Physiology of glare and readaptation (including age differences)

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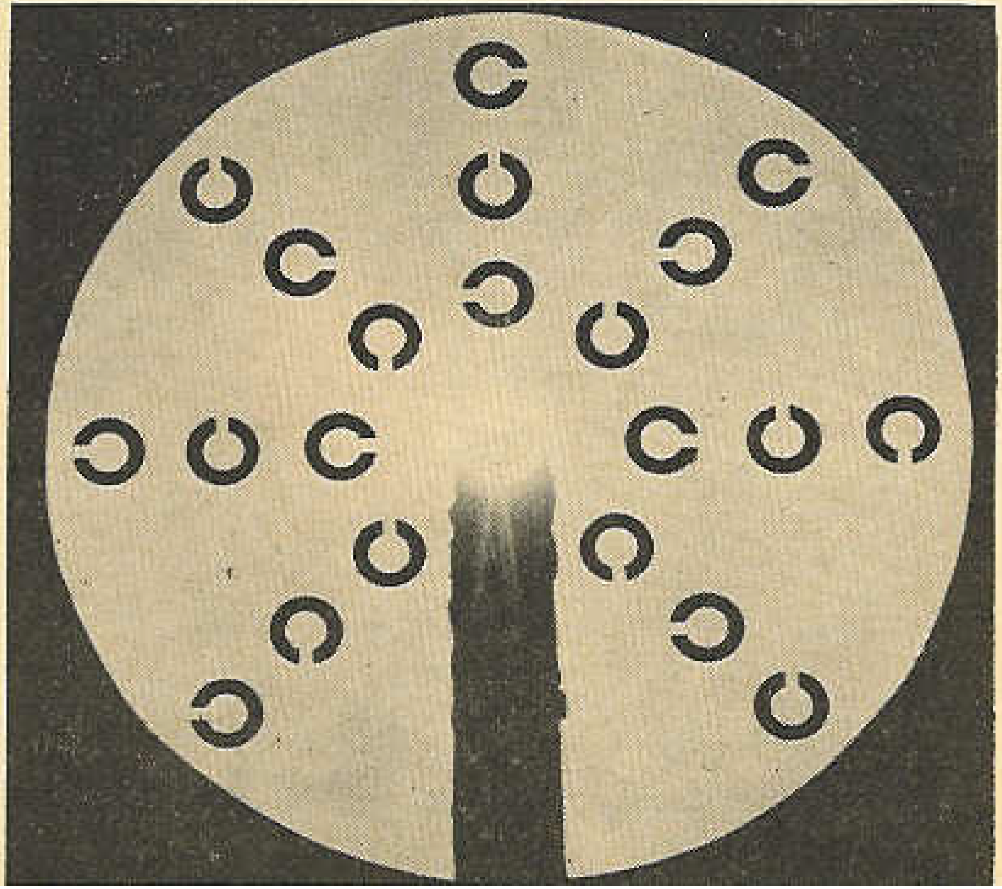
Glare terminology

- Discomfort glare: annoying, but not disabling
- Disability glare: peripheral glare source produces visibility loss (threshold elevation)
- Next slide shows stimulus configuration used by Ernst Wolf to measure effect of age on disability glare

Fig 1.—Appearance of the Landolt rings with both the glare source and the screen illumination turned up maximally.



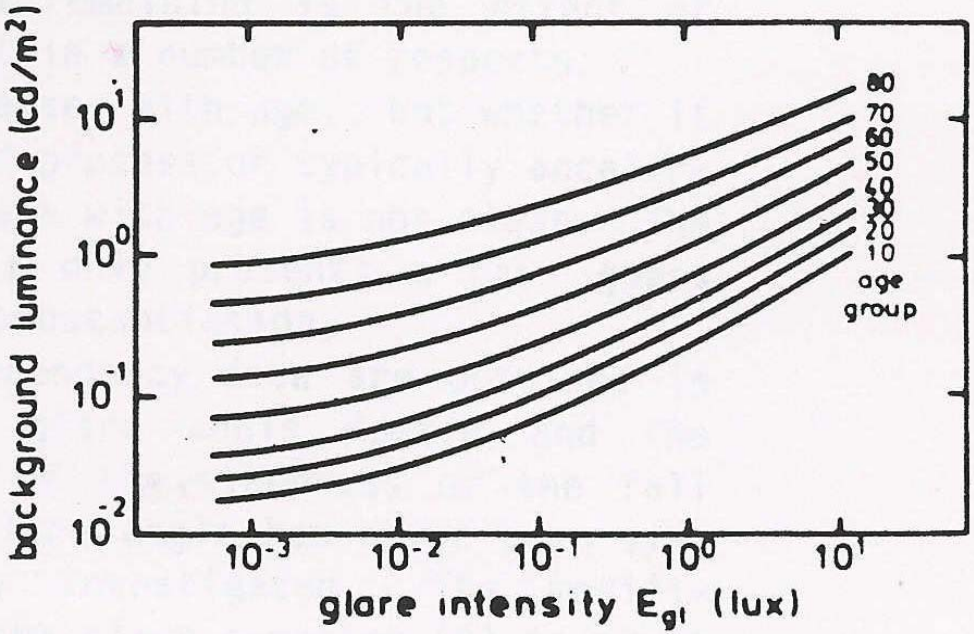
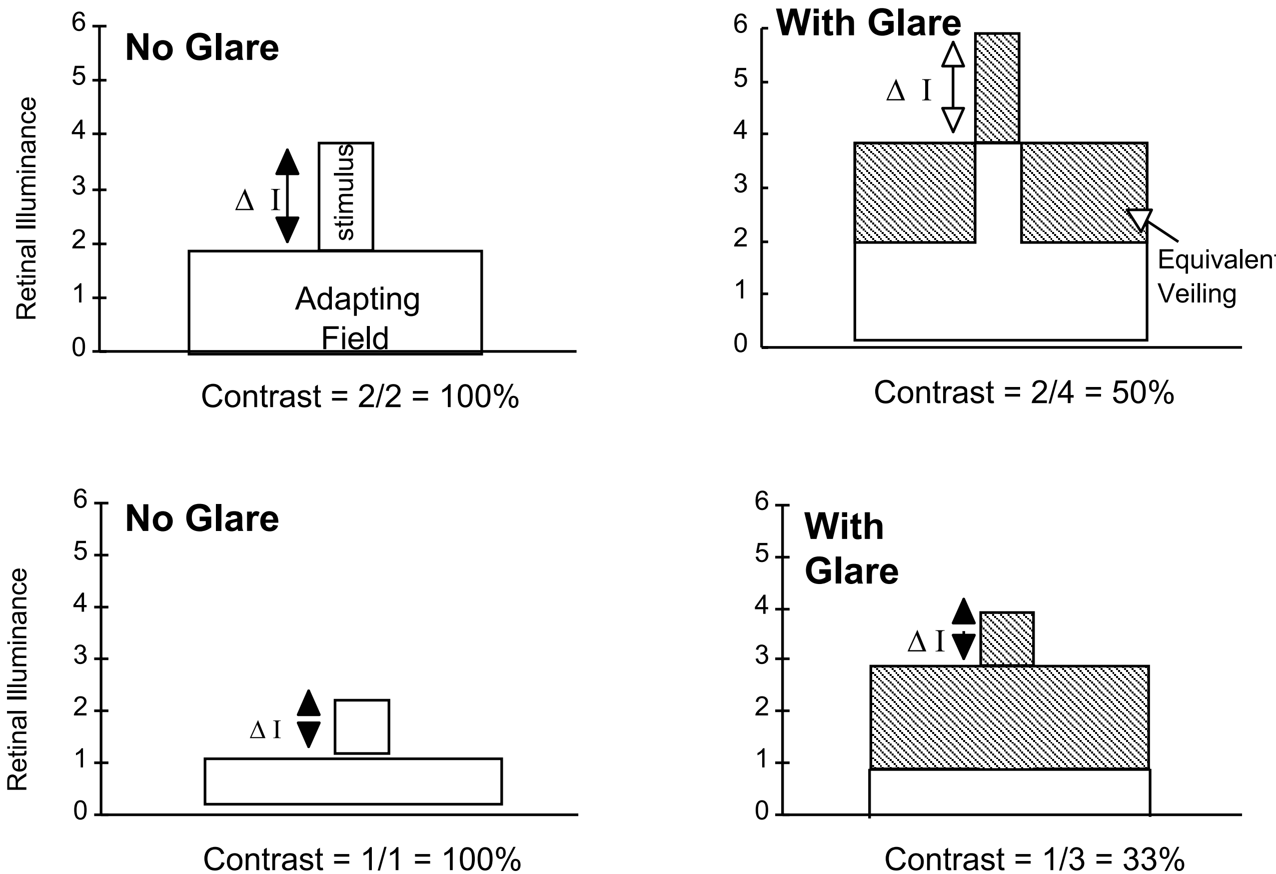


Fig.11. Increase with age in needed illumination of an acuity test chart under condition of glare. Averaged and smoothed after data of Wolf [46].

