Strooilight in het Oog

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Functie-effecten van verblinding

• Immediate blinding

• Differences between individuals of more than 10x found, depending on ocular condition

• Recovery time follows the primary effect

• Fatigue effects

• Shock/disorientation effects
The problem

Everybody experiences a spreading of light around bright light sources. It deteriorates vision, because contrast is lost.

To what extent?

The seeming luminosity of the light spreading.
Verblinding $\equiv$ Strooilicht

(according to international standards as set by the CIE)
Commission Internationale d’Eclairage (CIE): Disability Glare $\equiv$ Straylight

retinal straylight is caused by scattering of light in the optically imperfect optical components of the eye

Primary straylight contributors:

- normal eye
  - cornea
  - lens
  - sclera / iris
  - fundus
- increased in
  - cataract
  - corneal problems
  - refractive surgery
  - vitreous turbidity

4 straylight sources in the healthy eye

Point Spread Function (PSF)

- no stray light
- stray light

$\theta$ (deg)
Strooilicht kan worden gemeten met behulp van psychofysische technieken

It is characterized by the straylight parameter $s$
usually $\log(s)$ is given

typical values e.g.
young normal eye $\log(s) = 0.87 \ (s = 7)$
first signs of cataract $\log(s) = 1.5 \ (s = 30)$
(difference by a factor of 4 in straylight)
Hoe beïnvloedt strooilicht het zien?

gesimuleerde beelden voor vroege lens-troebeling
Straylight effects
Blinding at night

Intraocular light scatter increases retinal adaptation, which desensitizes the retina => GLARE

4 x increased straylight

Older healthy eye, log(s)=1.0
Eye with (early) cataract, log(s)=1.6
Glare/Straylight effects

Glare is not restricted to twilight conditions
Glare/Straylight effects
Contrast loss by retinal straylight
The signs in the NORI elevator

straylight difference of a factor of 2

Normal 67y, log(s)=1.3  Early cataract, log(s)=1.6
Glare/Straylight effects

Non-traffic related effects
Against-the-light face recognition

Young normal

First signs of cataract,
\[ \log(s) = 1.4 \]
Kwantitatieve effecten

N.B. in geval van retinale aandoeningen vormt strooilicht een dubbele handicap,

dit in tegenstelling tot de situatie bij gezichtsscherpheverlies door (lens)troebeling
### Kwantitatief Strooilicht Effect

The amount of contrast loss in typical traffic glare situations

<table>
<thead>
<tr>
<th>Oncoming lights</th>
<th>Illuminance on the eye In lux</th>
<th>Eye condition (cataract stadium/cornea problem/vitreous opacity)</th>
<th>Straylight parameter $10^{log(s)}$</th>
<th>Straylight luminance In cd/m²</th>
<th>Contrast loss (factor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low beams</td>
<td>0.34</td>
<td>Young healthy</td>
<td>0.8</td>
<td>0.17</td>
<td>1.2</td>
</tr>
</tbody>
</table>
|                 |                               | {
|                 | preclinical                   | 1.4                                                             | 0.7                              | 2                             |
|                 | mild/medium                   | 1.8                                                             | 1.7                              | 3.4                           |
| DRL (daytime running light) | 2.8                          | Young healthy                                                 | 0.8                              | 1.4                           | 3                     |
|                 |                               | {
|                 | preclinical                   | 1.4                                                             | 5.8                              | 9                             |
|                 | mild/medium                   | 1.8                                                             | 14                               | 21                            |
| high beams      | 79                            | Young healthy                                                 | 0.8                              | 40                            | 58                    |
|                 |                               | {
|                 | preclinical                   | 1.4                                                             | 165                             | 237                           |
|                 | mild/medium                   | 1.8                                                             | 400                             | 572                           |
Populatie-waardes voor strooilicht
Glare/Straylight and healthy aging

Straylight increases on average with age in healthy eyes (Visual Acuity $\geq 1.0$), but is highly individual dependent.
Straylight among European drivers

Data from the 2003-2004 GLARE study among 2422 European drivers

Frequently > 4x increased straylight levels are found.

danger zone for driving (at night)?

straylight increase >4x compared to young eye
Straylight compared to visual acuity. Often (early cataract) problems are missed by visual acuity.

Data from the 2003-2004 GLARE study among 2422 European drivers. Frequently > 4x increased straylight levels are found.

Visual acuity

- < 0.5 (<10/20) logMar > 0.3

Decimal visual acuity

- good 1.6
- 1.0
- 0.5
- bad

Straylight increase >4x compared to young eye, danger zone for driving (at night).
Hoe meten we het (functionele) strooilicht?
behoeft aan een praktisch meetinstrument voor strooilicht / verblindingsgevoeligheid

- Occupational testing. Pilots, driver licensing
- FDA: standard as defined by driving simulation

- First complaints in early cataract development. Early cataract surgery
- Refractive surgery effects on clarity of the cornea (functional effect of haze)
- Evaluation of corneal transplant procedures
- Corneal dystrophies ect.
- Contact lens induced changes
Assessment method for Glare/Straylight

Direct compensation method
Direct compensation method for retinal straylight assessment

Ring on: straylight on fovea (fixed)

Ring off: compensation light on fovea (variable)

Stimulus ring (straylight source)

Test field with counterphase modulation

Retinal modulation

No compensation

Direct Compensation

Modulation in test field
Compensation Comparison approach for clinical use

Two half fields, one with compensation flicker of different strengths

- Subject’s responses allow for estimation of psychometric curve for the comparison
- Position of 50% point of psychometric curve gives straylight value

Subject’s task:
Which test field flickers most?

