A Linearized Model for Flicker and Contrast Thresholds at Various Retinal Illuminances

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Abstract

Watson and Ahumada (1992 SID) predicted flicker thresholds for bright displays using a temporal contrast sensitivity function (TCSF). Under the assumptions that the falling limb of the TCSF is linear at all retinal illuminations and that the Ferry-Porter law can be extended to supra-threshold levels, the thresholds for any of the three variables (frequency in Hz, log10 contrast, and retinal illuminance in log Trolands) can be predicted from the other two from a linear model with four parameters.

Using the temporal contrast sensitivity function (TCSF) of Watson (1986) based on a gamma function impulse response, Watson and Ahumada (1992 SID Meeting Proceedings) provided a formula for predicting wide-field flicker thresholds. Here we provide simple linear formulas for predicting thresholds for sinusoidally flickering uniform fields.

We noticed that the falling limb of the TCSF is very nearly linear in the plot of log threshold contrast versus temporal frequency in Hz. Also, the Ferry-Porter law says that the flicker threshold is a linear function of retinal illumination in log Trolands. The assumption that the TCSF linearity holds for all illuminations and that the Ferry-Porter law holds at all log levels above threshold, we find that the thresholds for any of the three variables (frequency in Hz, log10 contrast, and retinal illuminance in log Trolands) can be predicted from the other two from a linear model with four parameters.

For example, predicting threshold frequency f(C,T) in Hz from log10 contrast C and log10 Trolands T, we can specify the four parameters as P =[f(0,3), f(-1,3),f(0,0), f(-1,0)]. Then

$$f(C,0) = f(0,0) + (f(-1,0)-f(0,0))\, C,$$

$$f(C,3) = f(0,3) + (f(-1,3)-f(0,3))\, C,$$

$$f(C,T) = f(C,0) + (f(C,3)-f(C,0))\, T/3.$$

De Lange (1958) measured flicker thresholds in Hz for a range of different frequencies and illuminances in the falling limb of the TCSF. For his observer L, the estimated P=[61.3, 46.1, 23.8, 10.7] and the RMS error in the predicted thresholds is 1.4 Hz.

References

De Lange, H. (1958). Research into the dynamic nature of the human fovea-cortex systems with intermittent and modulated light. I. Attenuation characteristics with white and colored light. *Journal of the Optical Society of America, 48*, 777-784.

Watson, A. B. (1986). Temporal Sensitivity. In K. Boff, L. Kaufman & J. Thomas (Eds.), *Handbook of Perception and Human Performance*. New York: Wiley.

Watson, A. B., Ahumada, A. J. (2011) Flicker Visibility: A perceptual metric for display flicker. Proc. SID.