Mechanism by which a peripheral glare source produces disability glare loss:

- Due to scatter by ocular media, some light from the peripheral glare source will illuminate the central retinal region containing the retinal image of the target one is trying to detect.
- This retinal illuminance was likened to an "equivalent veiling luminance," which decreased the contrast of test target.

Effect of an added veiling light on retinal image contrast depends on mean adapting field level (after Bichao, 1996)

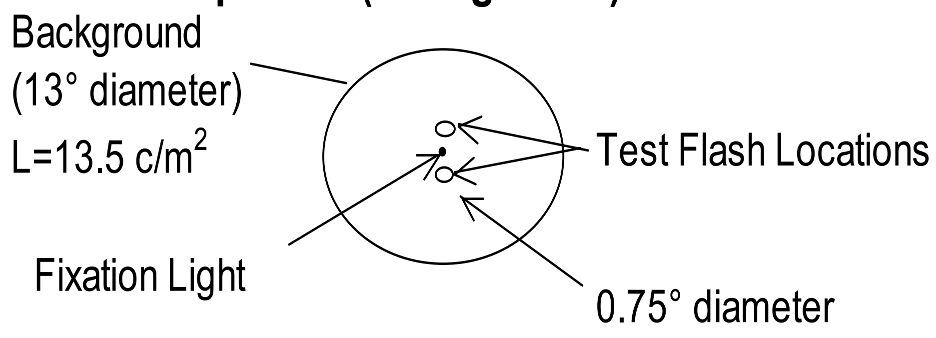


The Holladay-Stiles Equation:

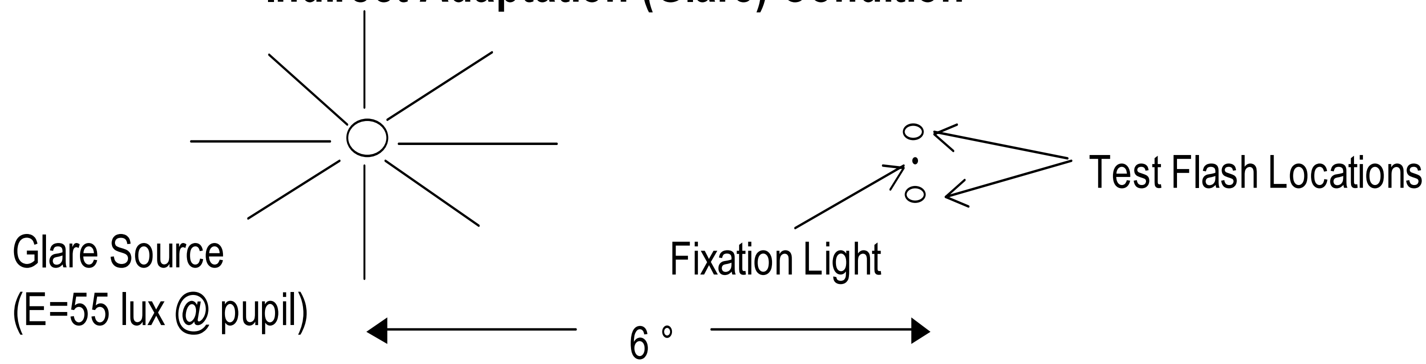
- Used to calculate the equivalent veiling luminance, $L_v(\theta)$ produced by glare sources at eccentricities > 1 degree.
- $L_v(\theta) = 10E/\theta^2$ where: E = illuminance (in lux) at pupil and θ = off-axis angle of glare source (in degrees).

Figure 1. Typical stimulus configurations

Direct Adaptation (Background) Condition



Indirect Adaptation (Glare) Condition



Typical stimulus configurations

Disability glare: loss and recovery

- Onset of peripheral glare source produces large initial visibility loss (threshold elevation).
- If glare source left on, sensitivity improves (threshold decreases) until a steady state (continuous) glare sensitivity level is reached.
- Disability glare formulas generally refer to sensitivity under the steady-state condition.

Human eye is frequently exposed to large, sudden changes in light level

- Entering (or exiting) darkened theater from bright afternoon sunlight
- Entering (or exiting) tunnels
- Having picture taken with camera strobe
- Glancing from dark desk pad to PC monitor
- Oncoming headlamps when driving at night

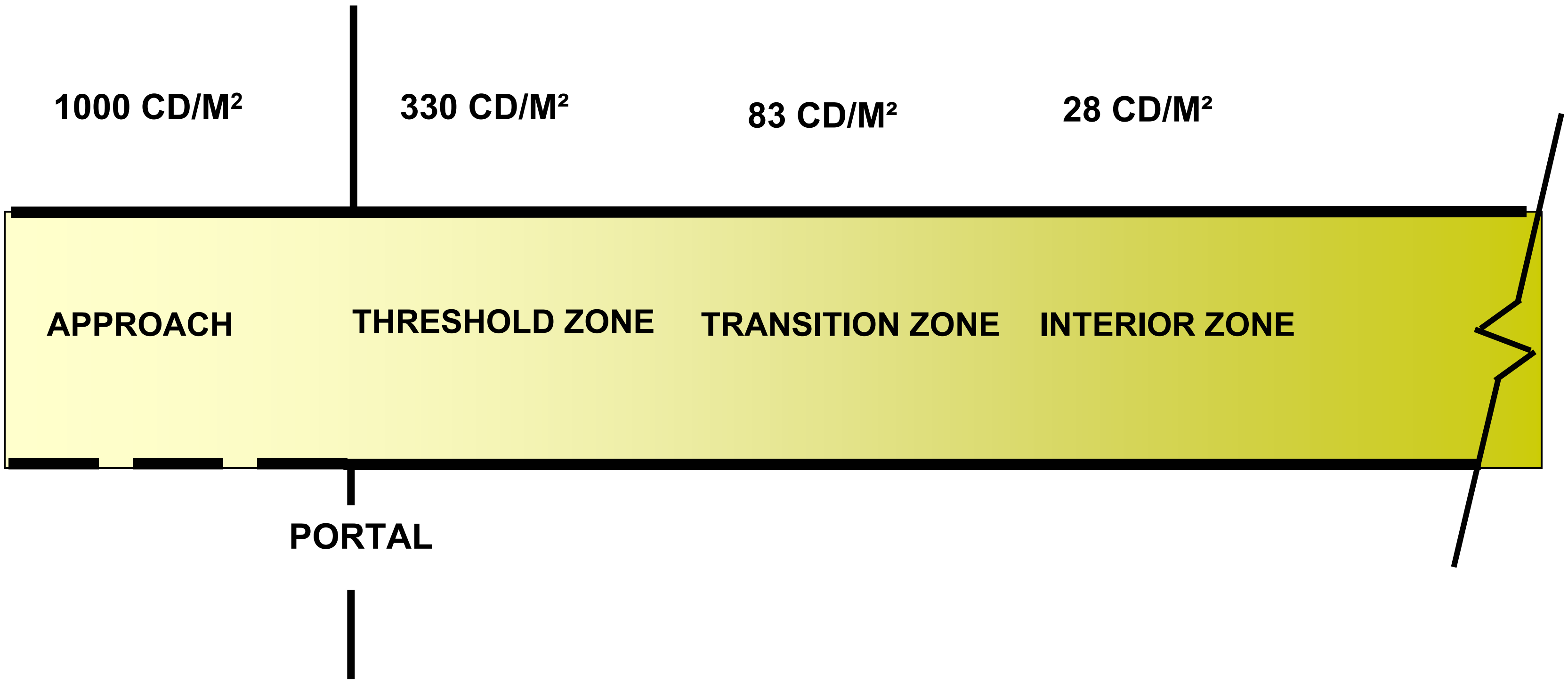
When lighting changes, eyes begin to adapt. Conventional ...

