Pennsylvania Paraoptometric Association

Contrast Sensitivity & Visual Perception

essilor

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What is contrast?

VA alone may not measure the quality of a patient's vision in "real life…"

In real life, contrast varies. A patient with "20/20" vision may complain of poor vision

5'

5'

What is Contrast Sensitivity Function (CSF)?

Contrast Sensitivity Function (CSF) designates perception thresholds

- Spatial Frequency +

Contrast Value -

INVISIBLE

INVISIBLE

VISIBLE

+

A typical threshold follows the curved line on the image

CSF development

CSF mainly develops from birth until age 6
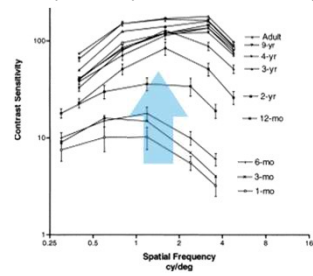
Russell J. Adams , Mary L. Courage **Using a single test to measure human contrast sensitivity from early childhood to maturity**
Vision Research, Volume 42, Issue 9, 2002, 1205 - 1210   http://dx.doi.org/10.1016/S0042-6989(02)00038-X

Measuring CSF

There are many tests which evaluate CSF- (e.g., the Functional Acuity Contrast Threshold)

| sf2 | sf4 | sf8 | sf16 | sf32 | sf64 |
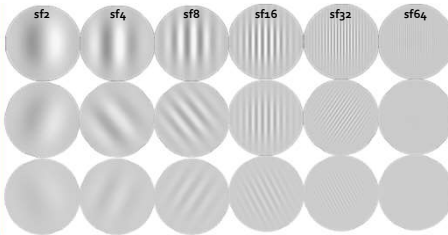
Measuring CSF

The Pelli-Robson test is the standard for clinical studies involving CSF

Measuring CSF -why bother?

- Detection of visual loss missed by VA testing
  - Optic neuritis (related to MS)
  - Early cataract formation
  - Corneal edema
  - Post refractive surgery
  - Early diabetes
  - Early macular degeneration
- Measurement of treatment results
  - ARMD (Photodynamic Therapy)
  - Cataracts
  - Optic Neuritis (methylprednisolone)
- Measurement of true visual function
  - Assessment of visual ability (e.g., driving)

What factors impair CSF?

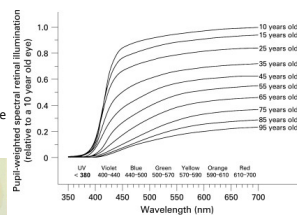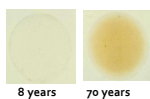### Effects of **luminance** on contrast sensitivity

- Reduction of spatial frequency cutoff (high lum = 40-60cpd) (low lum = 5-6cpd)
- Little impact to low spatial frequencies
- Scotopic CSF shows transition from cones-rods
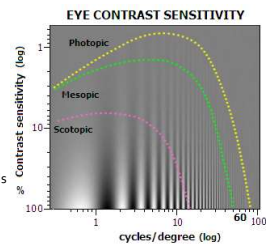
What factors impair CSF?

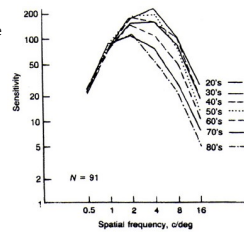### Effects of **luminance** on contrast sensitivity

- Retinal illumination decreases 70% from age 20-70
- Retina also becomes decreasingly sensitive to illumination

8 years   70 years

What factors impair CSF?
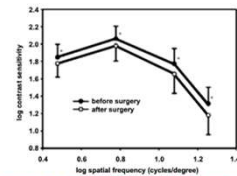
Effects of aging on contrast sensitivity

- Spatial frequency cutoff remains somewhat stable
- Decreased contrast perception- particularly at mid-high frequencies
- Greatest change occurs between ages 40-70

What factors impair CSF?

Effects of LASIK on contrast sensitivity

- Spatial frequency cutoff almost always remains the same
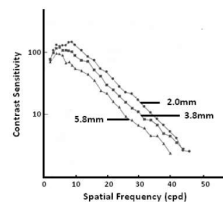- Decrease in contrast perception is common

Nayori Yamane et al., Ocular Higher-Order Aberrations and Contrast Sensitivity after Conventional Laser In Situ Keratomileusis. IOVS. 2004;45:3986-3990

What factors impair CSF?

Effects of pupil size on contrast sensitivity

- Reduction of spatial frequency cutoff (with larger pupil)
- Reduction of depth of field/focus (with larger pupil)
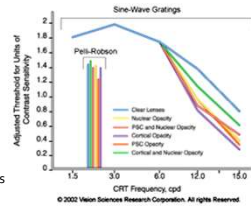- Increased retinal luminance / stray light (with larger pupil)

Campbell and Green (1965)

Slide 1

What factors impair CSF?

### Effects of **early cataracts** on contrast sensitivity

- Spatial frequency cutoff remains stable during early development

- Decreased contrast perception- depending on type

- Contrast deficits generally occur before acuity changes

Slide 2

What Factors Impair CS?

Effects of **diabetes** on contrast sensitivity
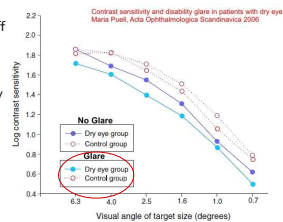
- Spatial frequency cutoff may remain stable

- Decrease in contrast perception is a common finding

Slide 3
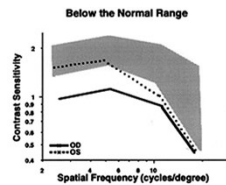
What factors impair CSF?

