]	active, energetic, vigorous
Zuckerman Affect Adjective Check List	afraid, calm*, cheerful*, contented*, desperate, fearful, frightened, happy*, joyful*, loving*, nervous, panicky, pleasant*, secure*, shaky, steady*, tense, terrified, thoughtful*, upset, worrying

*scored in reverse direction, the higher the rating of these words the lower the score on the particular factor.
[1] scale adapted from Nowlis Mood Adjective Check List.
[2] scale adapted from Clyde Mood Scale.

as controllers, but were without any air traffic control responsibility. It should also be noted that the controls worked without any days off during the six weeks of the experiment. The CMACL was administered to controls during the second through fourth weeks of the project. The schedule for the five day and five night shift assessments was the same as for one of the ATCSs which the controls were assigned to observe.

III. Results.

A. *Dissimulation.* It was decided to eliminate data taken from any subject who consistently scored on post-shift CMACLs beyond the normally expected range of scores on the dissimulation index.[10] This index was designed to screen CMACL records for response sets possibly differing from normative standards. One subject had critical scores on each of the ten post-shift records, but did not have any critical scores on the before-shift protocols; therefore, his data were excluded from further analyses. No other subject had more than two such scores.

B. *Mood Factors.* Due to unavoidable scheduling conflicts, several CMACL records were missing for each shift. Since examination of the records revealed no systematic sequence effects, it was decided to use the shift with the fewest missing protocols for all subsequent data analyses. This proved to be the third shift in each five-shift sequence (day, evening, and night) as only six CMACLs were missing for this particular shift. Scores for the subjects with missing records were estimated by using the mean of their scores on the other shifts.

To simplify comparisons, day and evening shifts were considered together in all comparisons with night shifts. Subsequently, all references to day shifts in the remainder of the report should be interpreted as including the evening shift from the HDT facility.

The mean scores for each group of subjects on each CMACL factor discussed below are presented in Table 2. The mean scores obtained from CMACLs administered before and after each type of shift are presented for all factors without respect to the presence or absence of significant effects.

1. Overall affect index. There were significant differences among the overall affect levels for the

TABLE 2.—Mean scores for the overall affect index and the 15 mood factors from the CMACL for each subject group before and after working each type of shift.

Factor	Group [1]	Shift			
		Day [2]		Night	
		Before	After	Before	After
Overall Affect Index (1–9) [3]	HDT	7.05	6.50	6.71	6.15
	MDT	7.43	7.05	6.86	6.42
	C	6.19	6.37	6.69	5.98
Aggression (6–54)	HDT	11.5	12.5	10.1	15.2
	MDT	8.4	7.2	9.9	8.3
	C	11.0	9.5	9.2	10.2
Anxiety (7–63)	HDT	13.2	14.0	16.2	14.0
	MDT	10.2	11.9	11.6	12.2
	C	13.5	14.2	11.8	15.3
Anxious (1–9)	HDT	2.8	2.4	3.7	2.8
	MDT	2.3	2.4	1.7	1.6
	C	2.2	1.8	1.8	1.2
Concentration (9–81)	HDT	44.9	37.8	47.6	41.2
	MDT	53.8	44.1	49.3	41.4
	C	43.8	41.2	46.0	41.2
Depression (12–108)	HDT	26.1	29.6	25.9	29.1
	MDT	20.6	20.1	24.1	24.2
	C	33.5	24.8	27.2	26.0
Distrust (3–27)	HDT	6.5	7.4	7.0	7.4
	MDT	4.6	4.8	5.4	4.5
	C	5.8	5.0	4.8	4.2
Dizzy (4–36)	HDT	5.9	6.0	5.7	6.5
	MDT	5.0	5.4	5.6	6.4
	C	6.5	7.8	5.5	7.2
Fatigue (8–72)	HDT	26.7	43.9	16.8	28.7
	MDT	19.4	25.1	32.4	45.4
	C	40.0	39.5	29.0	47.0
Friendly (3–27)	HDT	14.8	13.4	16.3	14.1
	MDT	18.7	15.7	16.4	14.2
	C	9.8	11.8	14.0	11.0
Nonchalance (2–18)	HDT	7.8	8.9	8.5	7.8
	MDT	9.3	7.6	9.4	9.4
	C	7.0	8.0	5.7	4.0
Sleepy (4–36)	HDT	15.0	26.7	8.1	17.8
	MDT	9.9	14.2	17.9	26.8
	C	21.2	20.0	14.2	28.0
Social Affection (4–36)	HDT	19.0	16.0	20.0	16.7
	MDT	22.0	19.6	20.0	18.4
	C	12.5	14.0	16.5	13.8

