How do we measures visual response to light?

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Measuring our vision response to light is a fundamental step in both psychophysics and physiology. But the different ways we measure the visual response gives us different response functions (e.g. lightness = cube root; receptors = logarithmic). Natural Scenes with nonuniform illumination generate very High-Dynamic Ranges (HDR) of scene luminances. This talk describes how intraocular glare transforms scene luminances into very different retinal luminance. Next, we report observers match to a variety of different ~ 6 log10 unit complex test targets. Then, it analyzes our visual response function using the quanta catch of receptors as input, observer matches as output. The results show that different HDR scenes have substantially different input/output visual response functions. The paper concludes with a summary of the visual mechanisms that give different responses to the different light distributions (scene content) in different scenes. Visual response functions vary in different parts of a single HDR scene.

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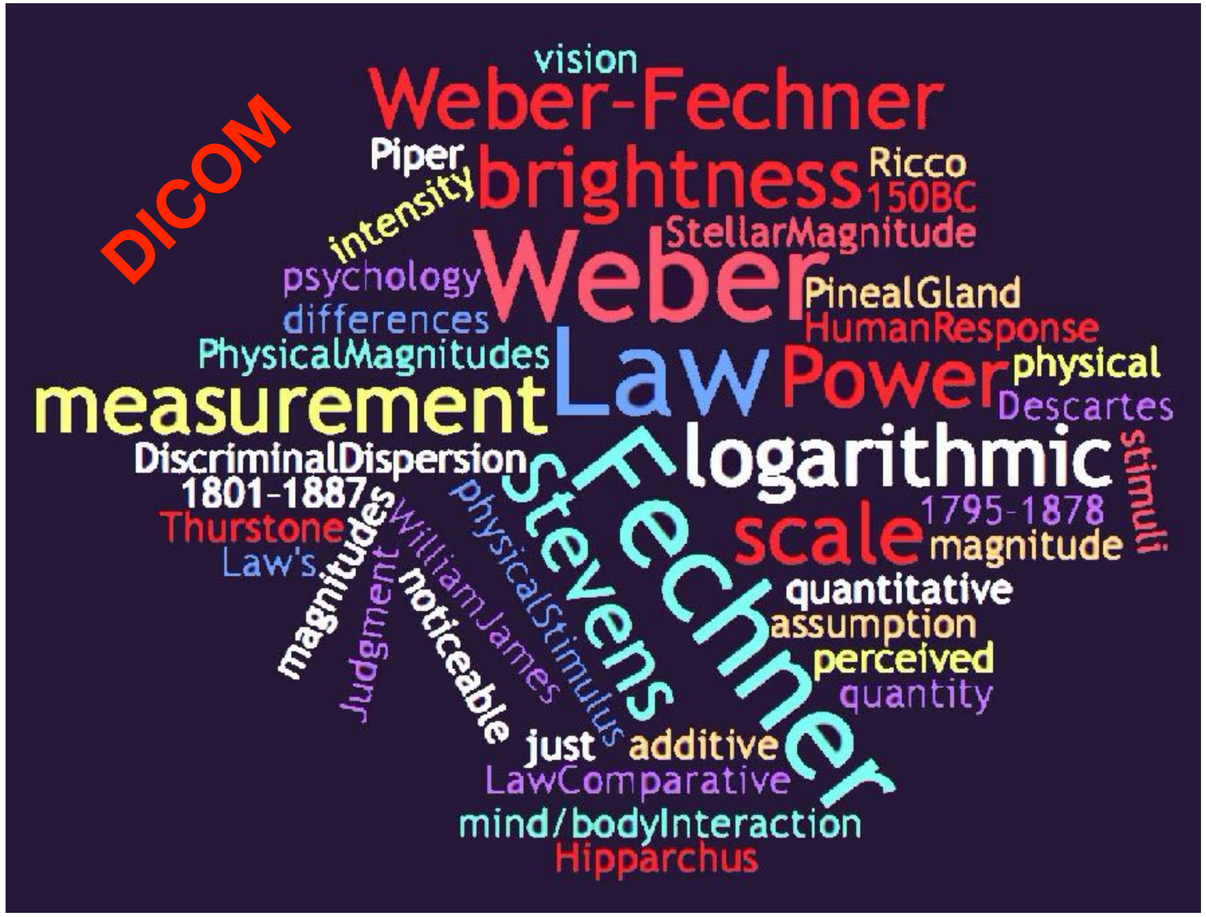
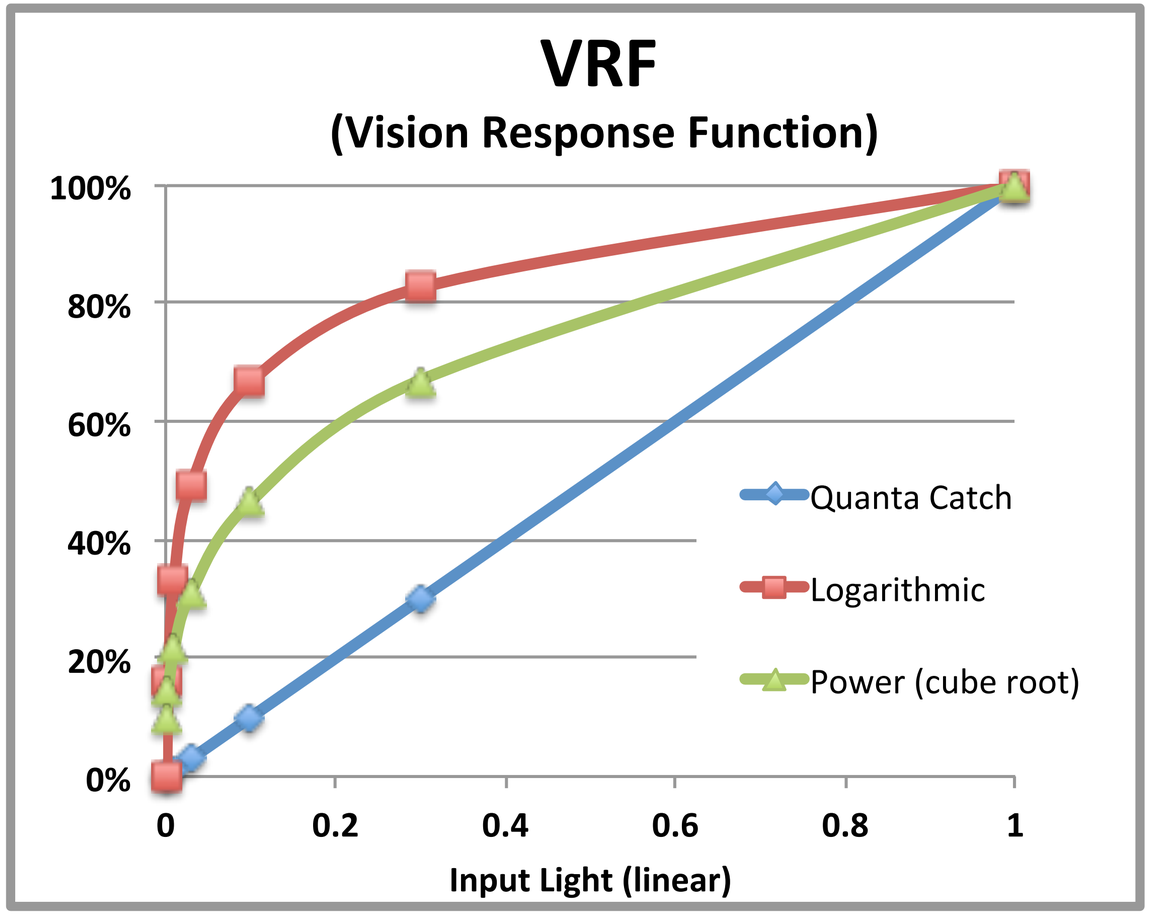
First step:
Response to a simple stimulus

