Aviation Vision and the Optometrist

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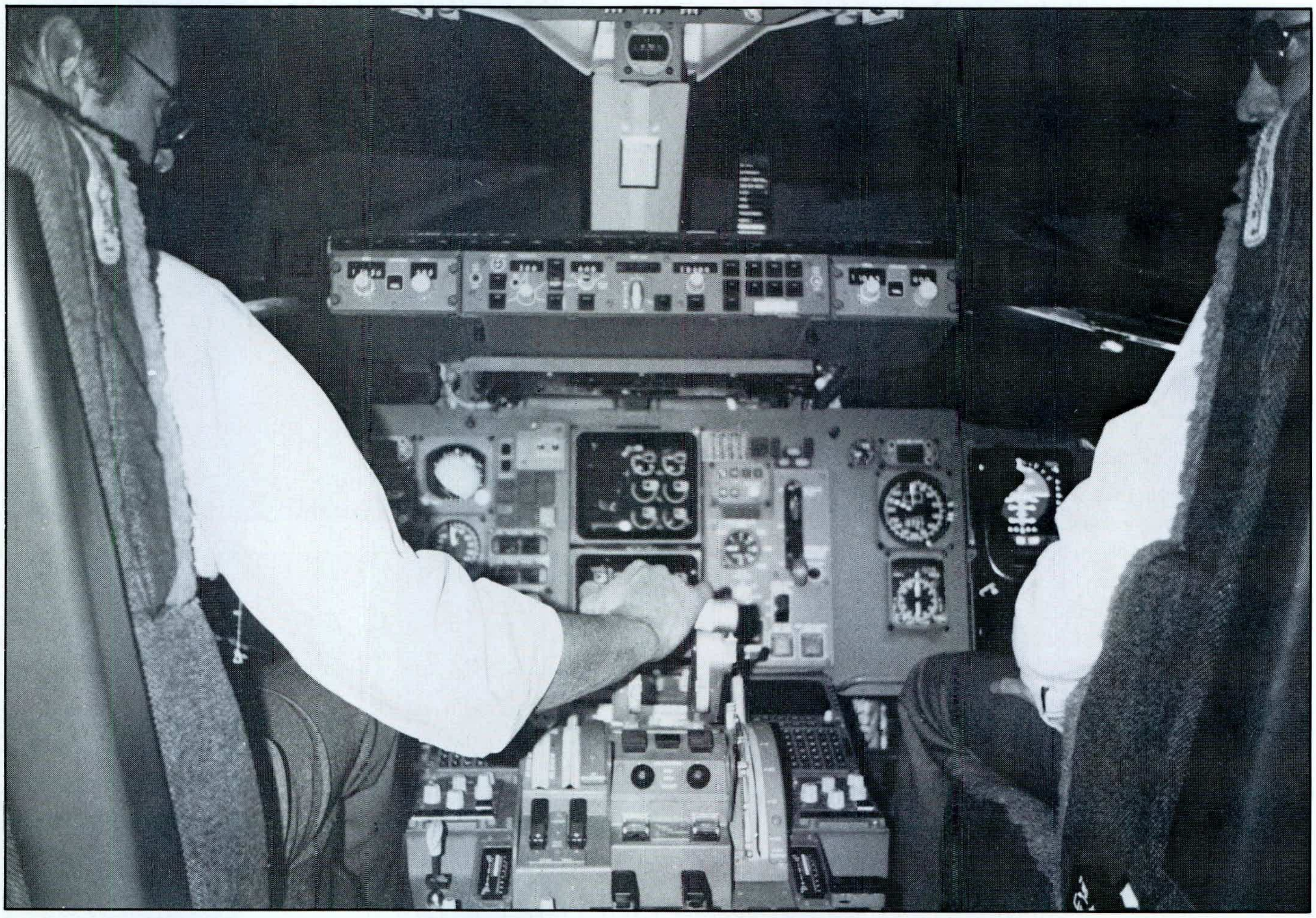

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Abstract

With new Federal legislation requiring the pilot to identify himself or herself as a pilot to the examining optometrist, it is important for the optometrist to have some knowledge of the flight environment.

Basic optometric techniques such as visual acuity measurements, depth perception, colour vision, etc. are discussed and related to the working world of the aviator.

