The Digital Film Viewer: A Novel Technology for Optimizing Film-Based Radiology

D Inbar and AR Sohval

RATIONALE FOR IMPROVED FILM VIEWING CONDITIONS

The diagnostic imaging chain is remarkably unbalanced (Fig 1). Modern radiology departments generate high quality films using state-of-the-art x-ray equipment, screen-film combinations, and quality film development. However, at the final link in the imaging chain, these films are read on a conventional viewbox, a device virtually unchanged for the last 100 years, which bleaches out 50% or more of the gray levels recorded on film. Compromised viewing conditions cause visual fatigue, impair diagnostic accuracy, and result in lower productivity.

The Digital Film Viewer (DFV) developed at the SmartLight Research Laboratories is an innovative device which uses digital optronic technology, based on the psychophysical principles of human vision to optimize film viewing conditions. Adaptive optics and automatic digital masking help reveal details hidden on the film and enhance lesion detectability. The DFV is the only system which automatically ensures compliance with MQSA, EC 96 and DIN quality standards and guidelines for radiographic film viewing.

OVERCOMING THE FIVE PRINCIPAL DEFICIENCIES OF THE CONVENTIONAL VIEWBOX

Illumination Level

Problem. Human visual perception is optimized at illumination levels in the range of 50–500 nits¹ (Fig 2). Intensities below this level fail to adequately stimulate the cone photoreceptors. Higher intensities cause intra-ocular scatter. Conventional viewboxes have a fixed intensity, typically 1,500 nits, and do not cope well with films of

varying optical density, resulting in degraded lesion detectability.

Solution. The Digital Film Viewer automatically senses the optical density of the clinical image and adjusts the light intensity accordingly, to optimize illumination level. With a variable backlight output range of 500–10,000 nits, the Digital Film Viewer accommodates a much wider latitude of film densities than a conventional viewbox.

Color Temperature

Problem. Day (cone) vision peaks in the yellow-green spectrum, while night (rod) vision peaks toward the blue (Fig 3). Recent research in the lighting industry² demonstrated that visual acuity is optimized when the color spectrum is matched according to intensity (film density). This is the same reason why yellow highway lighting of the 1960s has been replaced with the bluer-whiter lighting in the 1990s. The conventional viewbox has a fixed color spectrum which compromises visual acuity.

Solution. The DFV automatically color shifts the spectrum toward the blue for denser clinical images, enabling use of both photopic and scotopic vision systems for greater lesion discernability.

Glare

Problem. Uncontrolled glare emanating from the periphery of the film on the conventional viewbox causes two major problems:

1. glare forces the cone photoreceptors in the eye to adapt to a brighter illumination level, making it harder to discern subtle contrast differences (Fig 4), and
2. glare scatters within the eye and causes low level fogging of the retina, much like x-ray scatter on film (Fig 5). This glare effect worsens with age.³

Solution. The DFV senses the size and location of the film and digitally masks the film to automatically eliminate extraneous glare. Masking eliminates visual fatigue and significantly enhances contrast perception and lesion detectability (Table 1).

From SmartLight Ltd., Haifa, Israel; and SmartLight Inc., Hackensack, NJ.

Address reprint requests to A. Robert Sohval, PhD, SmartLight Inc., 241 Main St., Hackensack, NJ 07601.

Copyright © 1998 by W.B. Saunders Company
0897-1889/98/1103-1059\$8.00/0

Fig 1. The unbalanced imaging chain.

Fig 2. Human vision (both spatial resolution and contrast resolution) is optimized at illumination between 50-500 nits. Data from Hill.¹

Fig 3. By spectral shifting toward the blue for denser films, the DFV enables use of both photopic and scotopic vision systems, improving lesion detectability.

Fig 4. A cone receptor's electrical signal output response for a given light stimulus depends on its light adaptation level. Masking extraneous glare significantly increases perceived contrast and lesion detectability.

Table 1. Masking Extraneous Glare Allows the Cone Photoreceptors to Adapt to a Lower Brightness Level, Improving Contrast Perception

	Unmasked	Masked
Lesion Brightness (nits)	90	90
Surrounding Tissue Brightness (nits)	100	100
Eye Adaptation Level (nits)	1,000	100
Actual Lesion Contrast	10%	10%
Perceived Lesion Contrast	1%	10%

Optical Scatter in the Film

Problem. The light emanating from the faceplate on the front of the conventional viewbox emerges in all directions. Much of it scatters within the film before reaching the eye,⁴ reducing contrast by up to 40% (Fig 6).

Solution. The DFV incorporates a micro-optic array to project a coned beam of light in the forward direction toward the reader. Reducing the

scattered component of transmitted light improves contrast perception and lesion detectability.

Ambient Light

Problem. Film reading is optimized with an ambient light level of about 50 lux.⁵ Excessive ambient light has an effect similar to glare and impairs lesion detectability. A totally dark room causes the pupils to dilate which, due to optical aberrations, degrades visual acuity.

Solution. The DFV automatically dims ambient room light during film reading to be at or near the optimal operating point (Fig 7).

DFV VS. CONVENTIONAL LIGHT BOX—LESION PERSPICUITY

Initial results based on a sampling ten readers divided into two different age groups have been analyzed.⁶ Older readers (average age 45) signifi-

Fig 5. Extraneous glare scatters within the eye, causing retinal fogging and lowering contrast perception. Data from Bourma.³

Fig 6. The light emerging from the front diffuser plate on the conventional light box scatters in the film before reaching the observer. A micro-optic array in the DFV projects light in the forward direction, reducing film scatter and improving lesion detectability.

Fig 7. The DFV controls ambient light to optimize visual acuity and contrast perception.

Fig 8. Lesion detectability with the DFV was significantly higher than a conventional viewbox, especially for older readers (age 45). The DFV compensated for age-related deterioration in visual acuity due to glare.

cantly under-performed younger readers (average age 25) using the conventional viewbox. The DFV dramatically elevated lesion detectability and compensated for the age-related deterioration in visual acuity due to glare (Fig 8).

THE DIGITAL FILM VIEWER—HOW IT WORKS

The DFV combines adaptive optics and automatic digital masking to optimize the conditions for viewing x-ray film, based on the psychophysical principles of human vision (Fig 9).

Fig 9. The Digital Film Viewer.

At its heart is a high resolution, artificial vision system which senses the size, location, and density patterns on the x-ray film. The system uses an array of computer-controlled electro-optical modulators to digitally mask the film according to the clinically

relevant area, adjust the illumination intensity and chromaticity, and dim the ambient room light level for maximum visual acuity. A micro-optic beam former shapes the light emerging from the viewer.

REFERENCES

1. Hill CR: Perception and Interpretation of Images. pp 567-583
2. Berman SM, Liebel B: Essay by Invitation. LD + A Nov: 12-17, 1996
3. Bourma H: Institute of Visual Perception. 1967
4. Abilgaard A, Notthellen JA: Increased contrast when viewing radiographic images. Radiology 185:475-478, 1992
5. Schober H: Allgemeine physiologische grundregeln fur die detailwahrnehmung im rontgenbild, in Stieve FE (ed): Bildgute in der Radiologie. Stuttgart, Gustav Fischer Verlag, 1966, pp 122-134
6. Eisenberg RL: private communication. January 1998