What is Vision's Response Function (VRF) to light?

Psychophysics
Light → VisualResponse

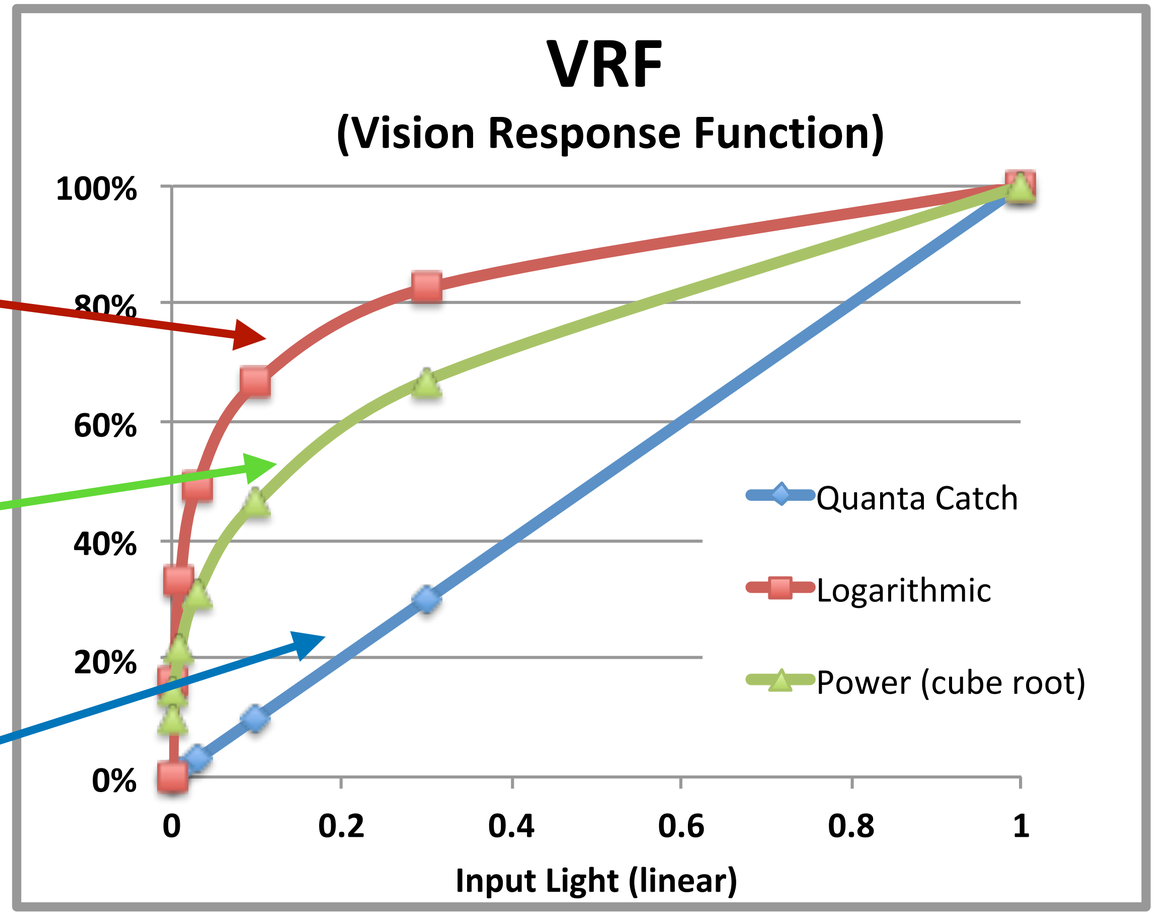




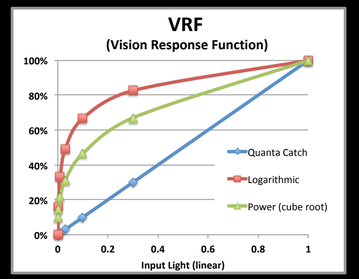
CIE L*

Retinal Receptor Response

Cone Quanta Catch (Opsin)



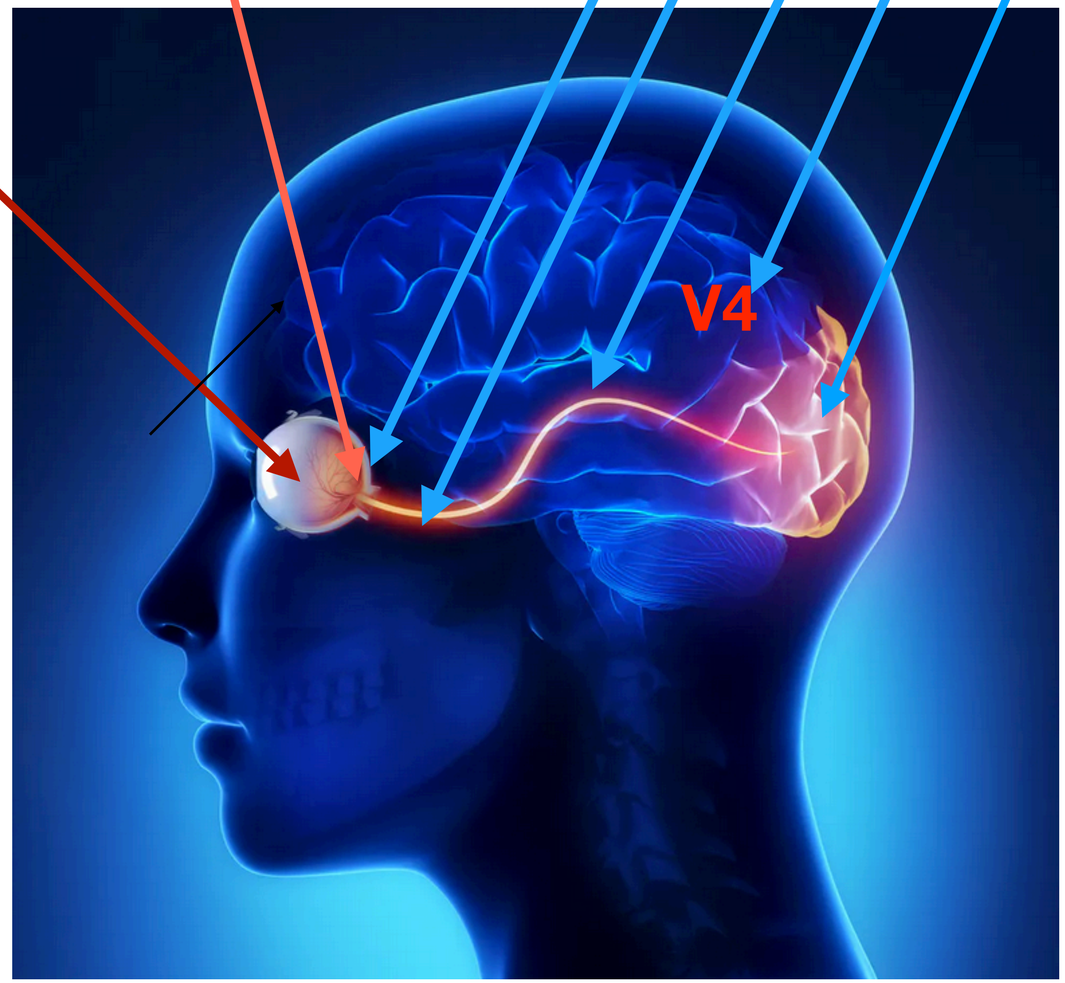
$$\text{Appearance} \neq f(\text{Scene}_{x,y})$$



