Blur Unblurred – a Mini-Tutorial

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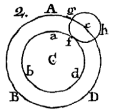
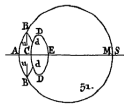
Summary

- Optical blur from defocus (=dioptric defocus), often confused with low-pass filtering, can occur with myopia, presbyopia or misaccommodation, or purposefully with plus-lenses to study effects of optical degradation.
- Perhaps surprisingly, the dioptric blur kernel is simply a **cylinder**.
- The blur circle's diameter is ~ pupil size·defocus. Its size can also be assessed from the near or far point.
- There is a simple formula to derive decimal visual acuity from defocus.

James Jurin (1738)



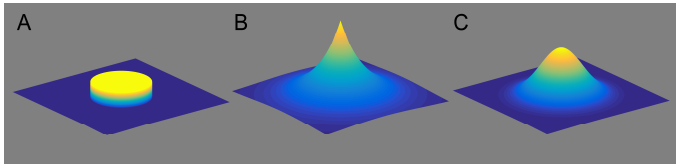
A "circle of dissipation" on a ring stimulus.



Jurin's eye model for accommodation

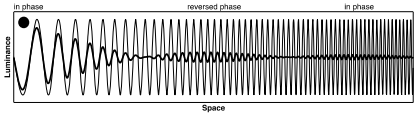
To induce blur Jurin proposed bringing a stimulus closer or farther than accommodation allows, and noticed physical blur is not perceptual blur.

Blur kernel shapes

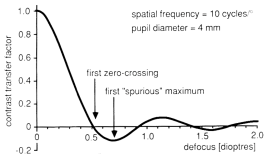


Dioptric blur | Exponential lowpass | Gaussian lowpass

Spurious resolution

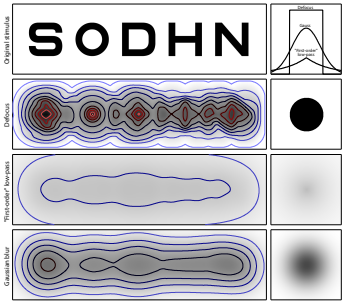


The effect of defocus on a frequency-sweep sine-wave grating.



The contrast transfer factor for a defocused periodic sinusoidal grating.

At 0.5 D defocus, contrast is zero.



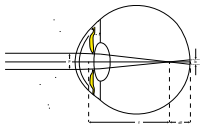
Effect of blur on Sloan letters: original letters and PSFs

Dioptric blur; disk kernel Ø= letter height

PSF with exponential drop-off Energy is spread over a wide spatial range

Gaussian blur. Blurred images increased in contrast. Isolumes = luminance steps of 7 %points

Blur-Disk & pupil size & defocus



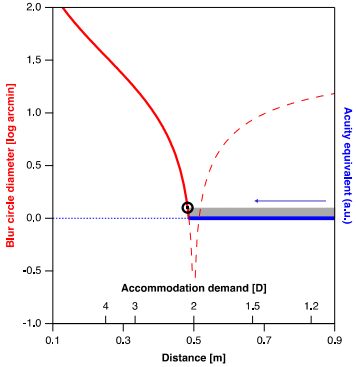
$$b° = 0.057\, p_{mm} D$$

$b°$: blur disk diameter in deg
p_{mm}: pupil size in mm
D: Defocus in diopters

The derivation is given by Smith (1982a) using the simplified Gullstrand eye. See **separate sheet.**

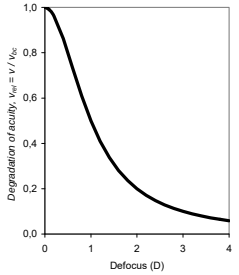
$$b_{stim} = p\left|\frac{d_{foc} - d_{stim}}{d_{stim}}\right|$$

Blur disk in stimulus space when the target is too near or too far.
p: pupil size



A target approaching from the right.
Blue line: Accommodation
Red line: Too near
Circle: JND

Visual acuity & defocus



$$v / v_{bc} = \frac{1}{1 + D^2}$$

v/v_{bc}: Acuity degradation
D: Defocus in diopters

$$v / v_{bc} \approx 1 - D^2$$

for small D

Example:
1dpt decreases acuity to ½ its value

References

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