TEMPORAL VISION PHENOMENA

AUTHOR

Thomas Salmon: Northeastern State University, USA

PEER REVIEWER

Scott Steinman: Southern California College of Optometry, USA

THIS CHAPTER WILL INCLUDE A REVIEW OF:

- Basics of temporal vision
- Phenomena associated with temporal vision

BASICS OF TEMPORAL VISION

Temporal vision deals with the way the visual system perceives changes in luminance as a function of time and is characterized by the **temporal modulation transfer function (TMTF)**. The basic stimulus used to study temporal vision is a *flickering light* whose luminance varies *sinusoidally* over time. Two important parameters describe the flickering light stimulus, and these can be varied to measure the person's temporal MTF:

Amplitude of modulation — the difference between the maximum or minimum luminance from the mean. From this you can compute **the percentage depth modulation**, which is referred to as **temporal contrast**

Temporal frequency in **Hertz** (cycles/second)

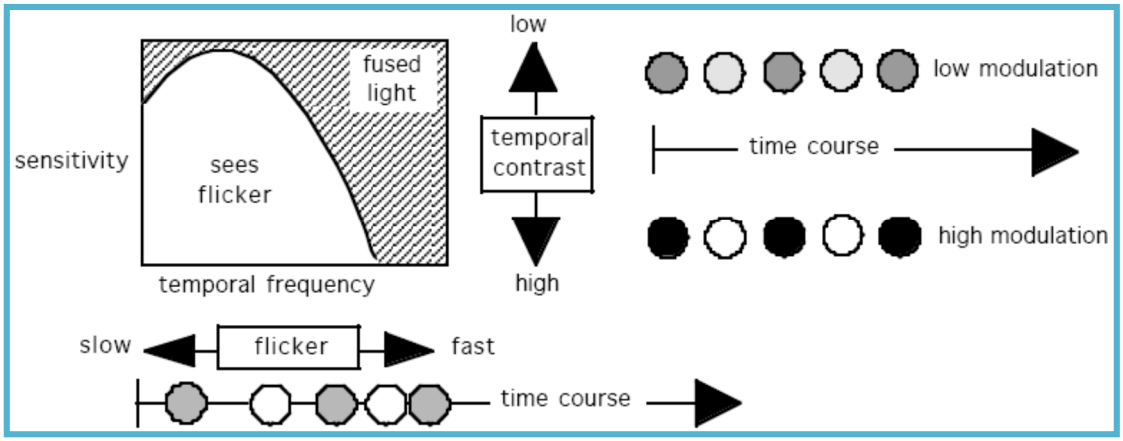

Figure 19-1: *The TMTF plots the limits of the ability to perceive flicker for various frequencies (x-axis and modulations (y-axis). High and low frequencies and high and low modulations are illustrated.*

BASICS OF TEMPORAL VISION (CONT.)

Figure 19-1 illustrates the general features of the TMTF and how the stimulus changes depending on its modulation and frequency. The TMTF looks similar to the CSF. The area within the TMTF indicates values of frequency and modulation for which flicker can be seen. Outside the function (shaded region), frequency is too fast and/or modulation too low for the eye to perceive the flicker, and the light appears steady. As with the CSF, the function has maximum sensitivity for mid-range frequencies; sensitivity drops off at high and low frequencies.

Q. What is the CFF?

A. _____

PHENOMENA ASSOCIATED WITH TEMPORAL VISION

Schwartz, 2004 Fig. 8-8 shows how the temporal MTF changes with increasing retinal illumination. There is a general increase in sensitivity with greater retinal illumination. Note that the increased sensitivity is particularly marked at high frequencies.

The **Ferry-Porter law** states that the CFF (100% modulation, high frequency cut-off) increases nearly linearly with the log of the background illumination. The bottom part of Schwartz Fig. 8-8 illustrates the Ferry-Porter law. Note the log scale on the x-axis, linear scale on the y-axis. Also notice that the cones have a higher CFF, so they can detect rapid flicker better than the rods.

The **Granit-Harper law** states that the CFF increases linearly with the log of the stimulus area. Therefore, it's easier to detect a flickering target if it's large. The reason for this is that large targets fall onto more of the peripheral retina, and it is more sensitive to flicker and motion.

The **Broca-Sulzer effect** (phenomenon) states that a light with fixed luminance and duration of 50-100 msec will appear brighter than if it were left on for a shorter or longer time.

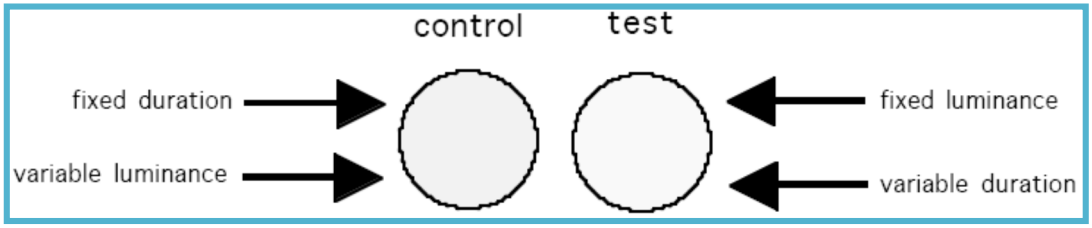

Figure 19-2: *Experimental set-up for the Broca-Sulzer effect, Brücke-Bartley effect and Talbot-Plateau law.*

