Aviation Medicine

Aviation psychology

II: Assessing workload and selecting pilots

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Workload

The principal impact on the crew of improved technology on the flight deck has been a reduction in the number of tasks that the crew must perform but an increase in the amount of information that must be monitored. Under such circumstances it is difficult to determine the extent of the pilot's workload, yet its assessment is crucial in deciding how many people are required to operate a given aircraft. In a military interceptor the benefits of having an additional person on board may be offset by the extra airframe weight and performance penalties that his presence entails. Airline economics dictate the presence of only the minimum number of flight crew commensurate with safe operation, and in a modern airliner the question becomes whether to have two or three people on the flight deck. These matters are overlaid with so many politicoindustrial considerations that an objective means of assessing workload is clearly desirable. Indeed the "two *v* three" crew issue was so strongly debated in the United States that a president's task force on crew complement was set up.[1] The report of this committee has stimulated the Federal Aviation Administration to be satisfied that workload has been formally assessed on any new aircraft before it will be certificated. It does not, however, answer the psychologist's problem of how to carry out such an assessment. Many techniques have been suggested, but these resolve themselves into methods that require the aircrew to give some form of rating of how hard they feel themselves to be working (the most famous of these being the Cooper-Harper scale[2]), secondary task techniques,[3] observational techniques in which the overt activity of the aircrew is analysed,[4] and the measurement of physiological variables, principally heart rate.[5]

All of these methods have severe deficiencies: subjective ratings are open to subjective bias, secondary tasks are intrusive, observation cannot indicate the cognitive load on the pilot, and heart rate is more affected by the pilot's perception of how critical the task is than by how busy it keeps him. At present, aircraft seeking certification in the United States (such as the European Airbus and the British Aerospace 146) have to use some combination of the techniques described above, but there is some encouraging basic psychological research (looking at ways of assessing how finite mental resources can be allocated) that may yield more acceptable methods of measuring workload.[6-8]

Social relationships

One aspect of the "two *v* three" crew debate that cannot be assessed is the way in which individual members of a crew relate to one another. The importance of such social considerations should not be overlooked. The worst accident in aviation history occurred when two Boeing 747s collided in fog at Tenerife. The captain of the aircraft that was taking off believed that he had received radio clearance to do so. The cockpit voice recording makes it clear that the first officer had heard no such clearance, and while he did express a reservation to the captain he did not force the captain to wait until he had ensured personally that take off clearance was confirmed.[9] Why he did not can only be surmised, but the reluctance of a first officer to express doubt in the competence of his captain is natural and has been clearly shown in a recent survey.[10]

Such problems are not easily resolved as they involve complicated interactions of the roles, status, and personalities of the crew members. With a better understanding of the problem some action may be taken in limiting the way in which crew members are rostered together and in changing operational procedures so as to minimise the way in which individual eccentricities can affect them.

Personality and selection

At the moment there is no formal method of identifying and selecting potential pilots with respect to their personality. Indeed, the method of selection used by the Royal Air Force has changed little since the war.[11] The RAF and most airlines rely on interviews and other subjective means to assess the character or personality of recruits. Not only does the personality of the potential pilot need to be assessed, however, but also his aptitude to perform the task. Considerable psychological research has been carried out into aptitude testing in aviation but it has had disappointing results. The main reason for any selection system is, of course, to save time and money. It would be quite feasible to use flying training itself as a selection process, allowing all candidates to start training and gradually eliminating those who fail to cope. In a system where the number of aircraft available is typically less than one tenth of the number of those volunteering to fly, however, some selection at the beginning is required. The usual procedure in any selection system is to analyse the job, to attempt to identify the skills required, to devise a set of scorable tasks that use those skills, and then to validate the tasks by computing the level of correlation between the score on the tasks and the trainee's final level of flying competence or his likelihood of completing training—the criterion score. This is illustrated in the figure: typical individual correlation coefficients in selection for flying are fairly low, and the individual data points may be enclosed by an ellipse of the type shown. Section (a) represents those who passed the selection test and passed flying training and section (b) those who passed selection but failed flying training. Research on this topic is hampered by the fact that full infor-