Future cockpit designs and their affects relative to the visual systems are also discussed.

As has been reported in a previous issue of the CJO (Volume 47, No. 3, September, 1985), Bill C-36 requires flight personnel to identify themselves as such to the eyecare professional. It is also the responsibility of the examining doctor to notify the pilot of any visual disorder which might affect his flight performance and to request his grounding until the problem is cleared up.

It is with this in mind that this article will review basic optometric techniques related to the flight environment, will give an overview of the flight environment itself and what changes in the cockpit we should expect in the future. This paper will give the optometrist a greater understanding of the visual world of the pilot allowing the eyecare practitioner to better care for the needs of his/her pilot patients.

Basic optometric techniques remain the same in the refraction of the pilot or pilot candidate. It is the interpretation of results based on a knowledge of the flight environment which is the important variable.

The visual world of the pilot consists of an "office area" (inside the cockpit) and an external area, (that area outside the cockpit). The "reading" distances (inside the cockpit) range from 37.5 cm (15") to 90 cm (36") with various degrees of lighting and sources of lighting. The external environment ranges from 75 cm (30") to infinity, also with varying degrees of lighting.

Not only is clear, sharp, comfortable vision a requirement for each environment, but the pilot must be able to move easily between the environments. While this is accomplished without problem by the youthful pilot, it increases in difficulty as the individual ages.

It is important for the practitioner to determine the type of aircraft flown as the cockpit environment can be drastically different from one aircraft to another. For example, the wide window area and dial complexity on the flight deck of an L-1011 contrasts sharply with the enclosed cockpit space of the Cessna 150. The pilot is able to adjust seat height etc. so that his working distance will remain approximately the same. Lighting can be adjusted by using thermostats; glare shields help in reducing outside glare.

The external environment presents a more complex picture. It can range all the way from the blackness of an overcast night with no visual reference points whatsoever to the brightness encountered when flying into a setting sun above the clouds. Lightning flashes will also add a deleterious variable to dark adaptation.

The effect of night myopia, plus the close supervision of lighted dials will serve to reduce distance acuity. Bright sunlight will produce visual fatigue and thus lower a pilot's visual efficiency. All of the above factors can be experienced by a flight crew when flying through many time zones, often during a single flight.

All of these factors must be kept in mind when the pilot patient comes for a visual consultation. It is not only important to examine the patient but the practitioner must be able to advise him or her about the problems which might be encountered in flight.

Visual Acuity

Snellen testing alone is a poor predictor of overall visual ability[8]. The standard acuity test typically uses high contrast optotypes at a high level of illumination to determine only the smallest detail that can be seen. However, a person's visual capabilities are not limited to high contrast conditions. The visual world of the pilot contains objects of varying sizes and often poor contrasts that must be viewed under both ideal and poor viewing conditions. Good vision requires sensitivity to contrast.

In one air force test, using a simulator[8], a group of pilots with the same visual acuity were asked to locate a plane parked in the middle of a runway. Some pilots actually saw the plane the equivalent of a full mile sooner than other pilots!

The eye must not only bring an object into focus, it must be able to separate that object from its background. The contrast sensitivity test determines an observer's ability to see a wide range of object sizes under different contrast levels[13].

Depth Perception

It has been argued that good depth perception is not necessarily an important factor for safely flying an airplane[4]. Therefore, more people with suppression and monocular amblyopia are being certified to fly. As we will see, however, these conditions will become grounds for failing the flight physical when new cockpit designs become operational.

The helicopter pilot must have perfect depth perception because most helicopter flight is low level and contour flying requires excellent depth perception. Under these conditions, excellent hand-eye coordination is also essential.

Phorias

International Civil Aviation Organization (ICAO) regulations stipulate 6 eso - 6 exo and 1D hyperphoria as the outer limits for flight acceptance[14]. Of prime concern to the practitioner when phoria testing is the possibility of diplopia's occurring when the pilot is confronted with stressful low level illumination. This must be kept in mind by the eyecare professional as he or she goes through the battery of muscle balance tests.

Peripheral Tests

Good peripheral vision is an essential ingredient for safe landings. Awareness of our peripheral world as we look ahead locates our position in space in flying just as it does in driving a car. The sudden appearance of an object in our periphery should trigger an immediate response in order either to avoid a collision or to set in motion emergency procedures.