TABLE 2.—Continued

Factor	Group [1]	Shift			
		Day [2]		Night	
		Before	After	Before	After
Surgency (5–45)	HDT	22.3	17.8	25.3	20.8
	MDT	25.9	23.7	20.9	17.6
	C	15.2	18.0	19.2	12.0
Vigor (3–27)	HDT	12.7	8.8	18.4	13.4
	MDT	17.9	15.2	12.9	8.0
	C	10.0	9.5	14.0	7.5
Zuckerman Affect Adjective Check List (21–189)	HDT	62.9	70.3	58.4	67.9
	MDT	49.7	46.6	58.1	65.4
	C	70.0	67.2	64.8	79.8

[1] HDT represents the high traffic density tower ATCS group MDT represents the moderate traffic density tower ATCS group C represents the control group.

[2] includes evening shift for HDT group and day shift for both MDT and C groups.

[3] possible range of mean scores for each factor.

three groups ($p<.05$*). Individual comparisons revealed that the index was higher for the MDT group than either the HDT ($p<.05$) or the C ($p<.05$) groups. These latter two groups were not found to differ from each other on the index. In other words, the affect state of the MDT group was more positive than that of the other two groups.

Another finding with the overall affect index was that the scores were higher, i.e., more positive, before shifts than after shifts ($p<.001$). However, there was also a significant interaction ($p<.001$) between subject groups and the before shift-after shift assessments (which will be called the "work" variable). Further analysis of this interaction by simple effects tests revealed that while all three subject groups showed a decrease in index scores from before to after shift assessments, the change was significant only for the two ATCS groups.

It was also found that the overall affect index scores were higher for day shifts than for evening shifts, ($p<.05$).

2. Aggression. No significant effects were found for the Aggression factor.

* Refers to the significance level of the associated F test from the analysis of variance for the factor under consideration.

3. Anxiety. There was what appeared to be a slight trend for HDT ATCSs to have higher Anxiety scores than the other two groups on the CMACLs taken before night shifts. The significant three-way interaction ($p<.05$) between subject groups, work, and type of shift tended to support this trend. However, this effect must be considered marginal at best, since all simple effects analyses for groups before and after each type of shift were non-significant. In other words, although there was a marginally significant three-way interaction, none of the effects within the interaction were sufficient to achieve significance, and therefore, it should probably be concluded that there were no substantial differences between groups, type of shift, or before and after shift assessment in Anxiety scores.

4. Anxious. No significant effects were found for the single word factor of Anxious.

5. Concentration. Apparently nearly all subjects, both ATCSs and controls, felt a higher degree of concentration before shifts than at the end of shifts, as the scores on this factor showed a general and significant decline as a function of work ($p<.001$).

6. Depression. On this factor, there was a significant interaction between subject groups and work ($p<.05$). This reflected what was

determined by simple effects analyses to be a significant decrease in depressive feelings as a function of working for the control subjects only. There were no substantial changes in levels of dysphoria for the ATCS groups, and these levels were well within what might be considered normal limits.

7. Distrust. Scores on this factor did not seem to be influenced to any significant degree by the experimental variables.

8. Dizzy. No significant effects were obtained from this factor.

9. Fatigue. It was apparent that feelings associated with fatigue were greater for all subject groups after having worked shifts than they were before beginning the shift ($p<.001$). This change was found to be greater when working night shifts than day shifts ($p<.05$). Looking at the significant ($p<.05$) interaction between subject groups, work, and type of shift, revealed that the control and the MDT groups had higher fatigue scores on both the before and after night-shift assessments than did the HDT ATCSs. On the day shift CMACLs, the controls reported more fatigue prior to shifts than either ATCS group; however, after day shifts both the control and HDT groups had higher scores than MDT ATCSs.