$$\text{Appearance} = f(\text{Entire Scene})$$

SCENE → *Optical Glare* → *Quanta Catch* → *Neural Spatial Comparisons*

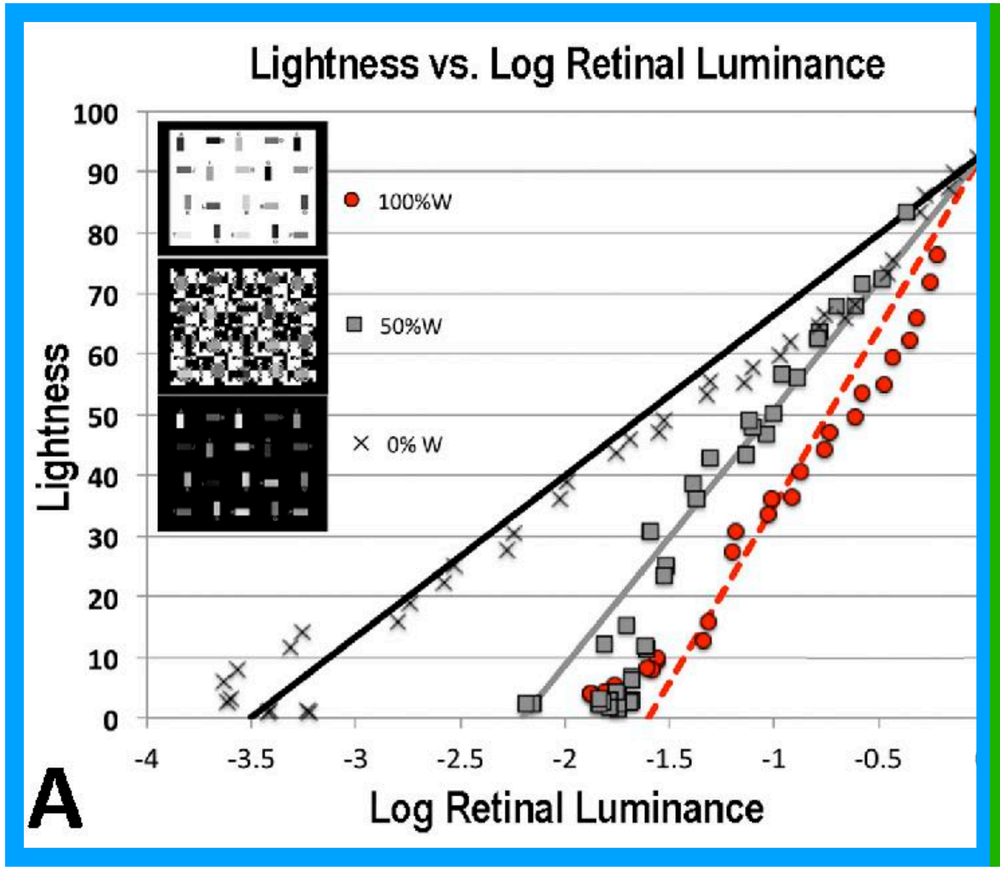
SCENE → Optical Glare → Quanta Catch → Neural Spatial Comparisons



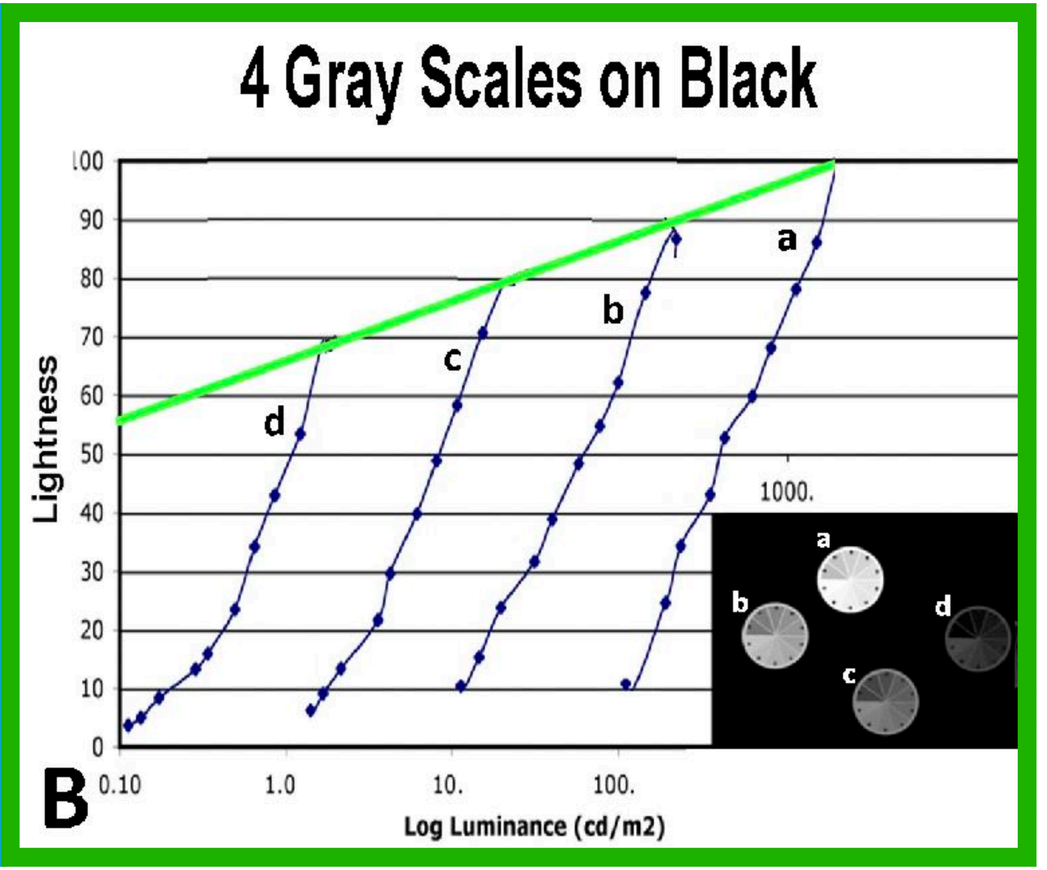
Second step:
Response to a complex stimulus