(When testing flying personnel, the author routinely uses the 1 mm white target in his perimeter. Target movement is faster than that utilized for the ordinary patient as he also likes to evaluate the speed of response.)

Colour Vision

The proper discrimination of colours is also important for safe flight. Taxi runways, with all their exits and entrances, are lined with blue lights while the take-off and landing runways are lined with white lights. Most modern airports also line the center of the main runway with white lights set in concrete.

It has happened often that pilots have landed or tried to take off on taxi runways. Full colour discrimination, therefore, is a must.

Within the cockpit, coloured lights and, in particular, red ones are used to attract the pilot's attention as emergency indicators and as landing aids in the Vertical Approach Slope Indicator (VASI) system. For example, in the two-bar VASI, a high approach will be seen with both bars white, while a low approach presents both bars red, with red or white being the proper profile.

Cathode Ray Tube (CRT) sets in Boeing 767 generation aircraft have varying shadings of colour. As many as four sets can be in use at one time, all using different colour combinations (Fig. 1). This can contribute to visual fatigue and ways to counteract this must be discussed with the pilot.

Dark Adaptation

With the adaptometer, practitioners test the eyes' ability to recover from glare. Speed of reaction is also measured. But the adaptometer can be used in another way. One of the difficult decisions we have to make with a pilot is when to prescribe at distance. As stated previously, using the acuity chart is not enough. The pilot who measures 6/6 or 6/9 in the office and needs, for example, a +1.00 or a +1.25 for 6/6 acuity will not be able to wear the R_x in flight. They usually complain of a reduction in distance acuity. This is probably due to the effects of space and/or night myopia. The author, in practice, reduces the final prescription by 0.50 diopters. To determine the most comfortable final R_x he will test the pilot in the adaptometer with the full correction found and then with the 0.50 D. reduction and then prescribe the lenses which give the best results.

Refraction

Plus or minus three diopters of power has been designated by ICAO regulations as the outer limits of acceptable ametropia[14].

People interested in aviation as a career, whose refractive error might surpass these limits in the future, must be advised about this before they make aviation their life's work. Hopefully, in the future, this regulation will be modified because the uncorrected visual acuity which these range of powers represent will vary with age, media and macular conditions.

Cockpit distances

The single most important factor the examining optometrist must remember when examining a pilot (especially the presbyopic one) is the varying visual distances used by the pilot. It is essential for the practitioner to know the type of aircraft flown and what level of command functions are carried out by the patient.

Even knowing the cockpit layouts of most commercial aircraft flown, the author usually asks the pilot to measure the distance from his or her eyes to the major instrument areas, as each pilot naturally likes to set the seat in the most comfortable position. Most aircraft have positioning mechanisms which allow them to set the seat precisely at the position most comfortable for the individual pilot.

The distances from the pilot's eye to the instruments in the overhead panel in the Boeing 767 ranges from 37 cm (15") to 65 cm (26"). Most pilots will sit at least 75 cm (30") from the front panel which puts them at least 90 cm (36") from the dials on the 1st officer's side. The 2nd officer has an engineering board to look at on the bulkhead directly in front which is probably 53 cm (21") away and he or she will also look at the dials on the front panels which could be 100 cm (40") +/− away.

Some aircraft have overhead dials which don't necessarily have to be read, eg. the Lockheed L-1011, while others like those in the 767 must be read. This will necessitate the placement of a bifocal in the upper portion of the lens.

In the author's opinion, the lineless bifocal will become more and more popular with the flying fraternity. Tests[2] are currently underway to determine how well they work in the cockpit. In his personal experience, the author has had varying results equal to those found in the normal population. Some claim to love them, others cannot adapt. Again it takes that special knowledge of one's patient which will determine the type of bifocal used. The switching of focal distances must be performed quickly, efficiently and comfortably. This makes the fitting of bifocals of extreme importance. In an emergency situation, a pilot cannot be hampered by a poorly fitted or designed optical correction.

Sunglasses

The tinted lens of choice is the gray #4 lens[4]. In this author's experience, it provides the best glare protection without altering the colour of the outside world and will probably maintain its popularity for years to come.

The varigray lens generally doesn't react well in the cockpit as enough ultraviolet light to affect the change will not penetrate the windshield.