10. Friendly. Scores were generally higher on this factor before the start of shifts than at shift completion ($p<.05$). There was an apparent trend for ATCSs to have higher scores than controls, i.e., to be more "friendly" than controls; however, simple effects analysis of the significant ($p<.05$) interaction between groups, work, and type of shift indicated that this difference was significant only for those CMACL records obtained before day shifts. In addition, it was determined that there was also a difference between the two ATCS groups in that case, with the MDT group having a higher mean Friendly score than the HDT group.

11. Nonchalance. Both ATCS groups scored higher than the control group on this factor ($p<.01$), however, the differences between the groups were confined to the night shift according to simple effects analysis of the significant groups by type of shift interaction ($p<.05$). There was also a significant ($p<.05$) three-way interaction, but further analysis revealed that it was due to the somewhat greater difference between groups on the after night-shift than the before night-shift CMACL assessment.

12. Sleepy. In general, subjects reported more feelings associated with sleepiness after shifts than they did before shifts ($p<.001$). Simple effects analysis of the significant ($p<.01$) interaction between work and type of shift indicated that the increase in these feelings was greatest for the night shift.

There were some interesting differences between ATCS groups on this factor as reflected in the interactions for groups and type of shift ($p<.001$) and the three-way groups, work, and type of shift interaction ($p<.01$). On night shifts, MDT ATCSs had higher "sleepy" scores than HDT ATCSs, while the reverse was true for day shifts (remembering that for the HDT group this was an evening shift). In other words, MDT ATCSs were "sleepier" on night shifts than HDT ATCSs, while the HDT group reported more feeling associated with sleepiness on their evening shift than the MDT group reported for their day shift. The scores for the control group usually reached or exceeded the level of the highest ATCS scores on this factor, with the exception of those CMACLs taken after day shifts, where the mean score for the control group was intermediate between the HDT group and MDT group scores.

13. Social Affection. The tendency to be affectionate and affiliative seemed to decrease considerably as a function of working, as the scores on this factor declined significantly from before to after-shifts for all groups ($p<.01$).

14. Surgency. As with several other factors, scores on the Surgency factor, an index of what might be termed the tendency to be outgoing and spontaneous, decreased as a function of work ($p<.01$), however, simple effects analysis of the significant interaction ($p<.05$) between work and type of shift indicated that this decrease was significant only for the night shift.

Two interactions with groups were significant; that of groups by type of shift ($p<.05$), and the groups, work, and type of shift interaction ($p<.05$). Analysis of the two-way interaction indicated that the differences which existed between the groups were significant only for the day shift, as the MDT group had higher scores than the HDT group, who in turn scored more highly than the controls on day shift assessments.

The three-way interaction further specified this effect to be significant only for the CMACLs taken before day shifts.

15. Vigor. This factor, a positive index of an individual's energy level, yielded scores which, not surprisingly, were almost the inverse of those obtained from the Sleepy and Fatigue factors. Energy levels were higher before shifts than after shifts for all groups ($p<.001$), although there were relative differences among the groups signified by the significant interactions between groups and type of shift ($p<.001$), and between groups, work, and type of shift ($p<.05$). The HDT group reported more "vigor" for night shifts than either the MDT or control groups, while for day shifts MDT ATCSs generally had the higher scores. However, this should be qualified by indicating that while the difference between the MDT group and the control group was substantial both before and after day shifts, the MDT and HDT groups had essentially equal mean scores on the CMACL taken before day shifts.

16. Zuckerman Affect Adjective Check List. There was a tendency for scores on this factor, a measure of general anxiety or affective distress, to increase as a function of working ($p<.01$). However, it should be emphasized that the scores were equal across groups, and were at a relatively low level even for the highest mean.