Subject’s answer:
Field with compensation: 1
Field without compensation: 0
Oculus C-Quant

Based on the Compensation Comparison method

Van den Berg et al. ARVO 2005
Patent owned by Royal Academy

caracteristics

• Functional assessment
• Fixed set of stimulus presentations, 1.5 min. test duration
• Data suitable for analysis with robust statistical techniques, such as Maximum Likelihood estimators
• Data allow estimation of measurement reliability
0.07 log units = typical measurement s.d.

0.3 log units

normal population values ± 2 s.d.
Standard error for an individual measurement
(0.07 log units = population average s.d.)
0.3 log units = factor of 2

log(s)=1.47 safe criterion value

(0.6 log units increase = factor of 4)

Standard error for an individual measurement (0.07 log units = population average s.d.)
Klinische voorbeelden

Relatieve onafhankelijkheid gezichtsscherpte en strooilight
glasvocht troebeling
preop visus 0.4++
strooilicht meer dan
10-voudig verhoogd
vitrectomie
postop visus 0.8
strooilicht binnen normale grenzen
Fuchs dystrofie
visus 0.7
strooilicht
6x verhoogd
na PKP vanwege Fuchs strooilicht bijna normaal
Cataract preop visus 0.7
Straylight 8x increased
Cataract postop
visus 0.9
Straylight low age-normal
pseudofaak
beperkte YAG opening
OD visus 0.4++
strooilicht >10x verhoogd
litteken na ulcus
OD visus 0.8+
strooilicht sterk verhoogd

Straylight parameter above normal limits (p < 0.01%)
onbegrepen klachten
OD visus 1.25
strooilicht hoog normaal
onbegrepen klachten
OS visus 1.25
strooilicht net verhoogd
ontevreden LASIK patient
visus 1.0
Strooilicht 2.5x verhoogd
Resumé

• verblinding = (retinaal) strooilicht
• wordt veroorzaakt door optische imperfecties
• kan betrouwbaar worden gemeten
• ook voor de praktische routine
• is van belang voor functie uitoefening
• is onafhankelijk van de gezichtsscherpte

Dank U
In pseudophakia straylight values often below that of the non-cataract age-peers

Straylight lens exchange?
Straylight values in pseudophakics compared to age-control values

Data from Dr R. Nuijts
Oculus C-Quant results on 17 subjects

- Repeatable (measurements #1 and #3 compared to #2; y = x line)

- Accurate (dashed line expected value with the BPM2 light scattering filter)
Straylight compared to visual acuity. Often (early cataract) problems are missed by visual acuity

Data from the 2003-2004 GLARE study among 2422 European drivers

Frequently > 4x increased straylight levels are found.

Straylight compared to visual acuity. Often (early cataract) problems are missed by visual acuity
Rough indications of straylight values in different patient groups

Key: ***** = as a rule; ****= often; ***=regularly; **=occasionally; *=rare

<table>
<thead>
<tr>
<th>Log(s) Straylight increase</th>
<th>0.9 1x</th>
<th>1.2 2x</th>
<th>1.5 4x</th>
<th>1.8 8x</th>
<th>2.1 16x</th>
<th>2.4 32x</th>
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</thead>
<tbody>
<tr>
<td>Young normal</td>
<td>*****</td>
<td>*</td>
<td></td>
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<tr>
<td>Healthy 65 year VA&gt;0.8</td>
<td>**</td>
<td>****</td>
<td>**</td>
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<tr>
<td>Healthy 80 year VA&gt;0.8</td>
<td>***</td>
<td>****</td>
<td>*</td>
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</tr>
<tr>
<td>Pseudophakic 80 year</td>
<td>*** (!)</td>
<td>***</td>
<td>***</td>
<td>*</td>
<td></td>
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<tr>
<td>Early cataract (VA &gt; 0.4)</td>
<td>***</td>
<td>****</td>
<td>**</td>
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<tr>
<td>LASIK (high myopia....)</td>
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<td>*</td>
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<tr>
<td>keratoconus (CL problem)</td>
<td>****</td>
<td>**</td>
<td>*</td>
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<tr>
<td>Cornea dystrophy or edema (VA &gt; 0.4)</td>
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<td>****</td>
<td>****</td>
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<tr>
<td>Fish eye VA = 0.4</td>
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<td>One case</td>
<td></td>
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<tr>
<td>Vitreous turbidity (VA&gt;0.7)</td>
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<td></td>
<td>****</td>
<td>*</td>
<td></td>
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</tbody>
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