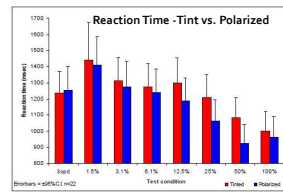### Effects of **dry eye** on contrast sensitivity

- Spatial frequency cutoff remains stable

- Decreased contrast perception- particularly in glare conditions

What factors impair CSF?

### Effects of tint (luminance) on contrast sensitivity

- Tested at 3cpd
- Reaction time up to 15% shorter with polar
- Decreases in contrast affected reaction time in both lenses

Reaction Time -Tint vs. Polarized

What factors impair CSF?

Effects of spectacle reflection on contrast sensitivity

- Spatial frequency cutoff is unaffected
- Contrast requirement increases significantly at all frequencies
- AR restores all but the highest frequencies to near normal
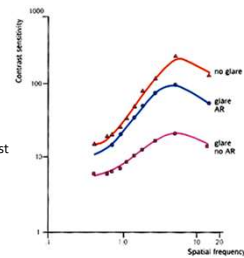
What factors impair CSF?

Even after cataract surgery, contrast perception remains somewhat below normal...
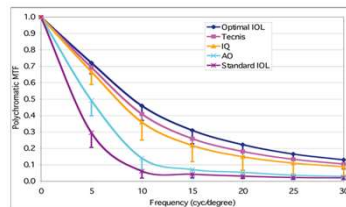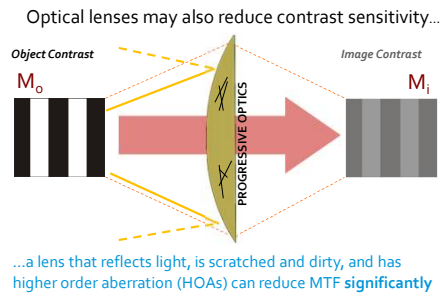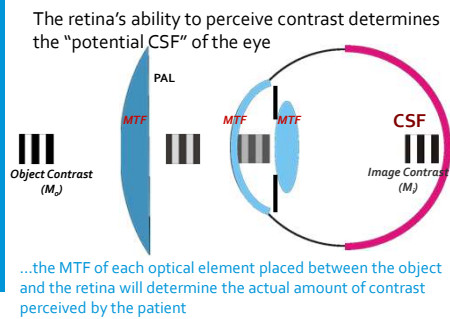

Figure 3. Comparison of an "optimal" intraocular lens with various IOLs (from Koch DD and Wang L, personal communication).

What factors impair CSF?

Optical lenses may also reduce contrast sensitivity...

Object Contrast

M_o

PROGRESSIVE OPTICS

Image Contrast

M_i

...a lens that reflects light, is scratched and dirty, and has higher order aberration (HOAs) can reduce MTF **significantly**

What factors impair CSF?

The retina's ability to perceive contrast determines the "potential CSF" of the eye

PAL

MTF

Object Contrast (M_o)

MTF MTF

CSF

Image Contrast (M_i)

...the MTF of each optical element placed between the object and the retina will determine the actual amount of contrast perceived by the patient

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Lenses & aberrations

HOAs (like coma) are the primary aberration in the central zone of a PAL design

COMA

ASTIGMATISM
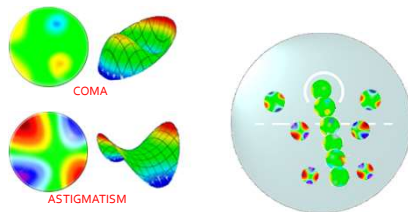
Symptoms of impaired CSF?

Patients with decreased CSF may present with the following symptoms:

- Difficulty with night-time vision
- Vision that "doesn't seem sharp"
  - (even though patient's VA may be 20/20)
  - noticed especially by emmetropes/low Rx patients
- Trouble reading in dim light

Many patients have "grown accustomed" to decreased CSF & may not present with symptoms
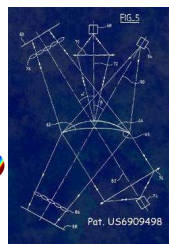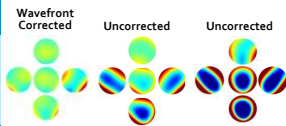

Preserving CSF

HOAs are minute aberrations which decrease image sharpness- (and CSF)

Preserving CSF

Reducing HOAs

- Equipment capable of analyzing the wavefront
- Calculations capable of reducing HOAs

Wavefront Corrected   Uncorrected   Uncorrected

FIG. 5

Pat. US6909498

Preserving CSF

- Manage ocular defects / stray light
  - tear film
  - crystalline lens
  - retinal health
  - pupil size
  - correct low order aberrations
- Manage correction with MTF lenses
  - control stray light
    - ✓ smudge / scratch-free surface
    - ✓ reduce reflections
    - ✓ polarization
  - control aberrations

Key Takeaways

- CSF – Contrast Sensitivity Function
  - A more comprehensive measure of visual ability
  - Sometimes reduced even in patients with 20/20 VA
- MTF – Modulation Transfer Function
  - Ability of a lens or system to transfer contrast
  - Can be reduced by a number of factors
- Higher quality eyewear may not increase VA- but will almost <u>always</u> improve CSF

THANK YOU

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Essilor of America