IV. Discussion.

Clearly the most pronounced variations in affect, as assessed by the CMACL, were associated with working and with the type of shift involved. In general, the subjects, both ATCSs and controls, indicated that their feelings were less positive after completing an eight-hour shift than they were before they started a shift. With respect to night shifts, feelings were generally less positive than those associated with day or evening shifts, and the degree of change toward negative feelings from before to after shifts was greater for night than for other shifts. Much of this variation in moods seemed to be a result of the effects of work activity on mood factors which were largely concerned with "physical" condition. As noted, the factors of *Fatigue*, *Sleepy*, *Surgency*, *Concentration*, and *Vigor* all showed strong shift and work effects, while only one "physical" factor, that of *Dizzy*, did not show these effects. Of the five factors which might be considered most directly related to "emotions," only the *Zuckerman Affect Adjective Check List* showed a significant work effect, with an increase in negative feelings from before to after shifts. The other factors with significant work and/or shift effects, namely *Nonchalance*, *Friendly*, and *Social Affection*, seem to reflect, at least with respect to the latter two factors, a decrease in sociability as a function of work. These findings are generally consistent with results of the research by Grandjean, Wotzka, and Kretzschmar,[6] with ATCS personnel in Europe, as well as with the general body of industrial research on a variety of occupations which has been concerned with fatigue and work schedules.[e.g., 1 5]

The factors which were expected to be most sensitive to differences in stress between the three subject groups, i.e., those of *Anxious*, *Anxiety*, *Aggression*, and the *Zuckerman Affect Adjective Check List*, were not found to vary as a function of these groups. In other words, there was no evidence to suggest variations in affect which would be expected with differential stress levels. It is, of course, possible that these measures are insensitive to the effects of stress, although the research previously cited from other contexts[2 3 7] suggests this is not the case. Instead, it seems more appropriate to conclude that stress, as measured by variations in affect, was essentially equal for all three subject groups. This equality in affect levels was also found by Grandjean, Wotzka, and Kretzschmar in their comparisons of ratings on affect items of a bipolar questionnaire administered to two European ATCS groups and a group of telegraph operators.[6]

It is of considerable interest that the two ATCS groups had scores indicative of more positive moods on several CMACL measures than did control subjects. In some respects, this may reflect the basically positive mood states that may be characteristic of persons who choose, and are successful in, the ATCS profession. However, it may also be a function of what might be called the "energizing" or "motivational" properties of their profession. In a previous study, Smith, Cobb, and Collins[11] found that one of the most positive aspects of the ATC profession according to ATCSs is the fast-paced, challenging, constantly changing nature of the ATC task. ATCSs appear to take considerable

pride in their ability to function well in this kind of environment, and are highly motivated by the challenge of ATC work. On the other hand, the control subjects used in this study probably felt much less challenged by their work than ATCSs, since the monitoring and recording of work activities of ATCSs tended to become quite routine after the first few shifts. In addition, the controls may have been reacting to the requirement that they work each day of the project without days off (ATCSs continued their normal schedule during the project which included days off).

The few differences between the HDT and the MDT ATCS groups on the CMACL factors may have been due, in part, to the relative activity levels associated with particular shifts. Thus, MDT ATCSs, whose night shifts were very low in traffic density and were covered by only one ATCS in the tower and one in the radar room, reported considerably more fatigue, sleepiness, and less vigor than HDT ATCSs on night shifts. The HDT ATCSs, while much less busy on night than day or evening shifts, still handled considerably more traffic than the MDT facility during the night. Conversely, MDT ATCSs reported less fatigue and related effects on day shifts, than HDT ATCSs did for evening shifts. In that comparison, MDT ATCSs were what might be termed "comfortably" busy, while HDT ATCSs were experiencing peak traffic loads that often exceeded 200 operations an hour. It should also be noted, however, that the scores obtained for these two ATCS groups under what appeared to be the most difficult conditions for each group, did not differ from each other, although the effects were associated with very high traffic density at one facility and very low traffic density at the other facility.

In sum, the findings from this study suggest that ATCSs, like individuals in most other occupations, find their work fatiguing, especially when night work is involved. They do not appear to suffer unusual changes in affect states as a function of their work. Instead they tend to have generally positive levels of moods and feelings, which may in no small part be a result of their membership in a challenging and rewarding profession.

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