- Light adaptation (going from dark room into bright sunlight) is relatively fast (2-3 min.)
- Dark adaptation (entering dark room from bright sunlight) relatively slow, cones requiring 5-10 min. and rods requiring 30-45 min.
- **<u>The point</u>**: Time course of both measured in minutes

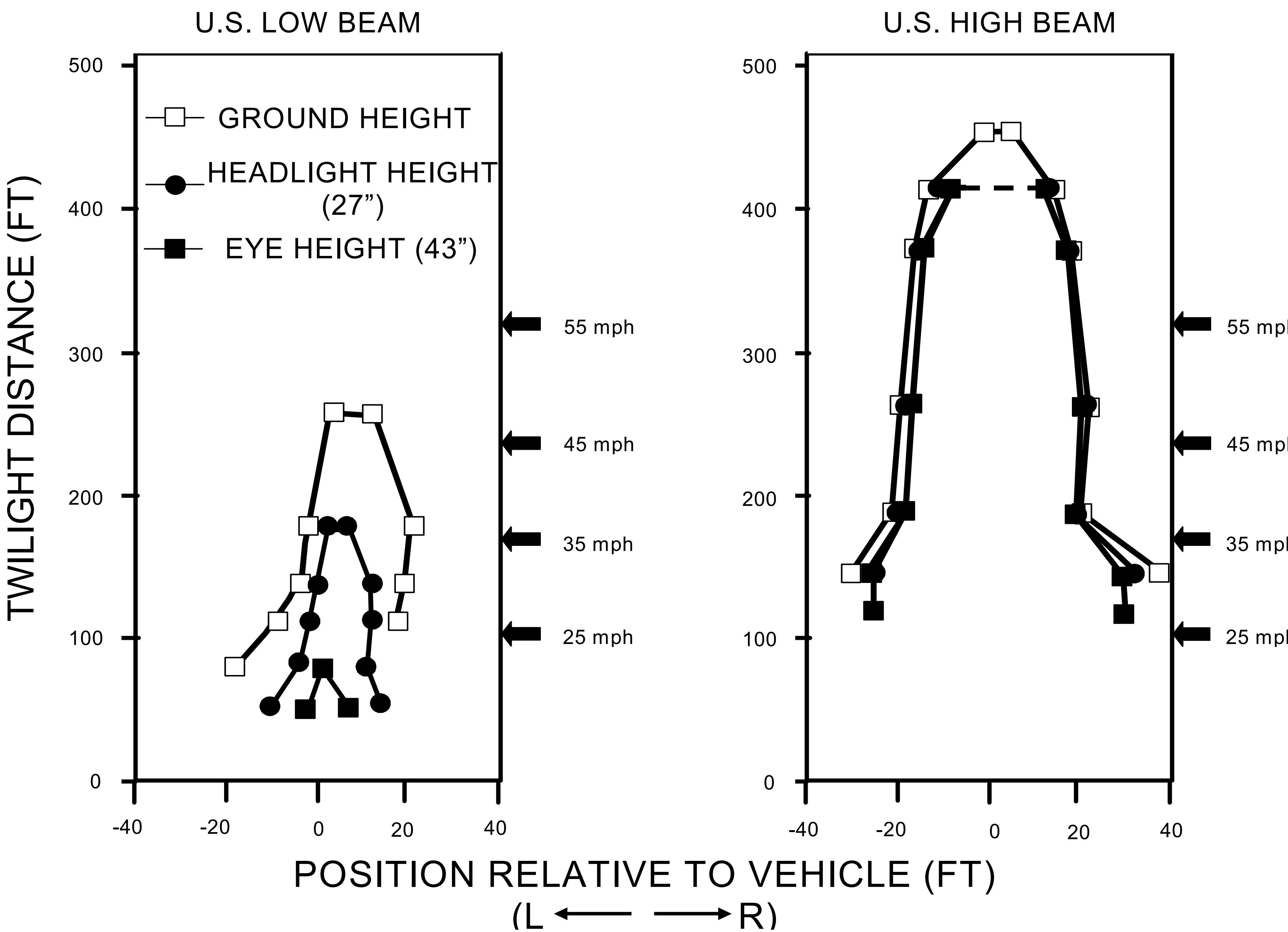
Back up to the initial 1-2 sec. after lighting change: Transient adaptation:

- Refers to changes in sensitivity occurring in the initial 1-2 seconds after sudden change in light level (increase or decrease)
- **Time course** measured in **tenths of a second or milliseconds**
- a.k.a. early light and dark adaptation
- a.k.a. early glare adaptation and early glare recovery

Practice for Tunnel Lighting (ANSI/IES RP-22, 1987)



http://www.azstarnet.com/public/startech/archive/032299/deville.htm


U.S. LOW BEAM
U.S. HIGH BEAM
GROUND HEIGHT
HEADLIGHT HEIGHT (27")
EYE HEIGHT (43")
TWILIGHT DISTANCE (FT)
500
400
300
200
100
0
-40
-20
0
20
40
55 mph
45 mph
35 mph
25 mph
POSITION RELATIVE TO VEHICLE (FT)
(L ← → R)