What is Vision's Response Function (VRF) to light?

A. DIFFERENT SCENE, DIFFERENT VRF



B. LOCAL RESPONSE

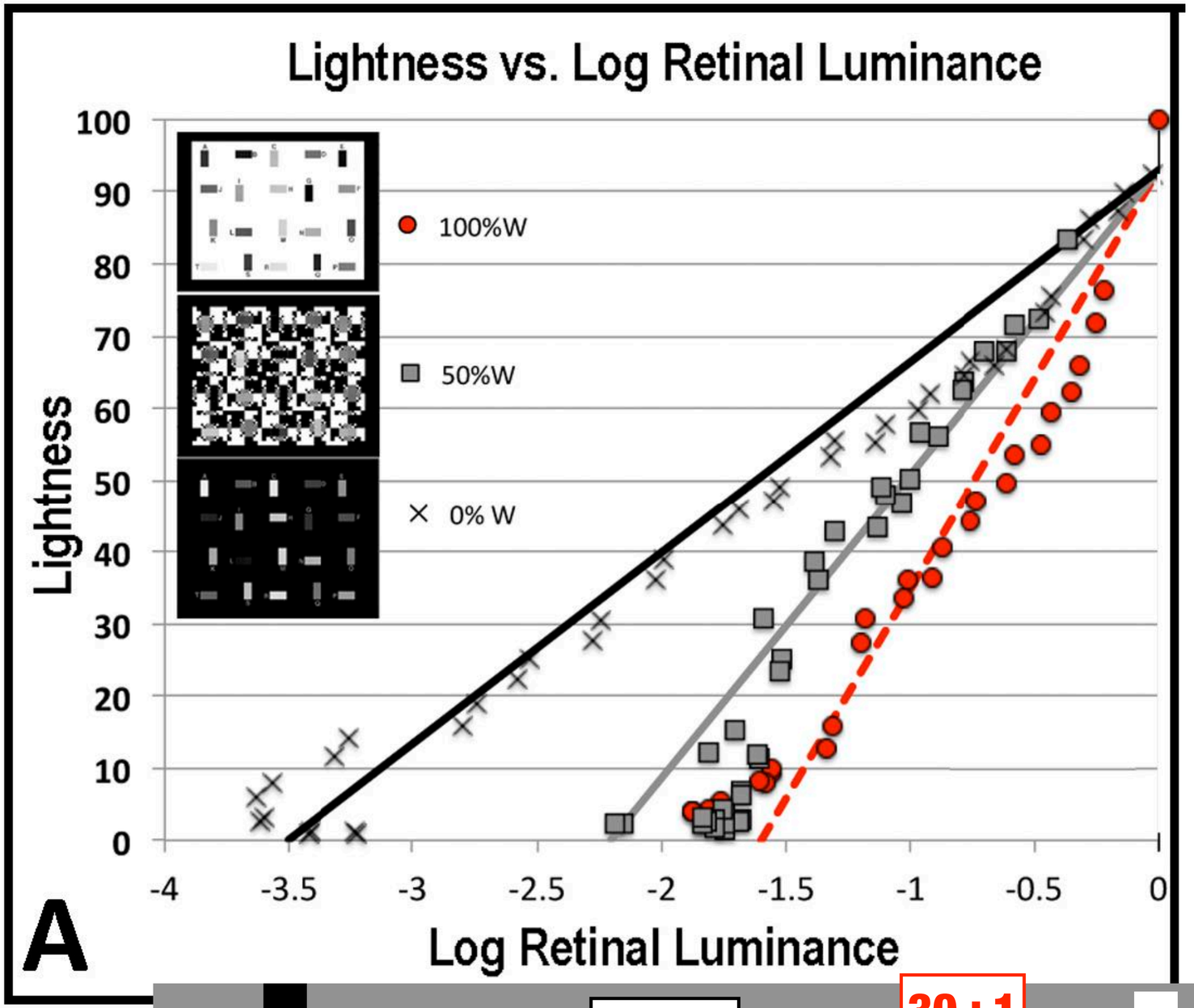


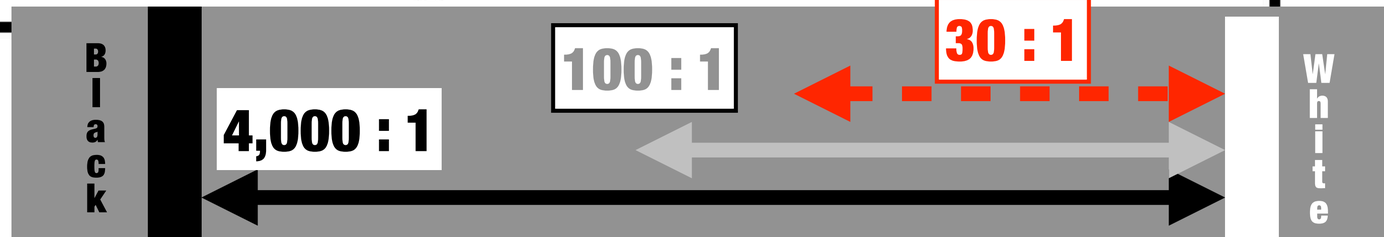
Different scene
Different visual response

3 HDR Scenes
Input Range ~10^6

Observers
