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BOREDOM AND MONOTONY AS A CONSEQUENCE OF AUTOMATION: A CONSIDERATION OF THE EVIDENCE RELATING BOREDOM AND MONOTONY TO STRESS

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16. Abstract

As air traffic control becomes increasingly automated, the various implications of this trend should be considered. One of the likely byproducts of highly automated air traffic control systems is an increase in boredom and monotony among controllers as a result of the anticipated reduction in task demands. Boredom and monotony are generally conceded to be negative factors that can have adverse effects on morale, performance, and quality of work. This paper examines the evidence for yet another claimed effect of boredom and monotony, viz, that these factors are stressors, and that because they are stressors, they may produce effects even more detrimental than those mentioned above. Both laboratory and field studies are examined for evidence of increased neuroendocrine activity during exposure to monotonous or understimulating conditions. It is concluded that the available data offer no support for the belief that boredom, monotony, or understimulation per se produces the syndrome of stress. However, monotony coupled with a need to maintain high levels of alertness, which might exist if controllers lacked sufficient confidence in an automated system, could represent a combination capable of eliciting considerable stress.

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BOREDOM AND MONOTONY AS A CONSEQUENCE OF AUTOMATION: A CONSIDERATION OF THE EVIDENCE RELATING BOREDOM AND MONOTONY TO STRESS

Introduction.

Boredom and monotony are widely recognized as undesirable side effects of repetitious work. With an increasing trend toward the application of computer control, more jobs are becoming automated and, despite a concomitant demand for programing and other computer-related work associated with a high degree of job satisfaction, there is concern that this trend will result in a net increase in the number of fragmented and routine jobs; in this event the effects of boredom and monotony will become increasingly important considerations in job design and personnel management.

Air traffic control is no exception to the trend toward automation. Although air traffic control is presently only partially automated, it is expected to approach full automation eventually, thus changing the role of the controller from one of full participation to that of a more or less passive systems monitor. In view of the current dislike among controllers for periods of low traffic load, which they find boring, unsatisfying, and generally objectionable (34,45), higher levels of automation will almost certainly produce increased complaints of boredom. While this effect can be anticipated and measures to reduce it can be included in the planning of the final system, it is unlikely that boredom and monotony can ever be completely eliminated in any highly automated system (19).

Few would dispute the statement that boredom and monotony are unpleasant, undesirable affective states. However, it is only recently that some investigators have come to consider them, as well as understimulation in general, not simply as unpleasant affective states or conditions, but as stressors that may be as potentially harmful to the individual as are the more commonly acknowledged effects of exposure to overstimulating conditions. Typical examples used to illustrate understimulating situations include sensory and perceptual deprivation, vigilance (monitoring) tasks in laboratory studies, and repetitive jobs in industry.

A major proponent of the view that understimulation and monotony are stressful is Levi (24,25), who has hypothesized that the relationship between stress and both overstimulation and understimulation takes the form of a U-shaped curve, in which the stress response is as great to extremely low as it is to extremely high levels of stimulation. Levi has taken Selye's concept of stress and extended it to include any psychosocial (or physical) change. Thus, Levi (25) states that:

> "In general, deprivation or excess of almost any influence is found to be stress provoking in Selye's sense of the word. For instance, high stress levels

> may be induced during sensory deprivation and sensory overload, in response to extreme affluence as well as extreme poverty, parental overprotection as well as parental deprivation, extreme permissiveness as well as extreme restriction of action, etc." (p. 14).

Others who view understimulation as a stressor include Caplan, Cobb, French, Harrison, and Pinneau (7), Frankenhaeuser, Nordheden, Myrsten, and Post (16), Johansson, Aronsson, and Lindstrom (20), Reighard (42), and Welford (55). If understimulation (which is a term typically used interchangeably with boredom and monotony) is an important source of stress, then attempts to reduce excessive workloads (overstimulation) through increased automation could have the ironic effect of replacing one sort of stressor with another.

The intent of this paper is to review the evidence relating to the alleged relationship between boredom-monotony and stress. For purposes of this discussion, boredom and monotony will be used interchangeably with understimulation. Strictly speaking, however, boredom and monotony refer to the subjective experience resulting from exposure to an understimulating (uniform or repetitive) condition. Stress will be used in the Selye (44) sense to refer to the nonspecific response of the body to any demands placed on it, with principal measures of stress being biochemical indices of increased sympathetic-adrenomedullary and pituitary-adrenocortical activity. However, since autonomic and electrocortical changes associated with increased "activation" or "arousal" (26) are commonly considered to be components of the generalized stress response (10,22,38), some studies employing responses of the central or autonomic nervous system will be considered when biochemical indices are lacking. Finally, since clinical and experimental evidence suggests that chronic or recurrent elevation of arousal levels may lead to a variety of diseases (10,14,21), studies purporting to relate monotony, boredom, or understimulation to the incidence of illness will also be included.