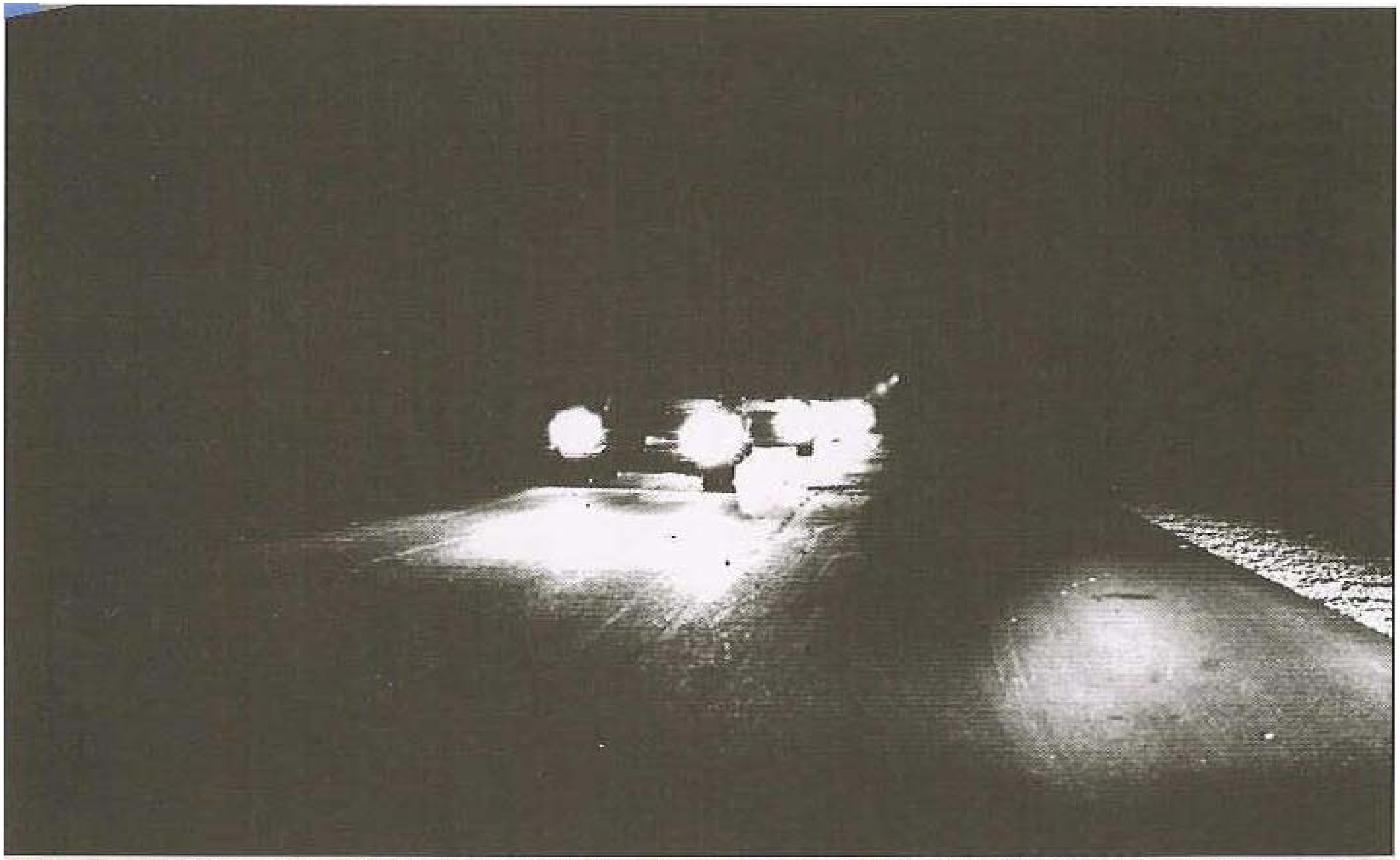


Figure 9-8 *Unseen pedestrians stand on the pavement beside four approaching cars on low beams. The camera cars low beams do not reveal the presence of the hazard.*

Transient (glare) adaptation: How measured?

- Measure threshold for brief test flash (TF) presented at various times re: onset of glare or adapting field change.
- Next 2 slides show stimulus timing and stimulus configurations.

Stimulus Onset Asynchrony (SOA): a.k.a. "tau"

- = time between onset of the 1 sec glare and onset of the smaller 20 msec duration TF.
- Positive SOA means that onset of TF lags glare onset by the X milliseconds.
- Negative SOA means that TF onset precedes glare onset.
- SOA = 0 = simultaneous onset.

