Contemporary Issue

Effect of CRT displays on vision

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ABSTRACT

Vision in glass cockpit of modern aircraft like Air Bus 310, 320, Boeing 767, Vajra is dependent on the colour displays used. Prolonged viewing of CRT displays can cause visual problems like Bezold Brucke effect, chromatic aberration, chromatic induction, small field tritanopia, Helmholtz - Kohlrausch effect, Abney effect etc. A questionnaire study was conducted on 30 pilots, flying aircraft with CRT displays. Pilots have experienced some of these effects under certain illumination levels. The effects on vision was analysed and remedies to minimize these effects are suggested.

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KEY WORDS : Vision in flying, CRT displays

Vision consists of three faculties, the acuity of vision, the field of vision and colour vision. The colour vision faculty plays a significant role in the glass cockpits of modern aircraft. Colour provides a powerful extra dimension for information flow through the electronic display. Colour displays in aviation have become common due to the visual attraction and enhancement of information processing. Vajra, Air Bus 310 and 320 and Boeing 767 are the few aircraft, fitted with the multicolour CRT displays, More modern technology is introduced by way of LCD in the Boeing 777 aircraft. In the cockpit, pilots reported that cyan, white and green were the best of all the colours, as

they provide sharp, easily distinguishable images. Magenta was found to be harsh. Amber, blue, brown and red are the other colours used in the displays. Use of more than eight colours is not recommended and lesser number is advantageous.

Visual phenomena that are encountered on colour displays

Spatial and Temporal constraints: Reducing the presentation time of the colour less than 50 to 200 ms and or the angular subtense to less than 10-

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15 min of arc may severely affect its perception. Even colours with high intrinsic saturation like 440 nm and 620 nm were called white in 50% of the presentations.

Small field Tritanopia : A tritanope is a dichromat with blue deficiency. Blue colour has a low resolution in both space and time. Hence it produces a small field or short time tritanopia in the situation of temporal and spatial constraint.

Effect of retinal location: If a source of light is not fixed at the central fovea, but impinges on photoreceptors in the peripheral retina, the perceived colour will be different from that experienced in central vision. This is due to the decrease in the number of cones with increasing retinal eccentricity. This effect is similar to that of desaturation.

Effect of Luminance - Bezold Brucke effect:

A variation in the luminance of a coloured light will be accompanied by a change in the hue. The colours presented with high intensities will tend to look like equilibrium colours. Increasing the intensity of coloured lights with wavelengths greater than 510 nm, will shift the colour to yellow i.e., 570-580 nm and wavelengths shorter than 510 nm will shift the colour towards blue i.e., 470-480 nm If the perceived brightness of an orange light is reduced by surrounding it with a brighter background, the colour will shift in the direction of red. Yellow and blue are the equilibrium colours.

Helmholtz - Kohlrausch (H.K) effect: This effect is actually a demonstration of the failure of using luminance measures for predicting brightness. This manifests either with the end colour of spectrum i.e., led or violet or saturated colours. When the luminance is increased all the colours do not show equal brightness. The red and violet or the saturated lights show more brightness. The H-K effect may surprise the display designer who tries by matching luminance to obtain equal brightness of a set of differently coloured symbols.

Abney effect: Adding white light to a coloured light will make the colour of the latter appear to be desaturated or washed out. With this there will be shift in hue. Thus for a mixture of650 nm and white light, the hue shift would be in the direction of purple. To maintain the same redness as produced by 650 nm, the white light has to be mixed with 610 nm. This effect is to be considered in forming colour displays as variations in saturation would be accompanied by changes in the hue.

Chromatic induction : The perceived colour of a light may drastically change under the influence of adjacent colours in the field of view. The change in the hue will be in the direction of colour complimentary to the one producing the effect. It is affected in three different situations such as (a) simultaneous contrast, (b) successive contrast, (c) chromatic adaptation. White characters may appear yellowish or pinkish when surrounded by blue and this effect can be nullified by using more bluish white colour.

Assimilation : Von-Bezold spreading effect: When a coloured background is interlaced with a pattern of a different colour, one may observe that the background seems to be blended with the colour of the interlacing structure. For e.g. white and black alpha numerics seen side on a blue background may cause the background to appear as being divided into lighter and darker blue areas.

