COLOR OF VDT's AND THE EYE Green VDT's Provide the Optimal Stimulus to Accommodation†

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Abstract

The longitudinal chromatic aberration of the human eye is substantial and therefore the colour of the phosphor chosen for VDTs will affect refractive state and accommodative demand. For most working distances, green stimuli (λ max 520 nm) are optimal.

Abrégé

L'aberration chromatique axiale de l'oeil humain est significative. Ainsi le choix de la couleur du phosphore utilisé dans un écran cathodique influence l'état de réfraction et la demande sur l'accommodation. Le vert (λ max 520 nm) est l'ultime choix pour la plupart des distances de travail.

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The recent dramatic increase in the use of visual display terminals (VDTs) in a variety of occupations has led to concern over possible detrimental effects on the visual system. Apart from the issue of radiation damage to the eye, an issue which has attracted a number of largely unsubstantiated claims and counter claims, attention has centered on the relationship between VDT use and the eye's focussing mechanism; i.e. accommodation (Cakir *et al,* 1979).

The indirect nature of the primate accommodative mechanism and the fact that it deteriorates with age in adults is well documented (Donders 1864; Weale 1962). The visual comfort of VDT operators is in large measure dependent on ensuring that the working distances of both the display screen and the keyboard are within their accommodative abilities. In addition to the gradual loss of accommodation with age (presbyopia), Östberg (1980) has shown that the accommodative mechanism exhibits signs of fatigue after extended VDT operation.

Relatively recent work has emphasized the importance of the relationship between chromatic aberration of the eye and accommodation. Discovery of the fact that the eye's refractive state varies with wavelength is attributed to Newton (LeGrand 1967). A number of studies, carried out with a variety of psychophysical and objective methods (Wald and Griffin 1947; Ivanoff 1953; Bedford and Wyszecki 1957; Bobier and Sivak, 1978), have shown that the human eye's longitudinal chromatic aberration amounts to 1.00 - 1.50 diopters between the C and F Fraunhofer lines (486 - 656 nm). In fact, experimental measures of this aberration are larger than that expected from calculations because of the exaggerated chromatic dispersion of the crystalline lens, especially at the blue end of the visible spectrum (Palmer and Sivak 1981; Sivak and Mandelman 1982).

It is commonly assumed that a specific wavelength within the chromatic aberration interval is in focus on the retina. The wavelength chosen has varied from 555 nm, the peak of the photopic spectral sensitivity curve, to 589 nm, the sodium line (Emsley 1952). However, beginning with Ivanoff (1953), it has been shown that the wavelength in focus varies with the state of accommodation (Millodot and Sivak 1973). When the eye is unaccommodated (fixating a distant target) a wavelength of about 650 nm is in focus. When the eye accommodates for targets located at closer and closer distances to it, the wavelength in focus gradually shifts toward the short wavelengths (Fig. 1 and 2). It is believed that chromatic aberration thus extends the eyes' range of accommodation. At a distance of 0.5 m the wavelength in focus is about 520 nm (Fig. 2). The effect of these findings on refractive procedures and on the refractive state of the eye in spectrally limited situations such as the underwater environment has been noted (Sivak 1975, 1979; Bobier and Sivak 1978; Woo and Sivak 1979).

Typical phosphors listed by Cakir *et al.* (1979) emit maximally in the blue-green region of the visible spectrum. Even the white phosphor mentioned (P4) has short wavelength emission characteristics (λ max 460/560). According to Cakir *et al.* the choice of phosphor colour may be based on personal preference rather than on any scientific reason, provided of course that contrast and display clarity are ensured. Nevertheless, it is possible that subjective reports by operators indicating a preference for green (Östberg, 1980) are a result of the relationship between accommodation and chromatic aberration just described. For a working distance of 0.5 m it would appear that phosphors P1, P31 and P39 (λ max 525 - 520 nm) would be ideal. Blue phosphors eg. P11, λ max 460 nm) would induce a small amount of near-point myopia (fig. 1) if the operator accommodates by an amount normally appropriate for 0.5 m. Presbyopes wearing near-point corrections may be overcorrected. Any long wavelength stimuli will, of course, result in an excess of accommodative demand and presbyopes will be undercorrected.

The use of closed circuit television magnifying systems by thousands of legally blind patients is of related interest. Television magnifying systems are believed to be superior to optical low vision aids because they reduce peripheral aberrations and distortions as well as postural tension and they permit binocular viewing of highly magnified images (Mehr *et al*, 1973). Until recently, all the systems available used black and white television monitors. However, coloured monitors are becoming popular perhaps due to the provision of a better accommodative stimulus.

The foregoing is meant to draw attention to the fact that the human eye suffers from a significant amount of chromatic aberration. The question of the portion of the visible spectrum in focus on the retina should be taken into account in the design and testing of video display terminals or any situation involving chromatic panel lighting.

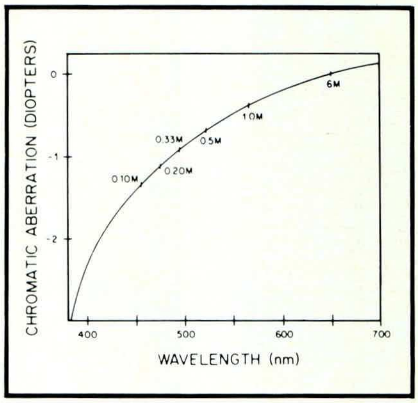
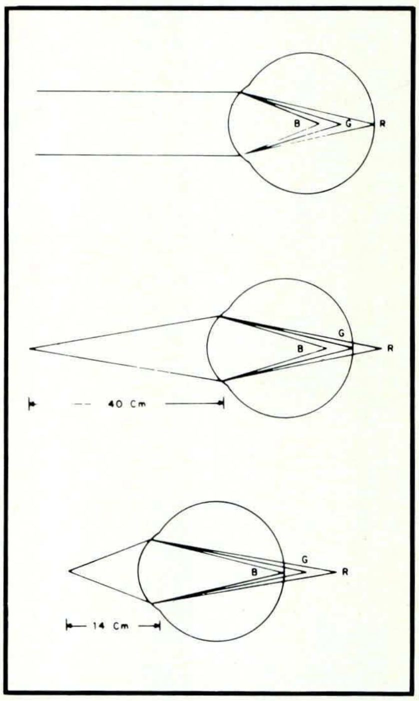


Fig. 1 Axial chromatic aberration of the human eye (adapted from LeGrand, 1967). The points on the curve indicate the wavelengths in focus for fixation distances varying from 6 meters to 0.10 meters. (after Millodot and Sivak, 1973).

Fig. 2 Schematic representation of the eye and the focal conditions of red (R), green (G) and blue (B) portions of the visible spectrum, for infinity and two finite distances.



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