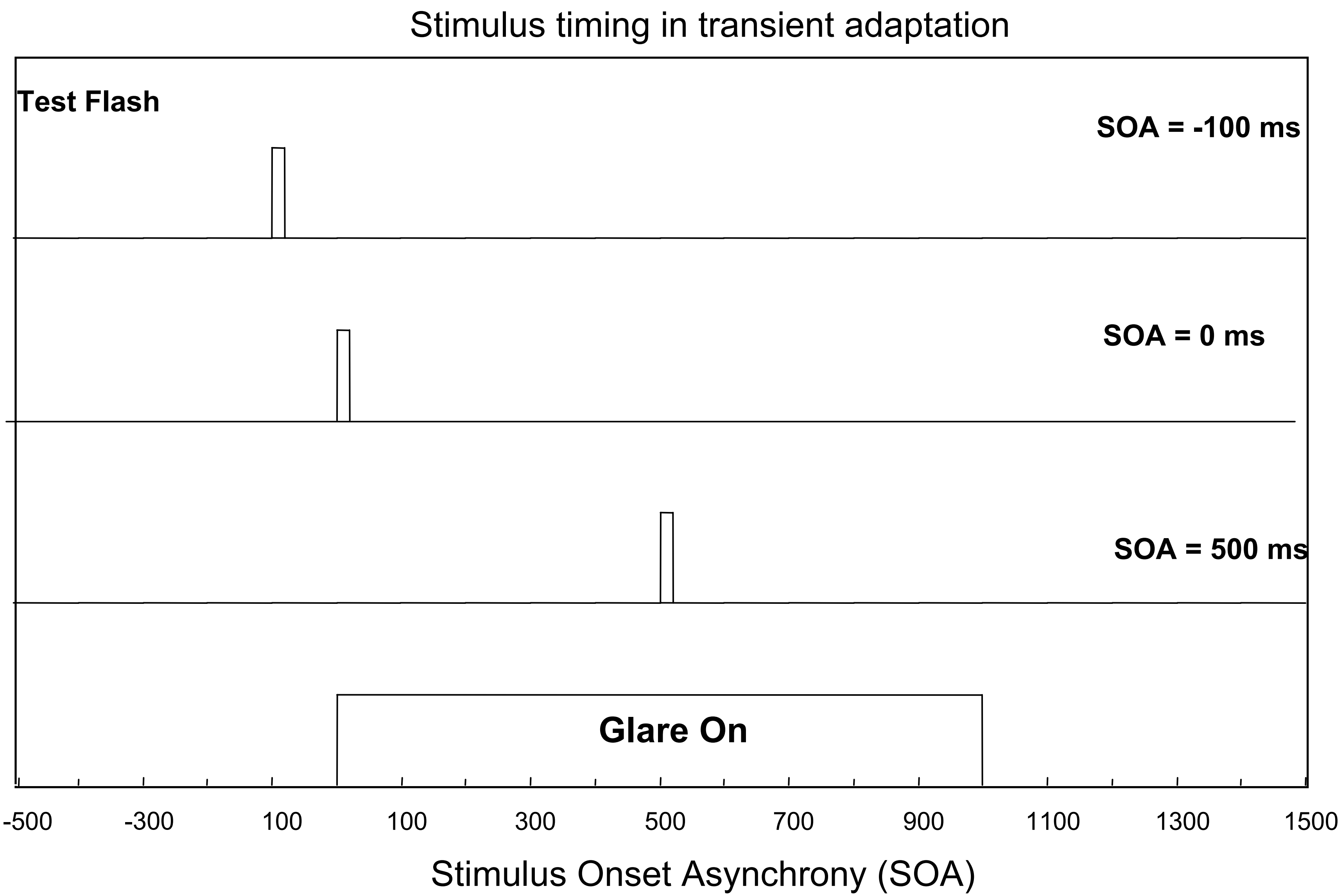


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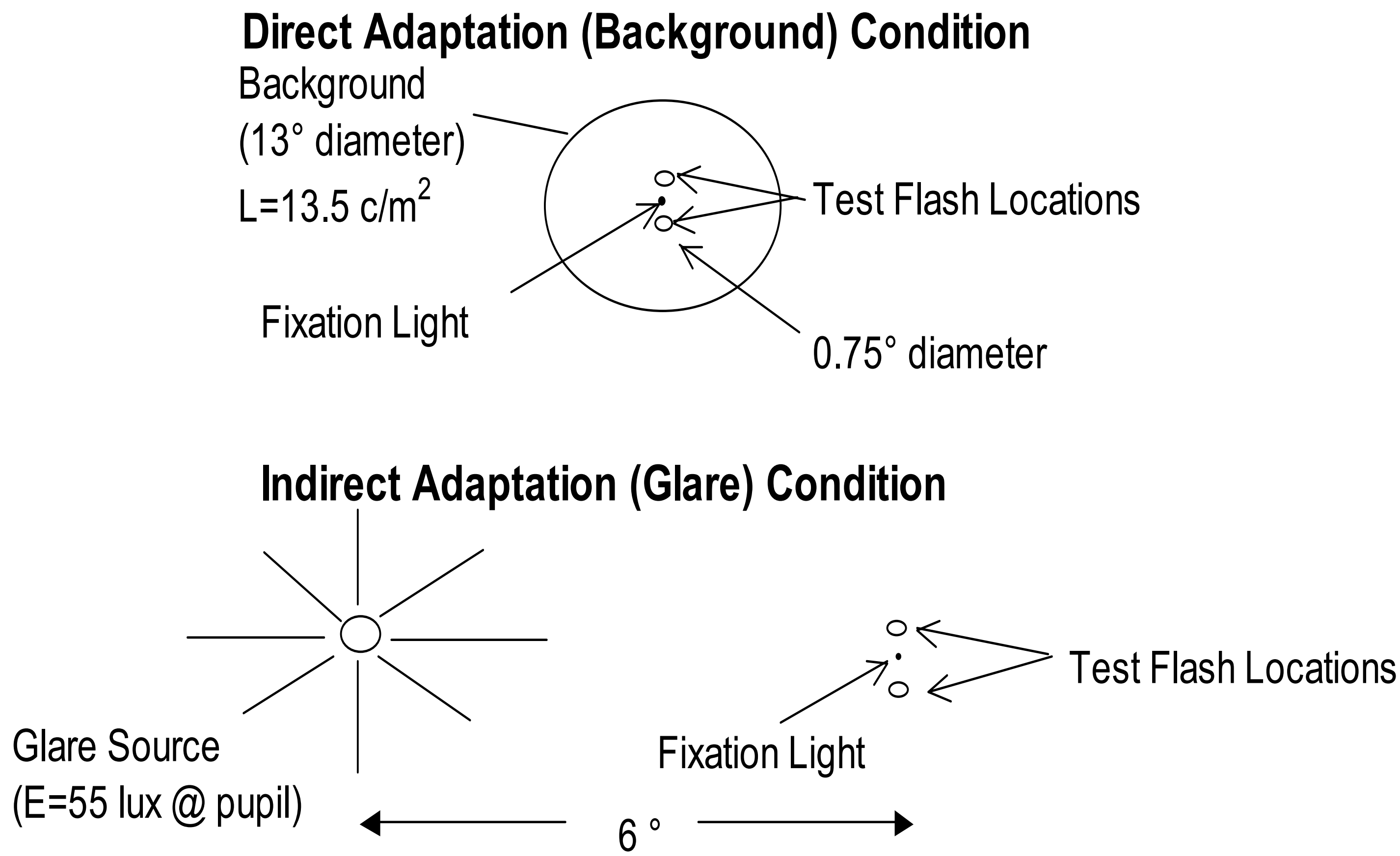
Figure 1. Typical stimulus configurations



Typical stimulus configurations

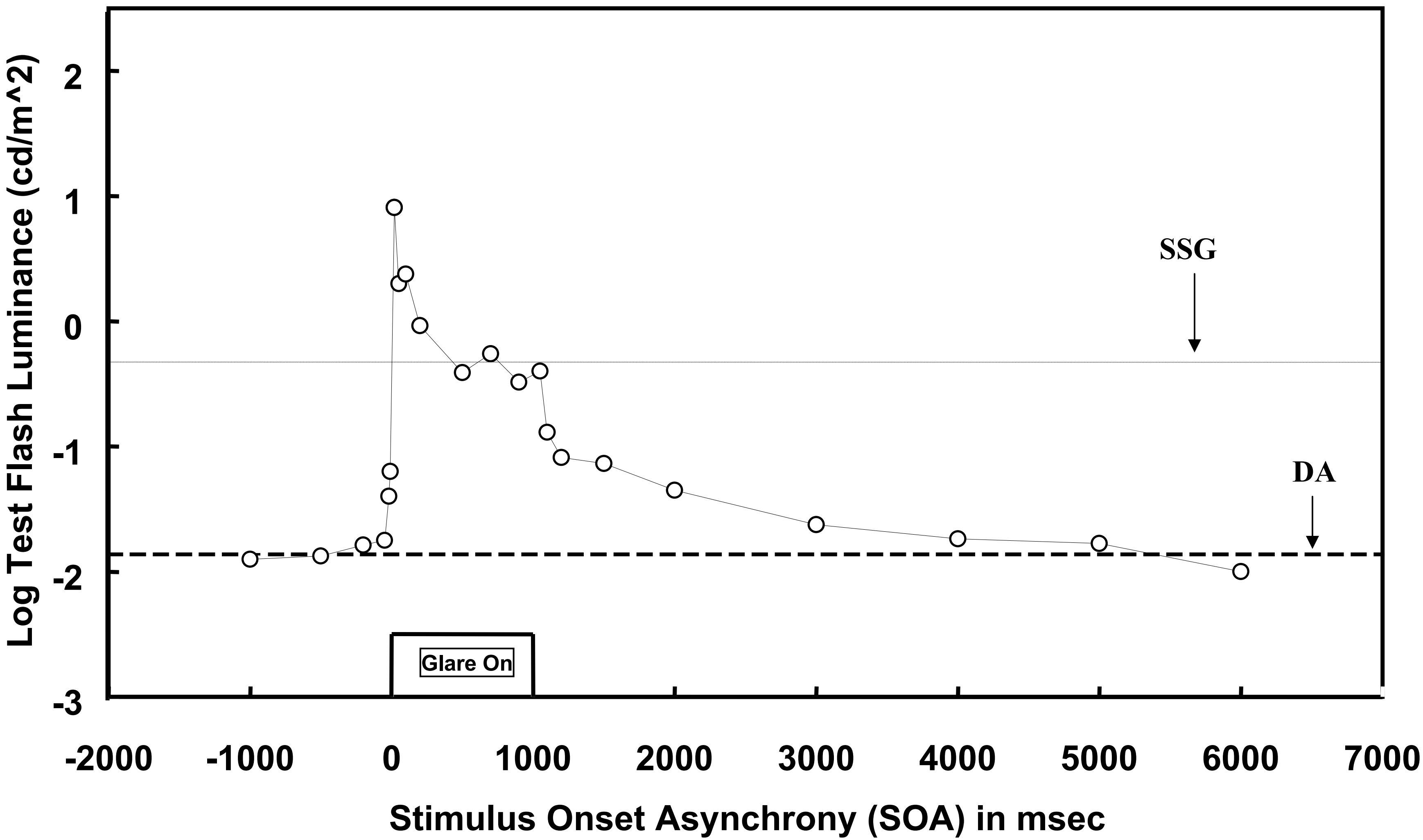
Method:

- Measure threshold over series of 10 sec. duration trials using 2-alternative spatial forced choice
- On each trial subject says “up” or “down”
- TF duration = 20 msec.
- Transient glare duration (if present) = 1sec
- Transient, 10-fold AF increment (decrement) duration = 1 sec.

