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Joint Committee on Postgraduate Training for General Practice, 14 Princes Gate, Hyde Park, London SW7 1PU. Tel: 01-584 6262.

Joint Committee on Higher Medical Training, Royal College of Physicians, 11 St Andrew's Place, London NW1 4LE. Tel: 01-935 1174.

Joint Committee on Higher Psychiatric Training, Royal College of Psychiatrists, 17 Belgrave Square, London SW1X 8PG. Tel: 01-235 2351.

King Edward's Hospital Fund for London, 14 Palace Court, London W2 4HT. Tel: 01-727 0581.

King's Fund Centre, 126 Albert Street, London NW1 7NF. Tel: 01-267 6112/9.

MAVIS (Medical Audio-Visual Aids Information Service), Centre for Medical Education, University of Dundee, Ninewells Hospital and Medical School, Dundee DD1 9SY. Tel: 0382 60111.

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Medical Recording Service Foundation, PO Box 99, Chelmsford, Essex CM1 5HL. Tel: 0245 421475.

Medical Women's Federation, Tavistock House North, Tavistock Square, London WC1H 9HX. Tel: 01-387 7765.

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Aviation Medicine

Function of the special senses in flight

II: Motion sickness and noise and communication

RICHARD M HARDING, F JOHN MILLS

Motion sickness

Motion sickness is a misnomer since it is a normal manifestation of sensory function in response to real or apparent, but unfamiliar, motion stimuli. Its incidence varies with environment: among those in liferafts in heavy sea states virtually 99% are affected, but in civil aircraft the incidence is usually well below 1% and rises to only about 8% in severe turbulence. About 60% of military aircrew in training are affected to a degree that degrades flying performance,¹ but this proportion declines appreciably as flying experience increases.²

The principal features are epigastric discomfort followed by increasing nausea, pallor, and sweating. The condition may then rapidly worsen (the avalanche phenomenon), with increased

salivation, feelings of warmth, and, of course, emesis. Secondary, less common features may include hyperventilation, frontal headache, flatulence, depression, and drowsiness.

Reason's neural mismatch theory provides a pragmatic model to explain why certain motion stimuli produce motion sickness but others do not.³ It also accounts for the occurrence of sickness when certain expected motion cues are absent—for example, in simulators. (It does not, however, explain why motion sickness takes the form that it does nor why it should occur at all.) The theory suggests that when motion sickness develops the sensory information provided by the visual, vestibular, and proprioceptive apparatus is at variance with that expected on the basis of past experience. The mismatch not only leads to sickness but also initiates changes within the central nervous system that are responsible for the development of protective adaptation.

Motion sickness in aircrew is best prevented by protective adaptation through repeated exposure to provocative motion environments and also by good postural stability within the aircraft, good control dynamics, sound ergonomic design, and the avoidance of unpleasant environmental conditions such as heat and odours. In passengers prophylaxis is a more realistic

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approach. None of the currently available drugs—including hyoscine, cyclizine, and promethazine—is, however, fully effective and all have side effects. Interest has recently been shown in the beneficial effects of cinnarizine (in seasickness) because of the low incidence of drowsiness.⁴

The effects of motion sickness in passengers may also be minimised by avoiding anxiety before and during flight and when affected by reducing sensory input by keeping the head as still as possible, preferably by lying down with the eyes shut. This will reduce the intensity of the sickness but not abolish it.