Laboratory Studies.

Task Performance. Probably the single study most frequently cited to support the view that both understimulation and overstimulation increase sympathetic-adrenomedullary activity was conducted by Frankenhaeuser et al. (16). Because of its importance, this study will be considered in some detail. Subjects performed a complex sensorimotor task (overstimulation) on one 3-hour occasion and a simple vigilance task (understimulation) on another. A third session (control) was spent reading magazines. Subjective ratings of boredom, unpleasantness, concentration, and irritation obtained during task performance revealed that boredom was the feeling state that differed most in the two tasks, with boredom being considerably higher during understimulation. Urinary excretion of adrenaline and noradrenaline was measured prior to and during the two task conditions and the control condition. Analyses of variance of these data revealed significant differences between the three

conditions for both measures. Interestingly enough, although mean values for adrenaline and noradrenaline were generally higher during the course of both treatment conditions than during the control condition, both catecholamines increased rather markedly during exposure to overstimulation, but they either declined continuously or showed a decline followed by a slight increase during understimulation. It is also interesting that the greater level of noradrenaline excretion in the understimulation relative to the control condition was present even prior to the start of these conditions. Since the authors failed to report individual comparisons between the treatment and control conditions at the various measurement periods, it is impossible to determine whether catecholamines for both understimulation and overstimulation were significantly greater than the control, or whether the significant main effect for treatment groups was the result of the much greater increase in sympathetic-adrenomedullary activity during overstimulation. On the basis of the evidence presented by Frankenhaeuser et al., it would appear premature to conclude that understimulating (boring) and overstimulating conditions both produce increased sympathetic-adrenomedullary activity.

Other performance studies in which boredom was a measured variable have generally tended to rely on autonomic rather than biochemical indices of sympathetic-adrenomedullary activity. The most extensive series of studies was conducted in the 1930's by Barmack (3,4,5,6).

In his initial study, Barmack (3) was concerned with how boredom was related to changes in oxygen consumption and blood pressure during performance of a repetitive task. His data strongly suggested an inverse relationship between reported boredom and physiological arousal, i.e., with reports of sustained interest, oxygen consumption and systolic and diastolic blood pressure either remained the same or increased, while reports of increasing boredom were associated with declining levels of physiological activity. In addition, he also found reports of increasing boredom to be associated with decreased performance efficiency and increased drowsiness. One of Barmack's more interesting findings was that administration of benzedrine significantly increased wakefulness, blood pressure, and heart rate, with a significant reduction in reported boredom (6).

Two more recent performance studies, in which boredom was a measured variable and arousal was assessed physiologically, fail to provide any strong support for Barmack's findings although neither of these studies offers any real support for the opposing view that boredom is a state of high arousal.

London, Schubert, and Washburn (27) manipulated boredom by using tasks differing in interest. Tasks rated high in boredom were found to induce higher levels of heart rate and skin potential than was the case with tasks rated low in boredom. However, the apparent difference in heart rate between the high- and low-boredom conditions was on the order of one beat per minute, and palmar skin conductance, the third measure of arousal used, failed to differentiate between the two conditions. Since subjects also rated themselves as being significantly more tired and sleepy during the boring tasks than

during the interesting ones, the authors' conclusions favoring a heightened arousal interpretation of boredom are not entirely convincing.

Thackray, Bailey, and Touchstone (50) examined the degree to which reported boredom and monotony were related to performance on a complex monitoring task and explored the general pattern of physiological changes associated with boredom. Subjects performed a simulated air traffic control task for 1 hour. Recordings of blood pressure, oral temperature, skin conductance, body movement, heart rate and heart rate variability, and performance measures of detection latency were obtained. In addition, subjects rated their feelings of boredom, monotony, and attentiveness at the beginning and end of the session. For the total group, a significant increase in detection latencies was accompanied by significant increases in boredom, monotony, and body movement, along with significant decreases in conductance, heart rate, blood pressure, oral temperature, and attentiveness. However, subjects falling at the extremes of rated boredom and monotony differed on only a few variables, with the high-boredom group showing a greater increase in detection latencies and heart rate variability and a greater decrease in attentiveness. The authors concluded that the nature of the pattern associated with high feelings of boredom and monotony suggested a pattern more closely associated with attentional processes than with "arousal," although they theorized that this change in indices of attention was probably the initial manifestation of a general decline in arousal that might well have extended to some of the other physiological measures had the session been longer.