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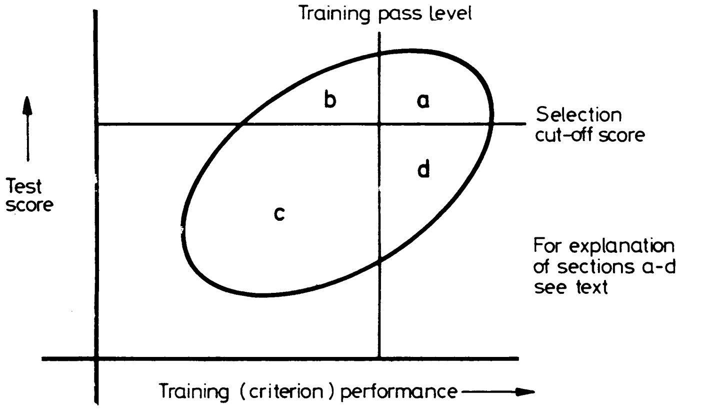
mation on the shape of this figure is unobtainable because as soon as a candidate fails the selection test no further data are available for him. Thus the precise nature of areas (c) and especially (d) (the test failures who would have passed the course) cannot be known in a working system. In practice, several aptitude tests are used, individually assessed, and then weighted in proportion to efficacy before being summed to generate a pilot index.[12] Today, in the RAF these selection techniques are augmented by a short period of formal flying training, when further selection is made.



Relationship between selection test performance and training performance.

Another intractable difficulty in designing a selection process is in the very first step of analysing the skills requirement of the job. Aircraft in the second world war required a high level of psychomotor coordination from the pilot, and the present selection tests still reflect this. Today's pilot must also possess such skills, but it is possibly more important that he should be able to assess quickly the priorities of the components of his task, be able to combine information from various channels to provide a coherent image of events, and have sufficient spare mental resource to be able to think and plan while controlling his aircraft. Traditional techniques of selection do not cover such requirements, but as microcomputers become more flexible and available selection testing is becoming increasingly sophisticated and soon the first real changes in pilot selection for 30 years will take place.

The types of artificial task used in the selection process are very similar to those used in the laboratory of the psychologist who examines the effects of stress on performance.

Stress, performance, and error

The variety of stresses to which a fighter pilot is subjected is probably wider than for any other occupation. The effects on performance of these physical and mental stresses—heat, noise, acceleration, vibration, hypoxia, anxiety, sleep deprivation, fatigue, and so on—have already been referred to in previous articles and are well reviewed elsewhere.[12] Theoretical models also exist for the effects of stress on performance.[14 15] The relevance of all this work to the definition of the cockpit environment is critical. For example, the larger the pressure differential that the aircraft hull must maintain the greater will be its weight and cost: thus strong economic influences exist to maximise the cabin altitude of aircraft. Care must be taken, however, to maintain intact the physiology and psychology of the inhabitants: the more stringent of these two requirements is the maintenance of psychological function. Experimental studies have shown effects of hypoxia on performance at altitudes as low as 5000 ft (1524 m),[16] but recent work highlights how fickle and variable such effects on performance may be, making practical interpretation of results extremely difficult.[17 18] The same is true of the effects of heat on performance: some workers have reported improvements in performance[18] while others have detected decrements.[19] What is clear is that even an apparently simple stress, such as heat, will produce different effects on performance depending on the subject's relative skin and core temperatures and whether he is being heated or cooled.