Subject groups:

- Young normals: N=7; 28.4 $\pm$ 8.5 yrs; VA's or 20/20 or better
- Elderly normals: N= 9; 73.8 $\pm$ 7.6 yrs VA's of 20/25 or better (Major trends confirmed on N = 58 more Ss)
- Next slide – Results for young subject

Threshold as a Function of Stimulus-Onset Asynchrony (SOA)



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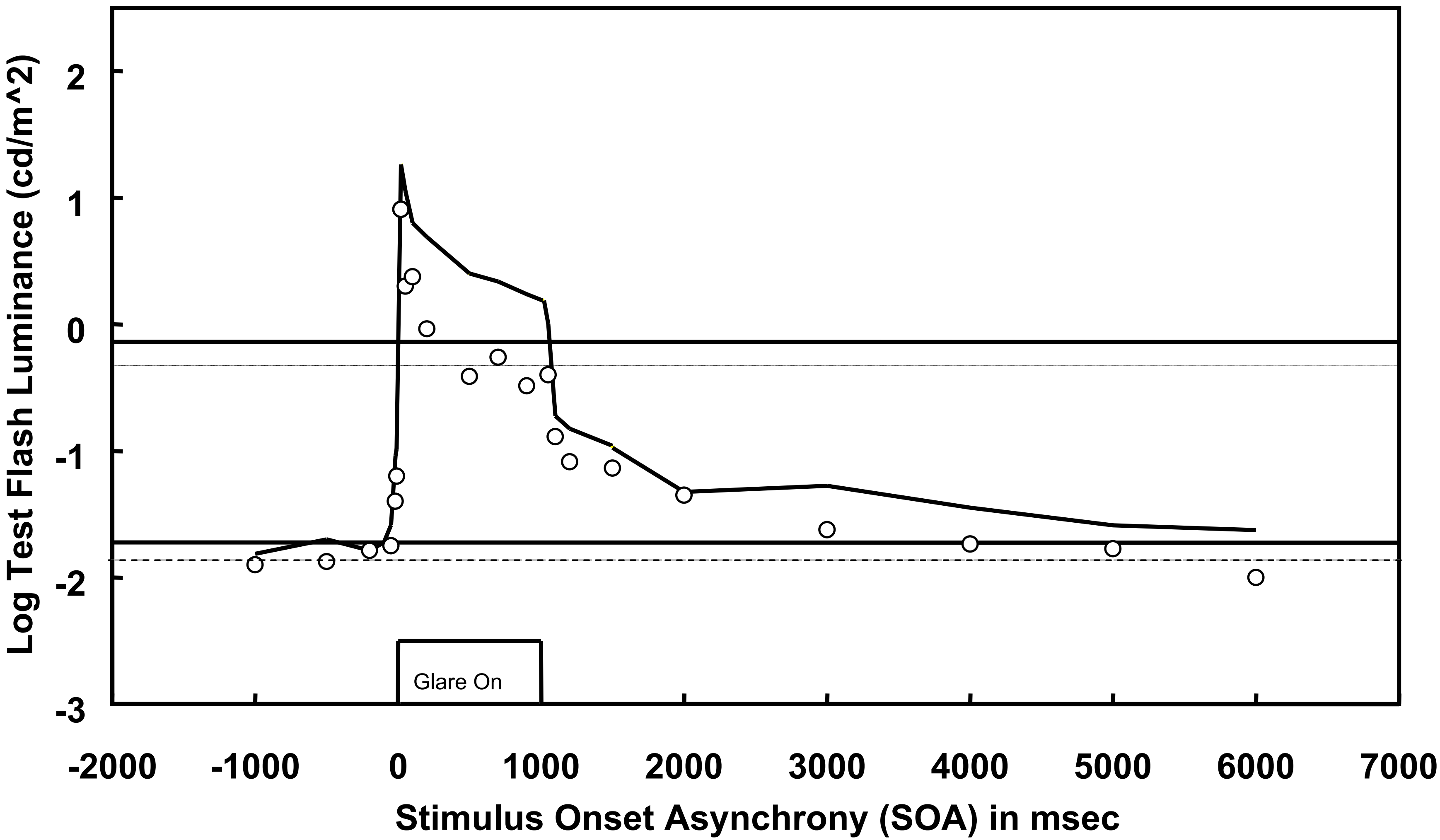
Slide illustrating the effect of age (1 young v. 1 elderly S)



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Visibility loss = Φ

Boynton & Miller (1963)

- = difference in log threshold for transient vs. steady state conditions.
- Works for decrements and increments.
- Decrement case shown in next slide.

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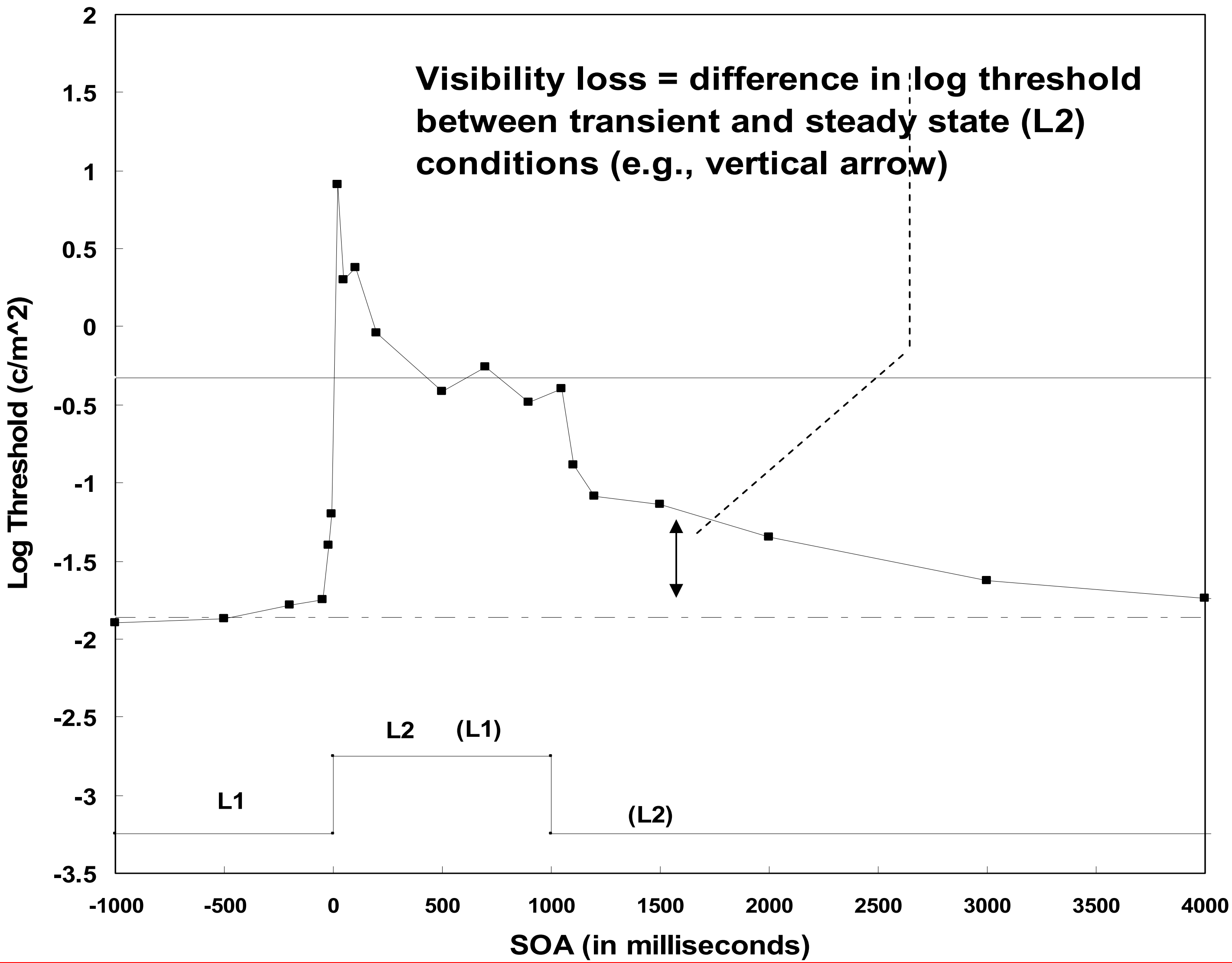