Noise and communication

Noise is essentially a subjective phenomenon and may be regarded as any unwanted sound. It is conveniently expressed on the logarithmic decibel (db) scale, which allows manageable measurement of the range of human hearing and on which zero db is taken as the auditory threshold (equivalent to a sound pressure level of 2×10^{-5} newtons/m² at a frequency of 1 kHz). A twofold change in noise intensity corresponds to a change in noise level of 3 db. Normal speech has a level of about 70 db and a busy street about 80 db, while high performance military aircraft and helicopters may produce internal noise levels of up to 120 db.⁵ Levels above 125 db are painful,⁶ and rupture of the tympanic membrane occurs at about 160 db.⁷

Aircraft noise is derived primarily from power sources including transmission systems, propellers (and helicopter rotors), and jet efflux. Noise also emanates from the interaction between the aircraft and the air through which it is moving (boundary layer noise) and from aircraft pressurisation, conditioning, hydraulics, and most importantly the communication system itself. The contribution of these various sources to total noise will depend largely on the type of aircraft, phase of flight, and location of the listener. For example, the overall noise level inside subsonic jet powered aircraft usually depends on boundary layer or cabin conditioning noise or both, while outside the aircraft it depends on the jet efflux, especially during take off and landing. In helicopters the engine and gearbox transmission, plus the sound of the rotors, provide most internal noise, while the rotor and exhaust produce most external noise.

Noise produces stress in several ways.⁸ Above about 90 db noise increases the degree of physiological arousal and hence irritability, fatigue, and the risk of accidents. In addition, by masking auditory signals—including speech—high noise levels make many tasks more difficult by increasing the degree of concentration required. Also the processing of information in active memory is affected, which increases workload even further.

In the long term the mechanism of hearing may be damaged, at first reversibly but later permanently. Prolongation of the time taken to recover the temporary threshold shift is an indication that cochlear damage is occurring.⁹

The reduction of both internal and external noise is clearly desirable. In aircraft the development of high bypass ratio jet engines has substantially reduced noise levels, while other more simple approaches—such as increasing canopy thickness, insulating cabin walls, and removing unnecessary airframe protuberances—have reduced aerodynamic noise. The careful siting of new homes, new airports, and flight paths, the restriction of night flying, and adequate home insulation also help reduce the problem.

The noise levels in aircraft inhibit communication both within the aircraft itself and between it and the outside world (air to air and air to ground). Speech is the only form of communication readily available to aircrew, since gesticulation and facial expressions are either inconvenient or impossible. Because speech has great variability in its power spectrum—the consonants having little vocal energy and the vowels much—its integrity needs to be preserved and protected in the face of competing, unwanted sounds. Consequently, special alphabets and methods of pronunciation have been developed in aviation

which allow trained speakers to improve their intelligibility substantially.⁹ Shouting or increasing the gain of the system both merely raise the overall noise level. Microphones and ear pieces improve communication by attenuating cockpit noise as much as possible; the efficiency of these devices is usually measured by their ability to maintain intelligibility at low signal to noise ratios. A difference of 10-15 db in speech level over noise will ensure adequate intelligibility of speech and sets the upper limit of acceptable ambient noise at about 85 db.⁹

Touch and smell

Touch is exploited in aviation in the design and shape of cockpit controls for easy location and recognition. Furthermore, the feedback of tactile sensation (feel) from the controls is of great value to the pilot, though it may be degraded (as in military aviation) if protective gloves have to be worn. Touch may be used as a warning mechanism in future cockpit design—for example, by enabling part of the control column to extend to stimulate touch receptors and attract the pilot's attention. Such tactile warning systems in the form of "stick shakers"—whereby the control column is shaken violently to warn of impending stall—are already fitted in many aircraft.

Finally, smell is a first line warning system, indicating fumes within the cabin or, in the case of military aircrew using personal oxygen equipment, suspected contamination of the oxygen supply.

Conclusion

Since much of what has been described above is self evident and immutable, there is little that the pilot, or his medical adviser, may do to overcome the limitations imposed by flight on human sensory physiology other than to be aware of them. We hope that forewarning will help to forearm.

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A woman with multiple sclerosis has had one child and is expecting another. Is there any precautionary treatment such as a special diet that the children should have to protect them from developing multiple sclerosis?

There is no known precautionary medical or dietary treatment that can protect children from developing multiple sclerosis—ALAN TURNER, senior registrar in neurology, Southampton.