Figure 19-2 illustrates how you could test this with an experiment:

- Present the test light for a predetermined duration, for example, 10 msec
- Subject must adjust the control light luminance until they appear equally bright
- Repeat for other durations of the test light. Data plots as shown in Figure 19-3

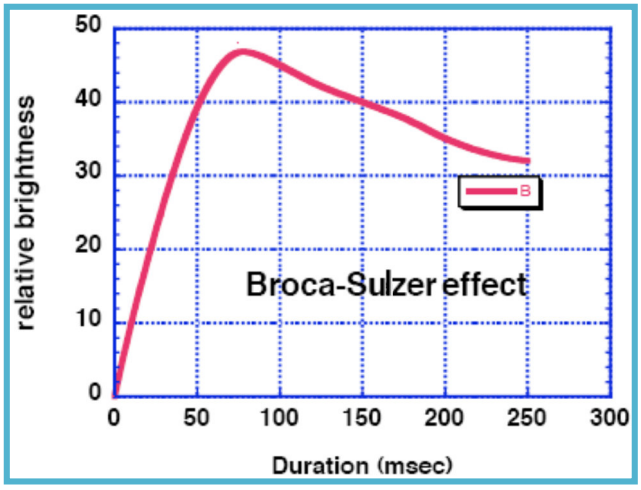

Figure 19-3: Broca-Sulzer effect

The plot is similar to Schwartz, 2004 Fig. 8-9. It shows that light appears brightest if it is left on for about 75 msec, though luminance is constant for all durations.

The Broca-Sulzer effect holds for a broad range of conditions:

- Dark and light adaptation
- All areas of the retina
- All colours

What accounts for the Broca-Sulzer effect? Some scientists thought it was due to the time course of ganglion cell action potentials (Fig. 8-9B,C). Schwartz specifically points out that this is not the correct explanation. It is due to some neural processing, but the exact explanation is unknown.

BRÜCKE-BARTLEY EFFECT (BRIGHTNESS ENHANCEMENT)

Set up an experiment like that described above (Broca-Sulzer effect), except make the test light flicker (Fig 19-2).

- The test variable will be frequency rather than duration
- Adjust the control light luminance to match apparent brightness
- At about 10 Hz, the flickering light appears brighter than a steady light of same luminance

This is called the Brücke-Bartley effect and is based on the Broca-Sulzer effect (Schwartz Fig. 8-11). A light that is flashed on for a duration of 50-100 msec appears brighter than if it is kept on for either a longer or shorter duration. A 10 Hz flicker is equivalent to an on-off cycle of 0.1 sec or 100 msec. This means that the light is on for ~50 msec; according to the Broca-Sulzer effect a light that is flashed for this duration looks brighter. Note that flicker is still visible at this frequency.

TALBOT-PLATEAU LAW

Use the same experimental set-up as for the Broca-Sulzer and Brücke-Bartley effects (Fig 19-2):

- Increase frequency to make the flicker exceed the CFF
- The light now appears to be steady
- It also looks dimmer. The apparent brightness is equal to the time averaged brightness of a steady light. That is, if the luminance profile of the flickering light is a square wave with the light on and off 50% of the time, it will appear half as bright as a steady light with the same “on” luminance

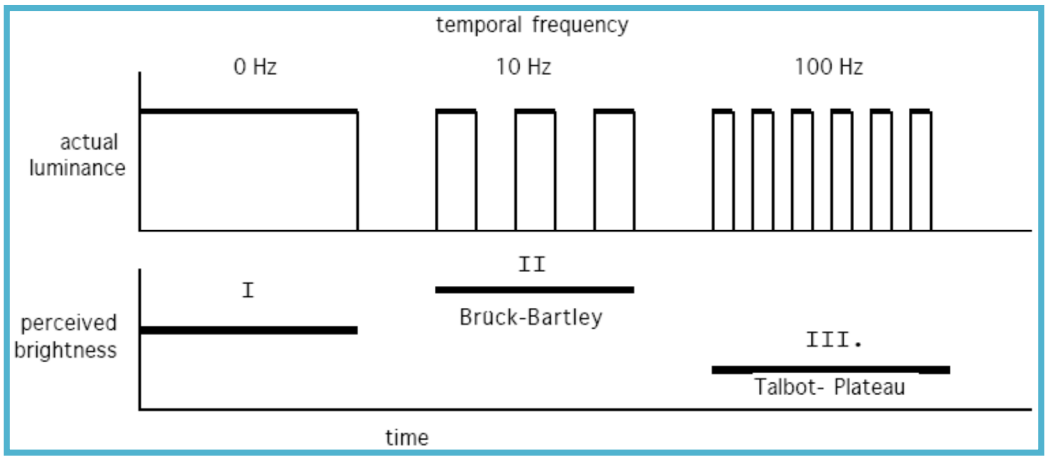

Figure 19-4: *Comparison of the Brücke-Bartley effect and Talbot-Plateau law*

In Figure 19-4, Section II illustrates the Brücke-Bartley effect; Section III illustrates the Talbot-Plateau law.

SELECTED READING/REFERENCES

- Schwartz SH. **Visual Perception - A Clinical Orientation, 3rd Edition**. Appleton & Lange, Stamford, Connecticut, 2004