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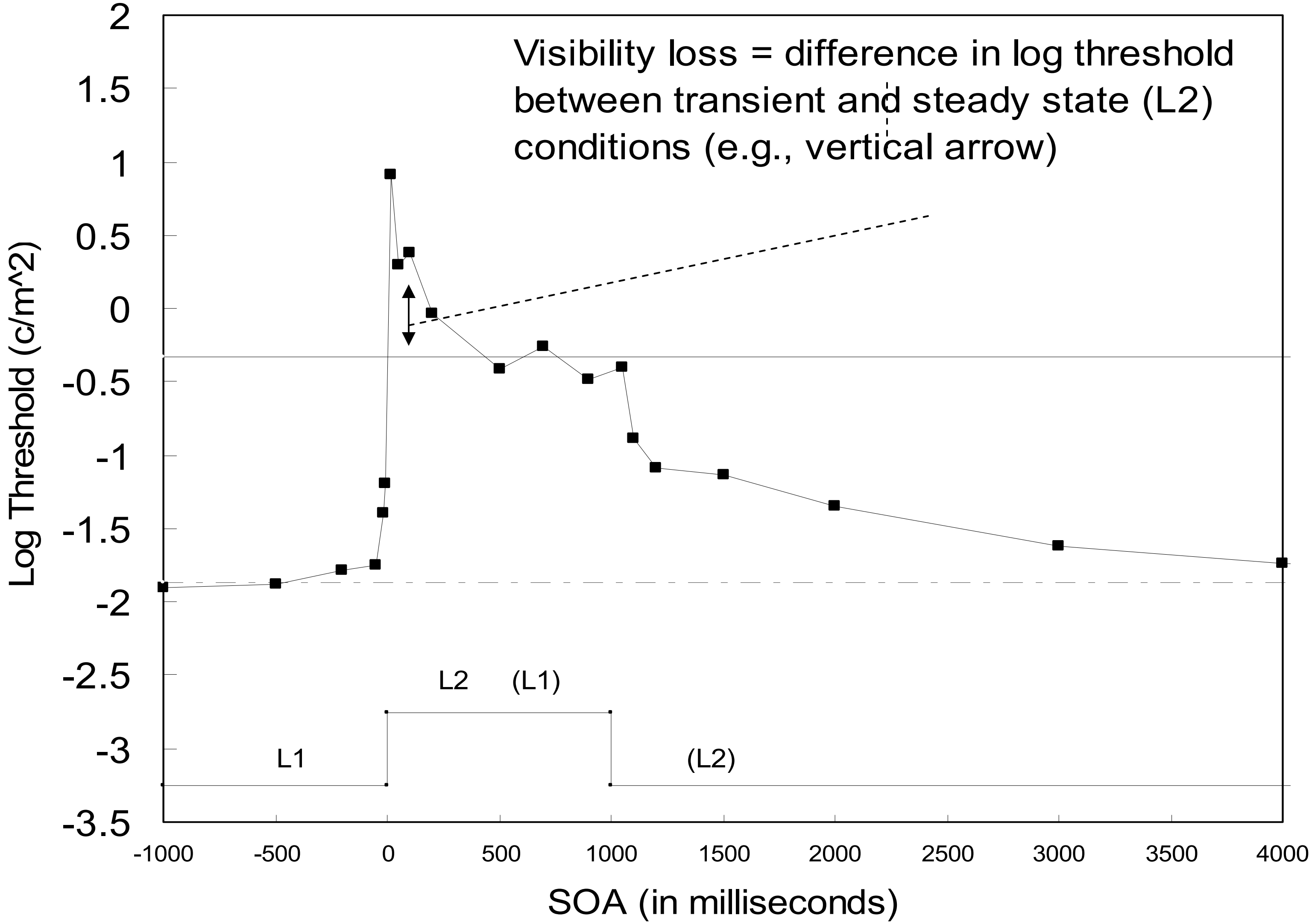
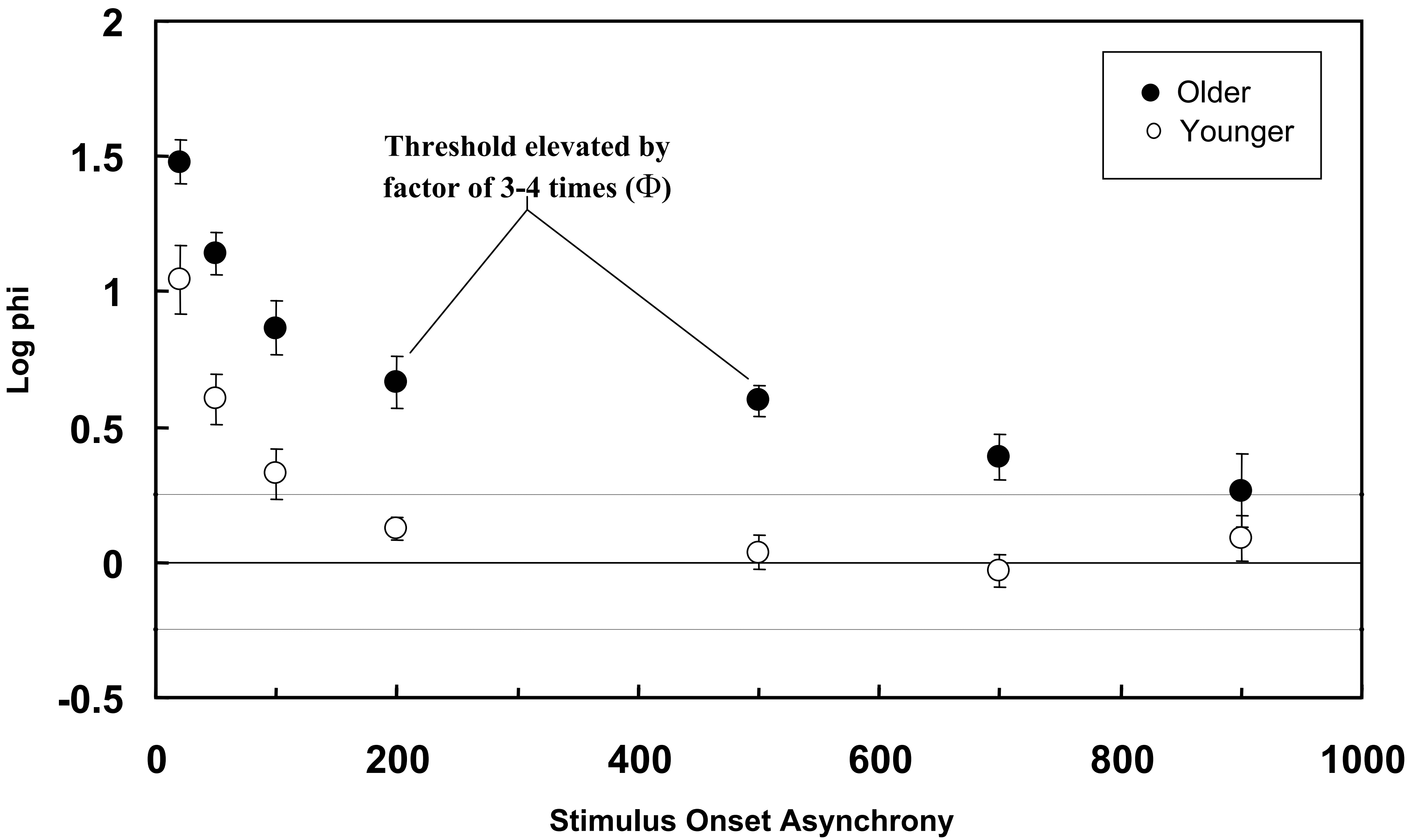

Visibility loss = difference in log threshold between transient and steady state (L2) conditions (e.g., vertical arrow)
Log Threshold (c/m^2)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-1000
-500
0
500
1000
1500
2000
2500
3000
3500
4000
SOA (in milliseconds)
L1
L2
(L1)
(L2)

Log Phi as function of SOA and age



Prior research (1950s – 1970s)

- ϕ larger for shorter SOA's.
- ϕ similar for both light level increments and decrements of same magnitude.
- ϕ depended more on ratio of change in light level than on absolute magnitude of change.