Polaroid lenses will pick up windscreen striations and produce visual fatigue and some visual distortion.

When bifocals are worn, the author generally will recommend a tint in the upper portion of the lens, gray #4, leaving the bifocal area clear. This enables the pilot to read dials without having to use dial illumination in daytime.

Visual Enhancement

For years, professional auto racing drivers have made use of various forms of visual training to enhance their reflexes and thus their driving skills. More recently, a whole new specialty, sports vision, has evolved because of the optometrists' ability to upgrade an athlete's visual skills.

These same sports vision enhancement techniques can be used to help the aging pilot. The ability to react to outside visual stimuli and cockpit emergencies with speed and accuracy is essential for safe flight.

Minimums have been developed which can be used to give an approximation of the speed with which an action can be performed under optimum conditions. As the pilot ages, it is reasonable to expect that under stress situations he or she will react below these limits. Reaction time, however, can be enhanced with training. This can be done in the simulator and is the subject of a future paper under development by the author.

Future Cockpit Designs and their Relationship to the Visual System

The appearance of electronic flight displays are already changing the design and appearance of aircraft cockpits. Traditionally, dials display such parameters as speed, direction, altitude, etc. The Electronic Flight Instrument System, however, displays all this information on only a few cathode-ray tubes. This system already exists in the Boeing 767 and will be even more sophisticated in the advanced A 320 passenger transport.

Already in use in military aircraft, commercially we will soon have sophisticated computer-graphics systems which will collate data from on-board sensors and digital terrain maps to give a realistic three-dimensional view of the environment around the airplane[11].

A Heads-Up Display system will allow the pilot to keep his or her eyes fixed "up front" while still allowing other instrument information to be read as well. The information is displayed at eye level on a transparent screen (called a combiner) mounted on top of the console[5].

This Heads-Up Display unit is already being miniaturized and moved onto the pilot's helmet for use in fighter aircraft, thus widening the pilot's field of view. The screens are now closer to the eyes. The use of a combiner for each eye will present a pictoral stereoscopic display and it is only a matter of time before this system will be used in commercial aircraft.

Also scheduled for tests shortly is a system[11] which will simulate the scene outside the aircraft as well as show images of communications and navigation-control panels. The pilot will be capable of interacting with the display by issuing voice commands or pointing. This system consists of a computer linked to two small CRT's mounted on the pilot's helmet. An optical system actually projects the CRT's screen images onto the pilot's eyes to create a stereoscopic image. Sensors mounted on the helmet will enable the computer to plot the position of the pilot's head and thereby update the simulated scene accordingly.

Conclusion

Almost daily, practitioners have patients who use VDT's on the job complain about the effects experienced during CRT use. Granted, many of the complaints may be exaggerated but there are legitimate symptoms. Dry, burning eyes, headaches and after-image complaints do occur after prolonged use of the CRT set. These symptoms can be alleviated by frequently looking away from the set, work breaks, and reducing glare and reflections from the screen.

These problems, however, are not so easily solved in flight situations. Constant monitoring of the CRT screen will be essential for safe flight and if the screen or unit is placed very close to the eye, the pilot will be unable to find relief. The visual effects will have to be carefully monitored. In the meantime, dry eye symptoms which are common in the cockpit will have to be alleviated with artificial tears and/or cold compresses.

The use of contact lenses in the cockpit has been dealt with in other articles [1, 3, 6, 7, 9, 10, 12] and will not be discussed here. It is sufficient to note that, with the acceptance of the contact lens by the aviation community, optometrists will be sought out more often to deal with visual problems that arise in flight.

When aviation was in its infancy and "seat-of-the-pants" flying the "right stuff", good eyesight was prerequisite for safe flight. Technology, however, evolved the modern sophisticated flight deck with its load of instrumentation and multi-pilot systems. Monocular amblyopes and even one-eyed pilots are now being certified with no detrimental effects, up to the present time, being documented. With the advent of the futuristic cockpit with its multitude of CRT sets, Heads-up Display units and flight systems using stereoscopic optical devices, we will be forced again to choose aviators who have perfect vision.

As eye care professionals who will be dealing with more and more aviation personnel, optometrists must know the environment in which the pilot works so that we will be able to deal with the visual problems when he or she seeks consultation.

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