On the optimal luminance transfer function in television

ON THE OPTIMAL LUMINANCE TRANSFER FUNCTION IN TELEVISION

J.J.Andriessen

introduction

In television the luminance transfer function is defined as the relationship between the luminances in the scene to be transmitted and the luminances of corresponding points in the TV picture. In designing the camera and monitor (receiver) system a linear relationship for a wide range of luminances is aimed at. Hence the luminance transfer function is a straight line with a given slope (Fig. 1).

The coefficient of slope is defined as $\gamma = \tan \alpha$.
One would assume the most logical value to be $\gamma = 1$, i.e. the luminance relations in the scene are reproduced identically on the TV picture tube. There are a few aspects of watching television necessitating a somewhat larger value of γ. One important factor is the relatively small luminance range attainable on the picture tube. Another important factor is the fact that watching television often occurs at night with a relatively low surround luminance.
In the following these aspects will be discussed briefly on the basis of literature. The discussions are only related to stationary pictures.

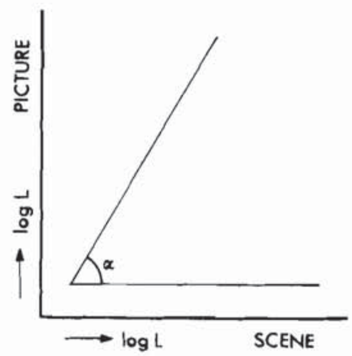

Fig. 1. The relationship between the luminance in the TV picture and that in the scene.

monochrome television

In a number of publications the value of γ is discussed. Grosskopf (1963) states that a 1 : 1 relative luminance transfer of the "middle greys" is essential in order to get optimal TV pictures. So for this range of luminances $\gamma = 1$. His TV pictures were watched within a light surround of, on the average, equal luminances as that in the picture. Bartleson and Breneman (1967a, b) concluded from their experiments that $\gamma \simeq 1.2$ for TV pictures watched in a relatively dark surround. Indeed, a $\gamma > 1$ seems to be plausible because of the fact that the luminances on the picture tube generally will be lower than that in the original scene. As a result of this, some loss of brightness contrast can result. This loss of contrast can be compensated by a higher luminance contrast on the picture tube, achieved with a $\gamma > 1$.

luminance level of the surround

Grosskopf (1963, 1966) and Bartleson and Breneman (1967a, b) discuss the influence of the luminance level of the surround to the picture tube. The luminance of the surround is an important factor, because the state of adaption of the retina is largely influenced by it. The state of adaption of the retina has significant consequences for the brightness perception of details on the picture tube. From the experiments of Bartleson and Breneman (1967a) it appears that the brightness estimates of image points in photographic reproductions with a light surround follow a steeper function than those with photographic reproductions in a dark surround. The experiments of Jameson and Hurvich (1961) show corresponding results.

Here, the subject had to adjust the luminance of a matching field in order to match the brightness of a testfield the surround of which could have a number of luminance levels. At a high level of surround luminance the adjusted matching field luminances followed a steeper function than at a low level of surround luminance. Consequently, watching television with a dark surround requires a larger value of γ than with a light surround to compensate for the then resulting limited contrast range.
A value of $\gamma \simeq 1.2$ as found by Bartleson and Breneman (1967 a, b) is certainly acceptable. For TV pictures with a light surround $\gamma \simeq 1$ may be sufficient. An important condition is here that the optical density of the monitor screen is such that incident light scarcely affects the luminance contrast in the picture (Grosskopf, 1963; 1966).

colour television

In colour television perception problems are still slightly more complex. As a result of the generally somewhat lesser sharpness of colour pictures compared with that of monochrome pictures, the brightness contrasts appeared to be lower (Bartleson, 1968). Secondly, the maximum luminance which can be realised on the picture tube is smaller than that of the monochrome picture tube, which may involve some loss of brightness contrast. In order to counterbalance these aspects the value of γ for colour television should be somewhat larger than that for monochrome television. A value of $\gamma \simeq 1.3$ appears to satisfy (Wood and Sproson, 1971).
An essential point here is the similarity of the three colour channels with respect to luminance output. Any dissimilarity will be particularly of influence in the lower range of luminances with the effect of a more or less colouring of the dark greys (Grosskopf, 1967).

summary

The luminance transfer function of a television system is generally represented by a straight line in a log-log plot of luminance in the original scene and luminance on the picture tube. The coefficient of slope is γ. The value of γ is discussed on the basis of literature. An important parameter appeared to be the luminance of the surround to the picture tube. For monochrome television and a dim surround $\gamma \simeq 1.2$. For colour television γ has to be somewhat larger, $\gamma \simeq 1.3$ seems satisfactory.

references

Bartleson, C.J. (1968) Color Perception and Color Television, Journal of the SMPTE 77, 1-11.

Bartleson, C.J. and Breneman, E.J. (1967 a) Brightness Perception in Complex Fields, J.O.S.A. 57, 953-957.

Bartleson, C.J. and Breneman, E.J. (1967 b) Brightness Reproduction in the Photographic Process, Photographic Science and Engineering 11, 254-262.

Grosskopf, H. (1963) Richtwerte zur Einstellung optimaler Bedingungen für die Betrachtung von Fernsehbildern, NTZ, Heft 1, 35-39.

Grosskopf, H. (1966) Experimentelle Analyse der Halbtonwiedergabe im Fernsehen, Rundfunktechn. Mitteilungen 10, 226-246.

Grosskopf, H. (1967) Vergleich der Elektro-Optischen Übertragungseigenschaften bei Schwarzweiss und Farbe. Rundfunktechn. Mitteilungen 11, 286-294.

Jameson, D. and Hurvich, L.M. (1961) Complexities of Perceived Brightness, Science 133, 174-179.

Wood, C.B.B. and Sproson, W.N. (1971) The Choice of Primary Colours for Colour Television, BBC Engineering 85, 19-36.