Although numerous other studies have investigated changes in arousal during exposure to vigilance or repetitive task situations, their primary intent has been to examine the extent to which performance covaries with arousal. While boredom and monotony must be inferred in the studies to be considered now, it is commonly accepted that most individuals find tasks of the type used to be boring and monotonous. Indeed, all of the studies considered thus far have deliberately employed such tasks to induce boredom, with Barmack (3), in particular, showing that rated boredom increases progressively during the course of repetitive performance.

O'Hanlon (35) and O'Hanlon and Horvath (37) report two studies dealing with catecholamine levels during vigilance performance that appear to be similar in design, but with findings directly contrary to those of Frankenhaeuser et al. (16). In both studies, indwelling catheters were used to allow relatively continuous measurements of biochemical changes during vigilance performance, as well as during a control period of magazine reading or viewing travelog slides. Relative to the control condition, there was an initial significant rise in adrenaline at the beginning of task performance (which was attributed to anticipation) followed by a decline to control levels by the end of the task session (180 minutes in the earlier study, 60 minutes in the more recent one). (It should be recalled that Frankenhaeuser et al. (16) found adrenaline to increase towards the end of vigilance performance.)

In neither study did noradrenaline levels for the experimental condition differ from those for the control condition.

Additional studies of vigilance and arousal have relied on autonomic or electrocortical measures. One of the most commonly used measures in these studies is palmar skin resistance (or its reciprocal, conductance). The general finding is that continued performance of repetitive or vigilance-type tasks is associated with declining performance efficiency and increasing skin resistance (declining conductance) (1,11,12,46,51). With the possible exception of a study by Ross, Dardano, and Hackman (43), who compared individual trends, there appears to be no evidence of an overall conductance increase during performance of typical vigilance tasks.

Other commonly employed measures include heart rate (12,46,49,50,51,52), respiration rate (46,51), and measures of EEG amplitude or frequency (11,36). While these measures frequently do not reflect as pronounced a decline in arousal as does conductance, and may even show no change, they nevertheless do not generally reveal changes that would suggest any increase in arousal level.

Sensory Deprivation or Isolation. . As stated earlier, exposures to conditions of isolation or sensory (perceptual) deprivation are frequently mentioned as sources of "understimulation stress." Often, it is the boredom or monotony felt to be produced by these environmental conditions that is implicated as a primary stressor (48).

In a recent review, Suedfeld (48) has dealt with the stressfulness of sensory deprivation. He notes that "the harmfulness of sensory deprivation has been discussed at great length, often without much evaluation of the known factors"(p. 61), and states further that the known facts are very different from the myths that continue to be perpetuated. In a questionnaire sent to over 20 leading researchers in the field of sensory deprivation, Suedfeld found that out of 3,300 subjects who had participated in sensory deprivation studies only one subject experienced stress that was sufficiently pronounced to require any subsequent treatment.

This is not to deny that boredom and monotony are commonly experienced in studies of sensory and perceptual deprivation. Most investigators, however, have relied on anecdotal reports of boredom among subjects or have noted comments concerning boredom in postexperimental interviews. Those few studies using a standardized questionnaire, such as the Isolation Symptom Questionnaire (33) which yields a measure labeled "tedium stress," tend to show that tedium is significantly greater among deprivation subjects than among controls (30). Yet, boredom does not appear to be a principal reason given by subjects who terminate a deprivation study early. In a study dealing with factors associated with tolerance for sensory deprivation, Myers (31) found two general, uncorrelated types of adverse reaction to deprivation. One was tedium and the other was labeled "negativity of subjective experience" (operationally defined by terms denoting a frightening, subjective "bad trip"). Subjects who terminated at some time during the course of the 7-day study scored significantly

higher on negativity of subjective experience than did those who completed the study, but there was no difference between the two subject groups with respect to the tedium measure.

While it is not always easy in studies of sensory deprivation to separate the effects of boredom from those of fear or apprehension, the available evidence suggests that subjects who elect to endure prolonged deprivation or isolation are bored by the experience but do not rate the experience as frightening (31). On the other hand, those who prematurely terminate the sessions tend to do so primarily for reasons of fear or apprehension rather than because of boredom (31,32). Because of this difference between subjects who remain and those who terminate sensory deprivation, it is of interest to examine biochemical changes in the two groups.