Match Lightness

Scene Content
sets
slope of Log Response

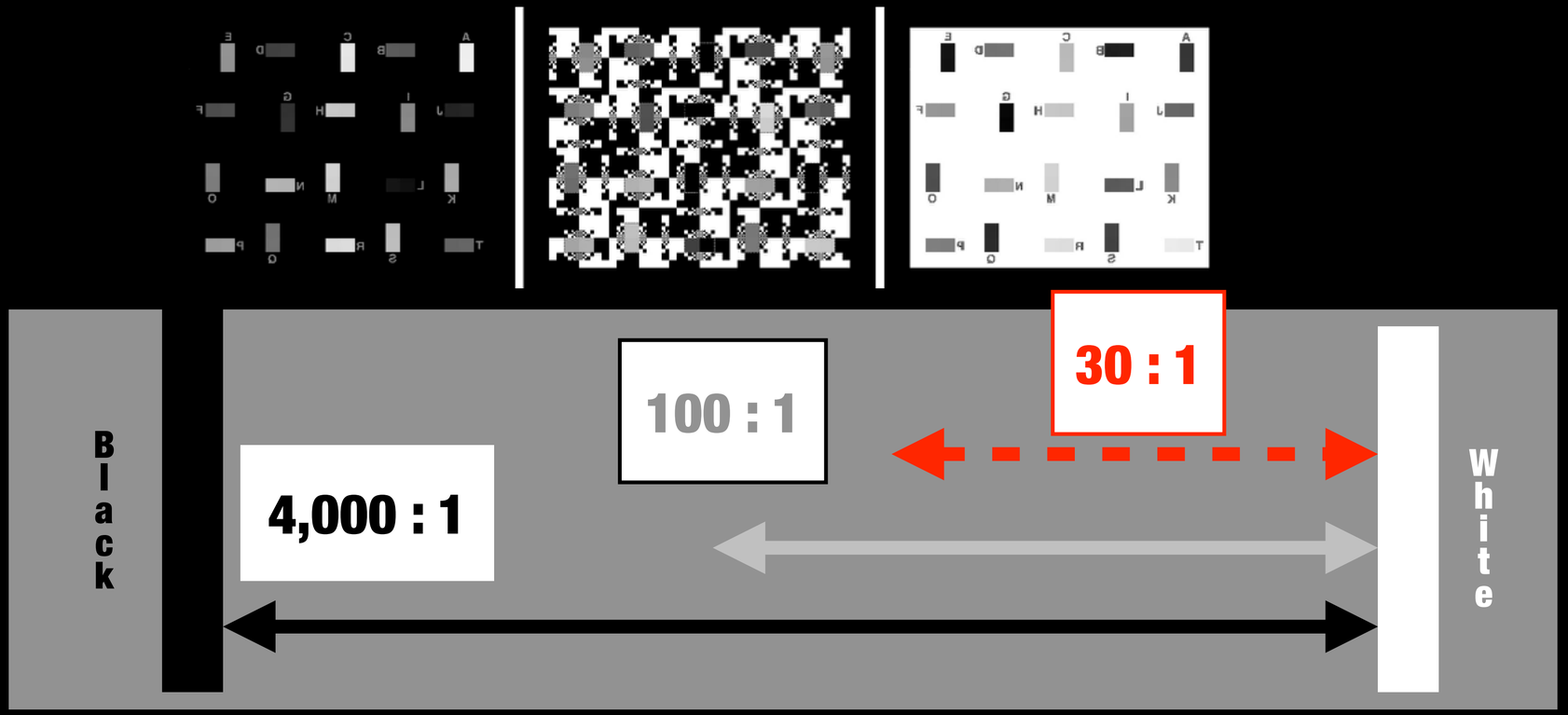




<McCann & Vonikakis (2017) Front. Psychol.
doi: 10.3389/fpsyg.2017.02079>

https://www.frontiersin.org/articles/10.3389/fpsyg.2017.02079/full

Appearance $= f$ (Entire Scene)

