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Visual Fatigue Reduces Pilot Performance

Unimpaired vision is essential to safe flight, and visual fatigue is a common experience among pilots. The authors discuss prevention, recognition and treatment of visual fatigue, while reminding aviators that hinderances to vision are a liability in the cockpit.

by

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Physiological fatigue decreases the capacity of an organism to function normally. Excessive optical stimulation or prolonged visual exertion will produce fatigue of the visual system (especially the eye and the muscles that move it). The term "visual fatigue" refers to the inability of the visual system to maintain effective and/or efficient functioning.

Over-use and General Fatigue Cause Problems

Visual fatigue can accompany an overall generalized state of fatigue or it can result from over-use of the visual system. An evaluation of the state of visual fatigue includes: 1. individual sensations (subjective component) of fatigue; 2. intensity and duration of the visual workload; 3. physiological changes of the visual system related to visual over-use. These are described below by the respective number.

1. The subjective feeling of visual fatigue consists of sensations resulting from use of the eyes. These sensations include scratchy conjunctival tissue, blurred vision, double vision and orbital area headaches. Individuals, of course, vary in respect to the patterns of their visual fatigue sensations.

2. Sustained visual monitoring can, of itself, cause fatigue, as can highly demanding visual tasks. Certain flight operations demand high levels of visual workload, including long duration flights, flights during bad weather, night flights, and flights into the sun or haze. The occurrence of a significant malfunction during flight can make the visual task more demanding if the aircrew is required to increase visual monitoring.

3. The visual system can become temporarily modified during over-use. For example, an individual engaged in heavy visual work can experience transitory ocular motor impairment, causing recession of the near point of accommodation (focusing), slowed or delayed rates of accommodation, impaired extraocular muscle balance, and recession of the convergence and divergence near point (10).

Internal and External Factors Contribute

Individuals with certain eye disorders have an increased possibility of developing visual fatigue. These disorders include improper refractions, extraocular muscle imbalance and poor eye coordination. There are several self-imposed stressors that can increase individual susceptibility to visual fatigue during prolonged and/or demanding visual work. These stressors include sleep deprivation, medications (illegal, non-prescription and prescription), alcohol (including hangover effects), tobacco (including withdrawal), and an inadequate diet

(deficient in Vitamin A).

Human engineering (human factors) aspects that may cause inflight visual fatigue include windscreen craze and/or windscreen haze, improper illumination of the cockpit or instruments, presence of excessive light contrast and/or reflected glass, scratched or dirty instrumentation, inadequate cockpit environmental control (temperature extremes and humidity extremes), cockpit red lighting, and inappropriate sunglasses (note: some polarized glasses are incompatible with electrical windshield heat due to the alternating electric current applied to the windshield) and/or inappropriately corrected prescription glasses (5,7,10,11). In addition, it has been reported (6) that the use of certain CRT (cathrod-ray tube) displays can induce visual fatigue due to selective adaptation induced by the periodic spatial frequency component (2 to 6 cycles per degree) of these displays. The result is that the control of reflexive visual accommodation is lost, and viewers experience blurred vision and focusing difficulties (2,6).

Symptoms and Signs Vary

Visual fatigue symptoms include burning, scratchy, dry or painful eyes. The scratchy sensation is that of "sand in the eyes". Excessive tearing, blurred vision, double images (diplopia), "heavy" eyelids, frontal or orbital headache, and overall visual discomfort are also symptoms common to visual fatigue (4,6). These symptoms can be grouped under the category of "visual strain". Visual strain is a common problem among individuals whose work involves the use of detailed visual displays or any other machine or instrumentation that requires sustained visual monitoring (9).

Signs of visual fatigue include conjunctival congestion (red eyes) and "ocular motor" impairment. Ocular motor functions include accommodation (focusing), vergence. (convergence and divergence of the eyes), eye movements (smooth pursuit and saccadic), eye-blinking (frequency and amplitude), and pupillary response (constriction and dilation).