Of the few studies that have examined catecholamine levels, the general finding is that there is little or no difference in either adrenaline or noradrenaline output between subjects who remain for the entire experiment and control subjects (57). In two separate 7-day studies, urinary excretion levels of catecholamines during perceptual deprivation (58) and during immobilization (56) were compared with levels of control subjects. In neither study did the catecholamine levels of experimental subjects who completed the experiment differ from control levels. Both studies, however, showed higher adrenaline, but not noradrenaline, excretion among quitters relative to those who remained for the entire session.

Comparable studies examining adrenocortical activity of quitters with those who remain during prolonged deprivation or isolation have apparently not been conducted (57). However, Zubek (57) concludes that 11-oxycorticoids, 17-hydroxycorticosteroids, 17-ketogenic steroids, and 17-ketosteroids all appear unaffected by prolonged perceptual deprivation or isolation per se. An exceptionally long confinement study (105 days) revealed no evidence of stress as defined by an increase in adrenal cortical activity among experimental subjects relative to control subjects (53).

Other Tasks or Stimulus Conditions. A number of additional studies have been conducted that bear upon the issue of boredom and stress but that do not fit the two previous categories of studies. In some instances, boredom is not even a factor of primary interest. A study by Levi (23), for example, compared catecholamine response to a bland, natural-scenery film (control condition) with responses to three films each chosen to evoke one of three emotional patterns: (a) laughter and happiness, (b) agitation and hostility, and (c) fear. Interestingly, self-reported boredom was the only subjective measure to increase significantly during the natural-scenery film, and this film condition was the only one in which both adrenaline and noradrenaline levels significantly decreased. Subjective responses to the other three films were generally in the expected direction, and all were associated with significant increases in adrenaline but not noradrenaline.

A similar study by Patkai (40) examined catecholamine excretion and subjective response to several kinds of situations designed to evoke either pleasant or unpleasant feelings. The four situations consisted of (a) playing bingo, (b) performing paper-pencil tests, (c) watching medicosurgical films, and (d) reading magazines. Lowest adrenaline values were obtained for the magazine-reading (inactive) condition. This was also the condition rated the lowest in interest (highest boredom). Noradrenaline did not differ among conditions.

Summary. The findings of these laboratory studies clearly indicate that understimulation and/or a psychological state of boredom or monotony are associated with low or declining rather than high or increasing levels of physiological activation. Thus, because changes in certain physiological indices are the most widely acceptable criteria of stress (2), we must conclude that boredom-monotony-understimulation do not produce such physiological effects and are, therefore, not stressors in the conventional sense of the word.

It should be noted, however, that in the studies just considered the understimulating environments are those in which the subject responds in a rather passive manner to a set of nondemanding experimental conditions. Thus, although perceptual deprivation, viewing bland travelog films, and watching for the appearance of an infrequent signal in a vigilance experiment differ in detail, all are characterized by a similar redundancy/reduction of the sensory environment in which little or no active participation is required and little information is conveyed.

When boredom and monotony are the subjects of stress studies in the field, a number of additional elements, not usually found in laboratory studies, may be included. We shall now consider some of these elements.

Field Studies.

An extensive investigation dealing with the impact of technology on workers' health and job satisfaction has been underway in Sweden since 1965 (17). Most of the studies conducted under this program appear to have involved employees of the sawmill industry. Johansson, Aronsson, and Lindstrom (20), for example, studied indices of stress in two groups of employees. One group, which they refer to as the high-risk group, consisted of workers who operated high-speed saws and edging equipment, while the control group consisted of repairmen and maintenance workers. Urinary excretion of adrenaline during the workday, past history of illness, and self-ratings of boredom, monotony, and tension were all significantly higher in the high-risk than in the control group. The authors chose to focus on monotony as a principal factor contributing to stress in the high-risk group. However, although the jobs of the high-risk group were apparently more monotonous than those of the control group, the former group worked also on machine-paced tasks with extremely short operating cycles that placed continuous, high demands on the ability to make fast and correct decisions.

Jobs of the control group were largely self-paced. Since monotony coexisted along with many other possibly stressful aspects of the jobs of the high-risk group (no opportunity to change jobs, isolation from others, high noise levels, little interest displayed by management, physical constraint imposed by job, etc.), performing a simple correlation of monotony with adrenaline excretion without adequately holding constant or partialling out the effects of these other job features does not allow one to conclude anything about the effect of monotony per se on stress. It should be noted that the authors (20) are aware of this methodological problem and state their conclusions regarding monotony and stress as tentative.