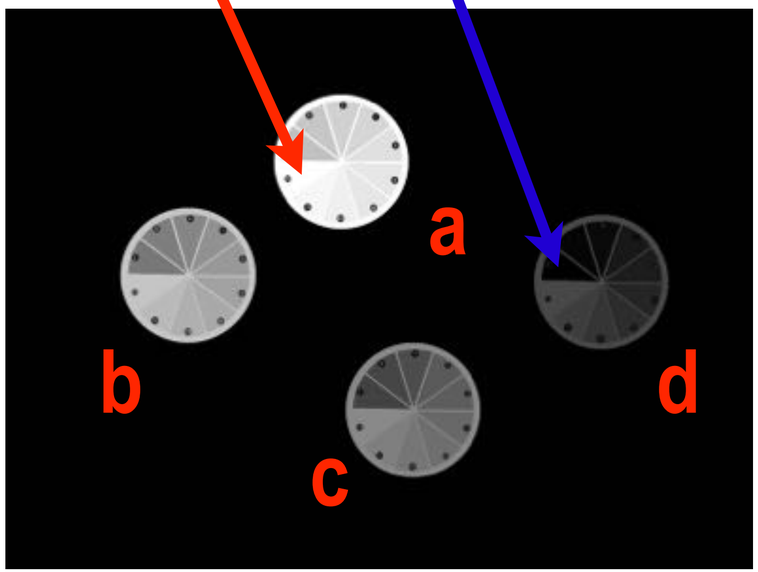


SCENE → *Optical Glare* → *Quanta Catch* → *Neural Spatial Comparisons*

Local response to light

digit 255 = 2094.2 cd/m²

digit 0 = 0.11 cd/m²

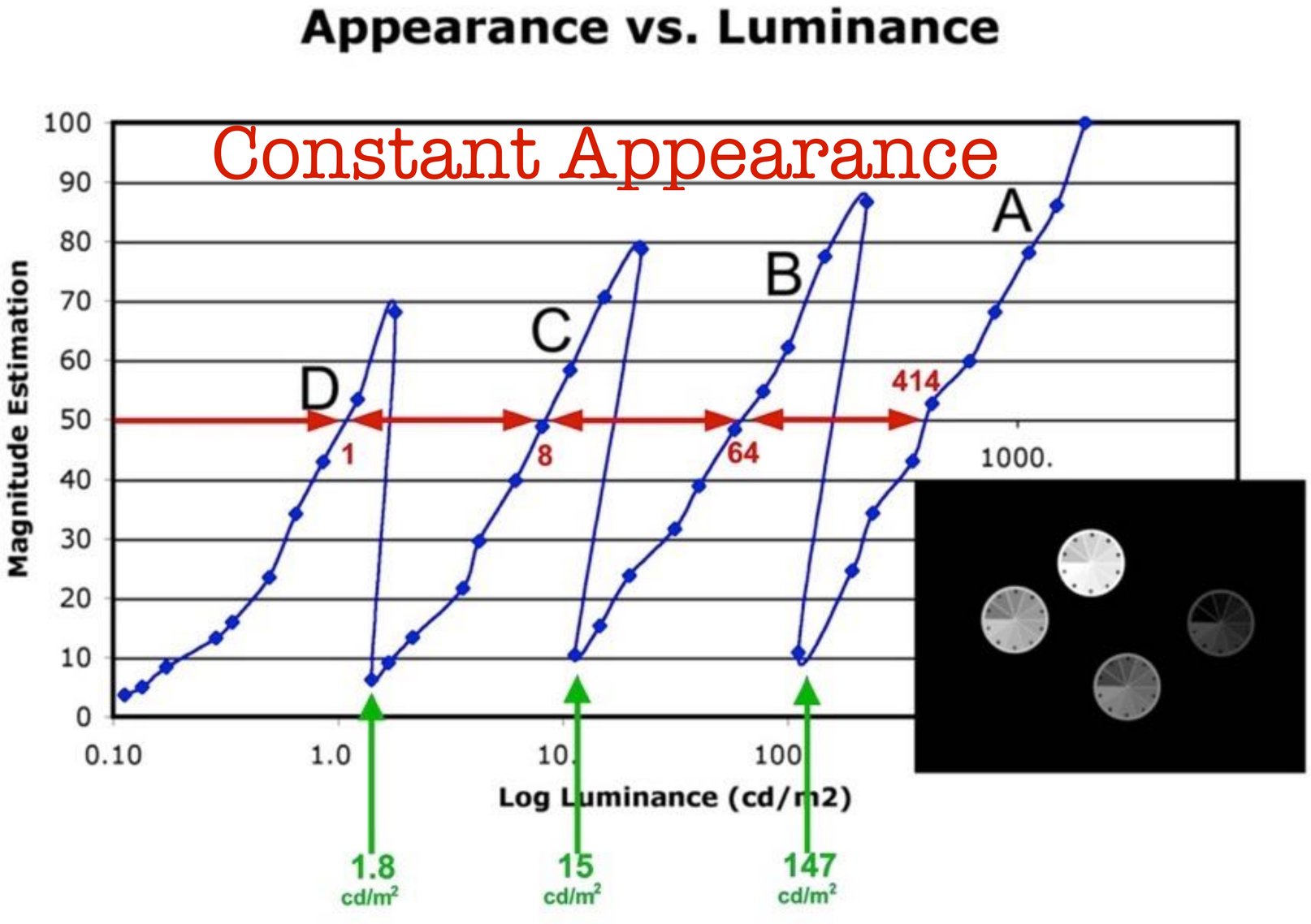


Goal Image

$$\frac{2094.2\ \text{cd/m}^2}{0.11\ \text{cd/m}^2} = 18{,}619$$

Synthetic HDR
(High-Dynamic Range)
Images

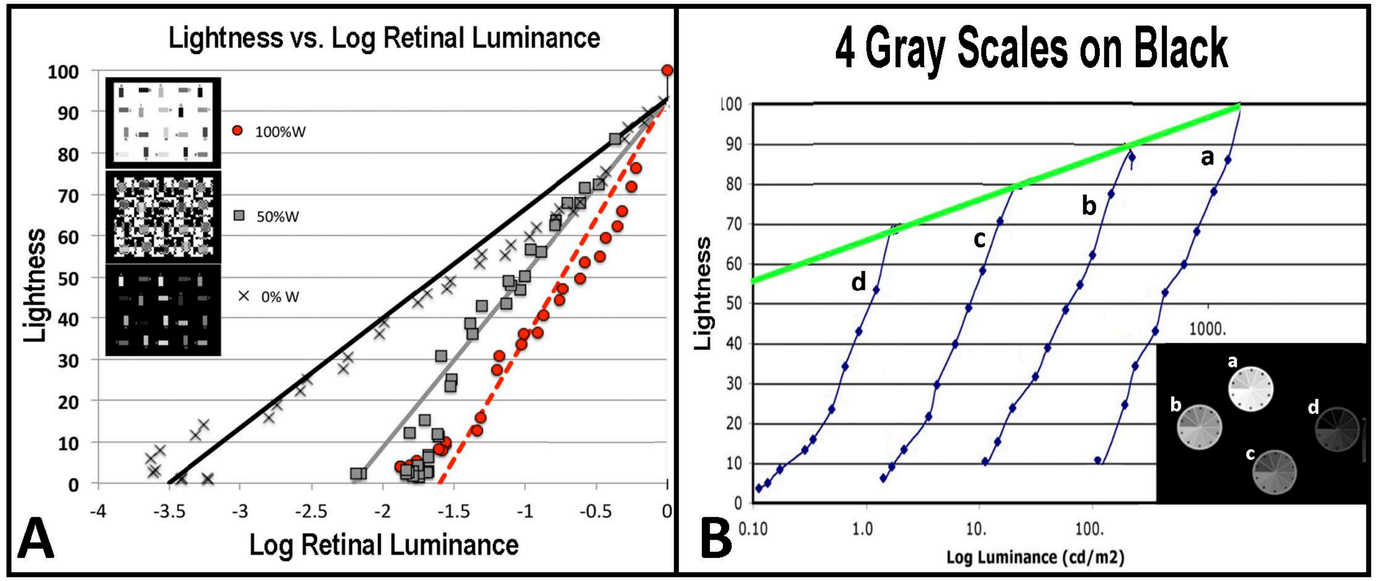
18,619:1



Constant Stimuli

Summary

6. What are Vision's many Response Functions (VRF) to Scenes?



The Appearance of Maxima have a fixed slope VRF in all scenes

The VRF Appearance of darker scene segments varies with the content of the scene

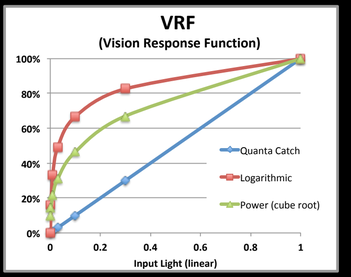
Rizzi & McCann (2009) Glare-limited appearances in HDR images, J. Soc. Info. Display 17, 3-12
https://www.retinex2.net/Publications/ewExternalFiles/SID3.pdf

McCann & Vonikakis (2017) Front. Psychol. <https://doi.org/10.3389/fpsyg.2017.02079>

McCann (2006) <https://www.retinex2.net/Publications/ewExternalFiles/06CIC34.pdf>

What are Vision's many Response Functions (VRF) to Scenes?

$$\text{Appearance} \neq f(\text{Scene}_{x,y})$$



$$\text{Appearance} = f(\text{Entire Scene})$$

SCENE → *Optical Glare* → *Quanta Catch* → *Neural Spatial Comparisons*

Take home messages:

Visual response to simple stimuli is very different from visual response to complex stimuli

A single VRF that describe HVS does not exist

Spatial distribution of visual information changes visual response

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