Operational Implications May Be Subtle

The most important consequence of visual fatigue of relevance to pilots is the possible inadequate perception and/or interpretation of in-flight visual information required to safely operate the aircraft. It is well recognized that one of the main tasks of aircrews flying modem aircraft is to perform continuous "visual monitoring"; therefore, pilots must be aware of the various aspects involved in visual fatigue in order that it can be prevented.

With the incorporation of the new multi-function video display monitors in the instrument panels of new civil aircraft, the visual monitoring task may become increasingly important to aircrews. Visual fatigue may, under certain circumstances, take on a new dimension. Since the symptoms resulting from visual fatigue produce discomfort, the consequence can be impaired performance (cognitive and psychomotor). As visual tracking and scanning are key functions constantly used during flight~ it is important to avoid visual fatigue to the extent possible. Ocular motor impairment resulting from visual fatigue generally leads to a significant decrease in eye-tracking performance (1). Visual tracking and scanning tasks under this circumstance are more difficult to maintain.

Accommodation of the lens of the eye can be impaired due to visual fatigue (8). Impaired visual accommodation causes the eye to overshoot or undershoot the target. Visual fatigue can produce a temporary recession of accommodation and vergence near points. This translates into a slowing of accommodation and loss of accommodative power (focusing to near distances) (3). Impaired accommodation and vergence affect a person's ability to quickly change focus from the instrument panel to the documentation (aeronautical charts, approach charts) and vice versa, as well as from the inside of the aircraft to the outside world.

Prevent It Rather Than Treat It

In order to eliminate individual predisposing factors to visual fatigue, it is important to make sure that any refractive error or any eye disease is corrected. The use of adequate corrective lenses and proper sunglasses is essential. It is also recommended that lenses be maintained free of scratches, and kept clean. The avoidance of self-imposed stressors (alcohol, tobacco, various drugs, and sleep loss, for example) is an important preventive measure.

In order to reduce visual strain, eyes can be rested by varying the viewing distance every few seconds or minutes (depending on the aircrew duties and other circumstances). Individuals who perform a moderate visual workload should take a 15-minute break after one to two hours of continuous work. Individuals performing high visual workload or a demanding repetitive task, should take a 15-minute break after one-half to one hour of work. If visual fatigue occurs during a flight, onboard rest (sleep) facilities can be utilized if the crew is augmented (12). Some reports have advocated slightly longer periods of work for non-aviation personnel (10). The use of various nonprescription soothing eye-drops may help to reduce certain symptoms. During night flight, the level of illumination of the cockpit and the instrument panel should enable the crew to read any information with visual comfort. It is important to obtain at least seven or more hours of sleep prior to undertaking highly loaded visual work.

Variables Gang Up To Impair Vision

Visual fatigue is a potentially hazardous condition adversely affecting a pilot's performance. It can impair the ability to maintain effective and efficient flying performance.

Visual fatigue may result from the interaction of multiple factors:

1. Individual variables such as fatigue tolerance, eye-system fitness, and self-imposed stressors

2. Operational variables that include work-rest schedules, multiple time zone dislocations, multiple take-offs and landings, short layovers, 24 hour layovers, night flight, and adverse weather

3. Human factors engineering variables that include the design, proper use and adequate maintenance of the cockpit environment and instruments

Visual fatigue can be self-diagnosed by recognizing its symptoms and signs. If, for example, when the eyes are closed and "rolled around", scratchiness occurs, visual fatigue is present. This is an effective test for visual fatigue, and is known as the "eye ball" test. The ideal solution to the problem is prevention.

If visual fatigue is occurring in flight, countermeasures should be taken as soon as possible for its control. These include the adoption of visual-rest periods (previously described), adequate sleep, and the avoidance of alcohol and tobacco. Visual fatigue represents a potential hazard during flight, since scanning for potential conflicting air traffic is slowed, as is instrument scanning.

Fortunately, visual fatigue can be avoided or minimized if crew members and operators have a proper knowledge of its prevention and/or recovery once it is present. •

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