A large-scale study of job demands and worker health has recently been reported by Caplan et al. (7). In this study, 23 occupations ranging from factory jobs to scientific/professional occupations were examined in detail. For purposes of this presentation, only those jobs in which workers reported boredom and monotony to be particularly undesirable features of their jobs will be singled out. These jobs were forklift driver, assembler (machine-paced), assember (machine-paced relief), assembler (non-machine-paced), and machine tender. Again, however, boredom was only one characteristic of these jobs. With minor exceptions all of the above occupations fell into a cluster characterized by above average feelings of (a) general job dissatisfaction, (b) ambiguity concerning future job security, (c) underutilization of skills, (d) poor social support from others, and (e) low participation. Workers in this cluster of jobs tended to report more anxiety, depression, irritation, and somatic complaints. Yet, none of the other indices of stress, including behavioral (smoking, coffee consumption, obesity) and physiological indicators (pulse rate, blood pressure, levels of cortisol, cholesterol, thyroid hormones, and serum uric acid), were higher in this cluster of jobs than in the other occupations studied; nor was the incidence of disease higher. As with the previously considered Swedish study of sawmill workers, even if the above cluster of factory jobs had shown definitive evidence of stress, one could not implicate boredom and monotony as principal sources of stress in view of the many other seemingly stressful characteristics of these jobs.

Reports of high occupational stress among telegraphers in Australia prompted another recent study (13). Stress in this occupational group was represented as arising from a "monotonous, highly skilled, repetitive task which demanded intense concentration amid noise and other distractions under conditions of machine pacing" (12, pp. 649-650). These job conditions were attributed to the introduction of semiautomated telegraphy equipment. Medical records revealed that telegraphers had a somewhat higher rate and duration of sickness absence than did the control groups (mail sorters and mechanics), with this higher incidence of illness confined largely to the rather large number (33 percent) of telegraphers diagnosed as neurotic. Among the entire group of telegraphers (neurotics included), the three most commonly stated reasons for job dissatisfaction were (a) monotony, (b) lack of sense of achievement, and (c) loss of personal contact. All of these reasons were related to the introduction of automated equipment. However, again there is no way of determining from this study what role, if any, monotony played in

precipitating neurotic disorders or in contributing to illness in general, since the effect of monotony cannot be separated from the effects of a number of other work elements also related to job dissatisfaction and (presumably) to stress.

The final research findings to be considered involve the question of stress in air traffic controllers. During a significant portion of their time, controllers are faced not with high traffic density, high "stress" situations, but with situations of low to moderate traffic density. As noted earlier, controllers much prefer high density conditions to those of low traffic load, which they consider boring, unsatisfying, and generally objectionable (45). In spite of their distaste for working under low traffic load conditions, physiological indices of stress suggest these conditions to be less stressful. Thus, controllers show significant increases in catecholamine levels and 17-hydroxycorticosteroids during times when traffic load is high, but little or no increase in these measures when traffic is light (18). Melton, Smith, McKenzie, Wick, and Saldivar (29) have recently extended these latter findings in a study that correlated excretion levels of adrenaline, noradrenaline, and 17-ketogenic steroids with annual traffic counts across different facilities having traffic densities ranging from very low to extremely high. The correlation of adrenaline level (the others were nonsignificant) with traffic count was 0.96. While the relationship of boredom to adrenaline level must admittedly be inferred in this study, the finding that low workloads (understimulation) are associated with low arousal (lower adrenaline excretion) is consistent with the findings of the laboratory studies reviewed earlier in this paper.

General Summary and Conclusions.

There can be no doubt that boredom and monotony are negative factors and that, with respect to the working environment, these factors can be detrimental to morale, performance, and eventually to the quality of work produced. Thus, it is not the intent of this paper to denigrate that view, nor to discourage attempts to reduce the monotony of industrial work through job enlargement and enrichment programs. The main purpose of this review has been to examine the validity of yet another claimed effect of boredom and monotony, that these factors are stressors and that, because they are stressors, they may produce effects even more damaging than those mentioned above. Contemporary literature dealing with the pathological effects of physical and psychosocial hyperstimulation is beginning to accumulate an increasingly larger body of evidence that such hyperstimulation can lead to serious disease conditions, including myocardial lesions (8), coronary arteriosclerosis (41), and psychoneurotic states (54).