Although it is difficult to model the effects of many such stresses on performance, a deterministic understanding will probably eventually be reached. There is, however, a large area of research into stress that is even more difficult—that of so called life stress. It seems intuitively reasonable that the performance of a pilot who has serious domestic problems might be affected. Much research has taken place in this area over the past decade,[20] and there is some evidence of a relation between the amount of life stress or life change experienced and the likelihood of illness.[21] Some research has also aimed at testing the hypothesis that those pilots who experience more than normal life change will also have a greater than normal chance of being in a flying accident—perhaps because of their preoccupation with their non-flying problems. Individual case studies tend to support such a notion, but statistical population studies do not provide any corroboration.[22] This is possibly because life stress is just one of the many features that may be important in the aetiology of accidents due to "human factors." The limitations of human sensory function, the design of displays and controls (see previous article 11 June, p 1880), and the social relationships on the flight deck are all of obvious importance, and it is true to say that all the effort of the civil aviation psychologist is ultimately aimed at preventing accidents.

The specific study of error has always concerned the most eminent psychologists,[23 24] and the importance of preventing not only aircraft accidents but also accidents in, for example, nuclear power stations has added new urgency to the problem. In the search for the "accident prone" several studies have shown that the neurotic extravert is more likely to be involved in a driving accident than the stable introvert[25] and that those identified in questionnaire studies as "adventurous" have a much greater probability of being involved in a flying accident.[26] At present attention is concentrated on the modelling of mental lapses[27 28] and the use of questionnaires, such as Broadbent's cognitive failures questionnaire.[29] The importance of this work is clear. Characteristically, the "adventurous" personality is likely to be concerned in an accident as a result of illegal low flying. It is the delicate task of the air force commander to encourage legal aggressive flying but to contain excessive risk taking or rule breaking by the few. The problem, of course, is to identify who the few are: individuals continually role play, and the flying supervisor may not identify a risk taking individual during normal contact with him. Assessing pilots more formally in this respect may thus help to identify suspect pilots and improve their management.

A more detailed understanding of the sort of lapses that occur to us all may be of even greater benefit. Many flying accidents occur because the pilot makes the correct decision to operate a particular control but in fact operates another. Examples of this behaviour are legion, but they attract most attention when spectacular consequences arise, such as when a pilot shuts a fuel cock when he intended to manipulate the cabin heater or when on the ground he intended to raise the canopy but in fact raised the undercarriage. Better ergonomics might help this problem, but a fuller understanding of the underlying mechanisms of human skill are a prerequisite of solution, if indeed solution is possible.

Conclusion

In this brief survey of aviation psychology no mention has been made of some other important topics such as training and checking pilots, the psychosocial problems of alcohol and flying, or the acute and chronic consequences of transmeridian flight. Nevertheless, I hope that the reader will have gained some insight into its scope and the important part played by the psychologist in many facets of aviation.

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New Drugs

Hypnotics and anxiolytics

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During the past 10 years the benzodiazepine group of drugs has come to dominate the drug treatment of sleep disorders and anxiety. Indeed, they are the most widely used of all prescribed drugs. In this article we shall therefore discuss the benzodiazepines in some detail and contrast them with other drugs.

Benzodiazepines

There is no doubt that the benzodiazepine drugs are effective. In high concentrations they are hypnotic and in low concentrations anxiolytic. Although there are some indications that the structure of a particular benzodiazepine molecule may influence its activity, in practice it is predominantly the duration of action that determines choice between benzodiazepines.

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DURATION OF ACTION

Because many benzodiazepines are metabolised in the liver to produce further active forms whose elimination from the body is slower than the parent molecule, care has to be taken when assessing information on the duration of action of these drugs. For example, medazepam has an elimination half life of one to two hours but is metabolised to oxazepam, which has a half life of 6-25 hours. Pharmacodynamic studies where the duration of measurable effects such as sedation are recorded are the best source of this information. These studies need to be done in healthy subjects of all ages and in ill patients, particularly when renal and hepatic function is affected, before one can confidently predict the duration of action in particular patients. Furthermore, to exclude the possibility of accumulation of slowly eliminated metabolites such observations need to be continued over days or even weeks. Because of the difficulty in doing such