McCollough Effect : If the eye is exposed alternately to a horizontal grating of green and black and to a vertical grating of red and black for 5-10 mins, followed by a black and white test target consisting of a pair of juxtaposed vertical and horizontal grids. Then the vertical and horizontal white stripes will be perceived as green and red respectively as they are the complimentary colours to each other. This effect is not seen with equilibrium colours blue and yellow.

Fluttering hearts phenomena : If under dim illumination, a picture of red figure on green background or vice versa is oscillated perpendicularly to the line of sight, the red figure seems to become dislodged and move out of synchrony with the background. This was first demonstrated by Helmholtz using heart shaped figures. This effect can be mitigated by mixing colours that are less saturated and less different in spectral composition.

Chromatic aberration: It is an optical effect, where the visual display with colours is widely spaced, it is difficult for the eyes to readjust continuously over a range of 2 D because of different refractions depending upon wavelengths. The multicolour displays would put the accommodation system under stress. Hence in an ametropic pilot, an adequate and proper correction with glasses is imperative.

Colour stereoscopy: Different colours appear in different planes and red is seen nearer that blue and this is known as colour stereoscopy. This effect ;s related to the prismatic deviation and chromatic dispersion of the light by the human eye lens.

A comprehensive study was conducted on bO commercial pilots, half of them formed the test group flying glass cockpit aircraft and the other half formed the control group flying non-glass cockpit conventional aircraft. The aim of the study was to identify the effects if any of viewing of the CRT displays of glass cockpit on vision with respect to both visual acuity, refractive status and presence of various phenomena related to colours of display. An attempt was made to identify the factors that would contribute to these effects and methods to overcome these effects in the interest of flight safety.

Methods

The methodology consisted of gathering information in regard to problems of phenomenon related to viewing of colour display through questionnaire proforma, clinical ocular examination during renewal medical and perusal of medical documents containing medical reports since the time of initial induction of subjects to glass cockpit aircraft. It consisted of a combination of objective and subjective method.

Results

A total of ten pilots recorded asthenopic symptoms, five each of the control and test group. All of them were ametropic wearing unifocal or bifocal glasses. However the history suggested that the occurrence of asthenopia was related to long duration of night flights leading to visual fatigue. Six of the test group pilots reported experiencing the phenomena involving colour vision. The Abney effect was noticed by three pilots and the colour stereoscopy by two pilots. One of the pilots who reported Abney effect also reported to have experienced the chromatic induction when the luminance of the CRT displays

was bright. One pilot noted spatial and temporal constraints in a dimly lit cockpit in the night. All these six pilots were ametropic, five of them hypermetropic and one was presbyopic. All the subjects found dim illumination of CRT displays more comfortable especially at night and during daytime higher levels of illumination of the displays was found to be ideal. To prevent eye strain due to glare from the displays, the subjects felt that the dome light within the cockpit should be kept switched on during flight and could be switched off only during dusk to facilitate viewing of the runway lights. The clinical visual parameters and the perusal of medical case history of test group proved that there is no direct relationship between flying a glass cockpit and decreased acuity of vision.

Discussion

The study was aimed at identifying the problems in visual function in pilots of aircraft with CRT displays in glass cockpits. The variables considered included age, total flying hours, hours on type, number of years of spectacle wear and number of prescription changes since conversion to glass cockpit aircraft. A comparison of these variables for the test and the control group did not yield any statistically significant result. The asthenopic symptoms reported by some of the ametropic subjects were related to long hours of flight rather than to the colour displays. The colour phenomena enumerated were observed by only a few subjects. Abney effect was reported to occur during the day flight due to bright sunlight. The occurrence of other colour phenomena in ametropic aircrew were also related to either too bright or too dim illumination levels within the cockpit.

Conclusion

Due to the various phenomena related to the colour displays, firstly an appropriate optical correction in ametropic pilot is essential and secondly adjustment of cockpit lighting illumination from high to dim depending on the external lighting conditions would help to minimize the eye strain related to coloured displays.

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