Experimental evidence that boredom and monotony can, through effecting increases in neuroendocrine activity, produce the syndrome of stress, is highly important and should be examined carefully. This has been the purpose of the present paper. From the laboratory studies reviewed here we cannot conclude that understimulation, in the several forms employed by these studies,

produces any significant increase in the commonly employed indices of stress or arousal.

The most typical pattern associated with exposure to repetitive or unvarying stimulation is one of decreasing physiological arousal, increasing feelings of monotony and boredom, and decreasing wakefulness and attentiveness. Indeed, the soporific quality of repetitive stimulation is so potent that even exposure to a repetitive combination of noxious stimuli consisting of powerful electric shock, loud jazz, and bright lights has been shown to produce declining wakefulness and sleep (39).

Given that laboratory studies of repetitive or uniform stimulation almost invariably induce decreased levels of arousal, why is stress or increased arousal so frequently felt to be associated with monotonous, repetitive tasks in industry? If indeed such tasks are stressful, the answer may lie with elements of the total job other than simple repetition or monotony. The study of Swedish sawmill employees discussed previously illustrates one such element. Although workers in the high-risk group rated their jobs as boring and monotonous, the jobs themselves were characterized by fast, machine-paced work demanding continuous attention and alertness in order to avoid production "bottlenecks" or serious personal injury. If one were to analyze separately these various job elements, it could be hypothesized that exposure to a repetitive situation results in a process somewhat analogous to that of habituation (decreased arousal or cortical alertness) which, when combined with the opposing requirement to maintain a constant high level of alertness (increased arousal), results in considerable effort or energy expenditure on the part of the individual. This is supported by the fact that these sawmill employees commonly reported utter exhaustion and fatigue at the end of their shifts. Repetitiveness in combination with a need for high alertness appears related to stress in other industrial jobs as well. Thus, repetitive, machine-paced work with a need for intense concentration and errorless performance also characterized the work environment of the telegraphers studied by Ferguson (13). Compared with supervisors, mechanics, and sorters, telegraphers complained the most of monotony and boredom and had the highest incidence of stress-related disease. In the study by Caplan et al. (7), forklift drivers, machine-paced assemblers, non-machine-paced assemblers, and machine tenders were the occupations in which high levels of boredom were reported. Interestingly enough, although all of these occupational groups complained of boredom and job dissatisfaction, only among the machine-paced workers were somatic complaints, anxiety, depression, and frequency of dispensary visits uniformly the highest. As Caplan et al. note, ". . . if one were to pick out the most stressed occupational groups, they would tend to be the machine-paced assembly line workers" (p. 191).

The coupling of repetitive, monotonous work with requirements for high alertness, continuous and rapid decisions, and various penalties for any errors that occur, may very well represent a combination that is quite stressful. Such a combination has also been recognized by others, notably Frankenhaeuser and Gardell (15) and Johansson et al. (20), as being potentially

very stressful. However, these investigators attribute the stressfulness of this combination to the additive effects of two separate stressors--understimulation and overstimulation. The position advanced in the present paper is that it is the coupling of an arousal-reducing (nonstressful) task characteristic with the opposing requirement for high arousal that may make this combination particularly stressful.

With regard to air traffic control work, the extensive literature dealing with vigilance performance provides ample evidence that exposure to monotonous monitoring tasks is almost invariably associated with some decline in attentiveness (28,47). Thus, in some of the proposed highly automated air traffic control systems of the future, such as a Control-by-Exception, Level III concept in which the controller is almost completely "out of the loop" (9), it may be very difficult for a controller to sustain attention. Moreover, if the arousal-reducing properties of this level of automation are coupled with the necessity to maintain a constant, high level of alertness, there is suggestive evidence that this particular combination may be stressful. Such a combination could certainly exist if, in a highly automated air traffic control system, the controller lacked confidence in the system's ability to function adequately and reliably at all times.

In conclusion, it would seem that reports of boredom and monotony could serve most usefully as "marker items" or "flags" to warn that some of the elements in an automated job may be contributing not only to lowered attentiveness, but to general work dissatisfaction as well. Whether or not such a job is also stressful cannot be determined from reports of boredom and monotony alone. Future research in this area should not continue to employ some of the simplistic assumptions used in the past. If there is stress associated with high levels of automation, sophisticated techniques and approaches will be necessary if any real progress is to be made in our understanding of which job elements, either by themselves or in combination, actually do contribute significantly to occupational stress.

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