Prior research (more):

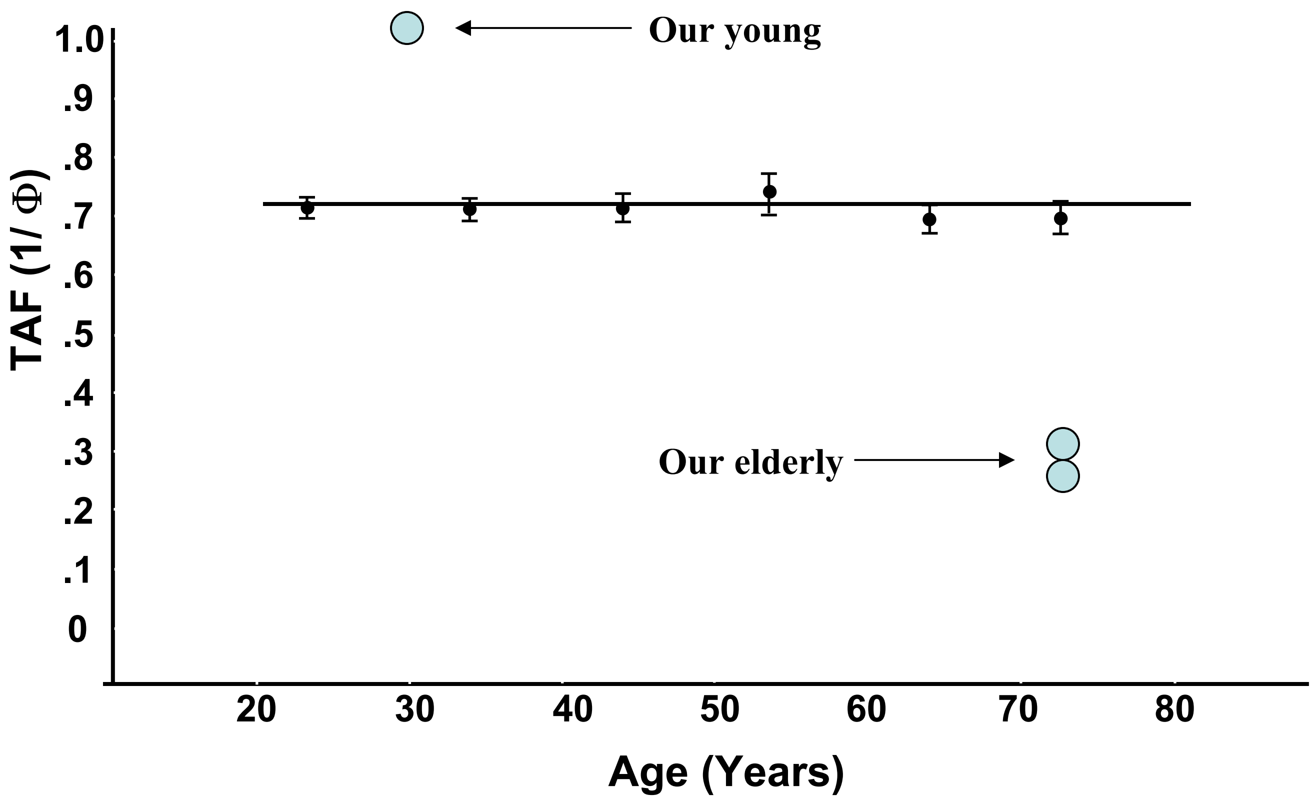
- The smaller the ratio of change, the smaller the visibility loss.
- Virtually no visibility loss observed for young Ss with 3-fold changes in light level at SOA = 300 msec.
- Thereby providing the tunnel lighting recommendations noted earlier.

Lighting handbooks assume TAF independent of age:

- Reason 1: Virtually all subjects used in 1960's and 1970's were were less than about 40 years of age -- even the investigators.
- Reason 2: Paper by Blackwell and Blackwell showing the following relation between TAF and age (next slide).

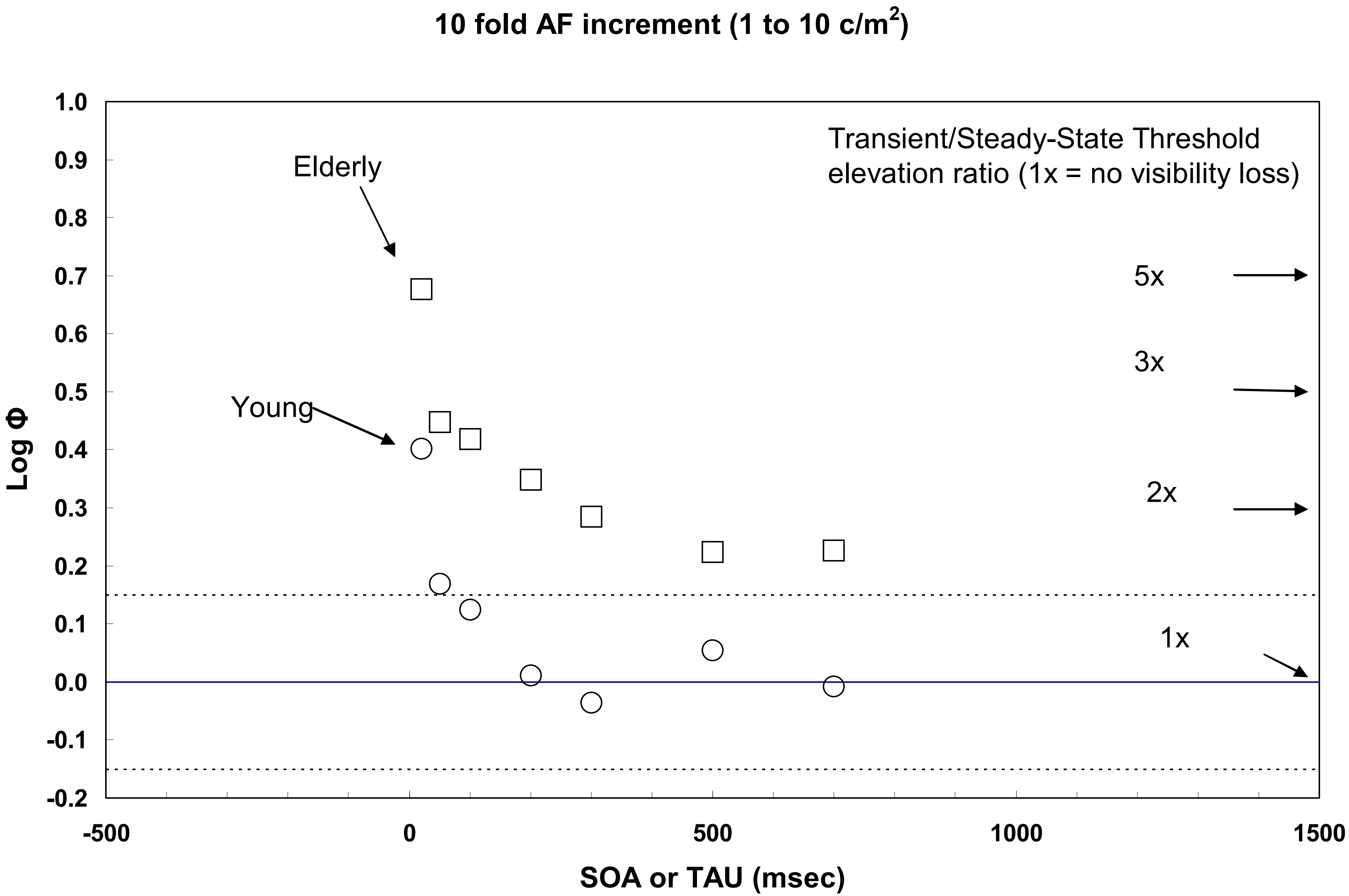
Sensitivity to The Transient Adaptive Effect as a Function of Age (Blackwell & Blackwell, JIES, 1980)

Sensitivity to The Transient Adaptive Effect as a Function of Age (Blackwell & Blackwell, JIES, 1980)



Subject groups:

- Young normals: N=9; 34.1 ± 10.6 yrs; VA’s or 20/20 or better
- Elderly normals: N= 7; 69.5 ± 7 yrs VA’s of 20/40 or better



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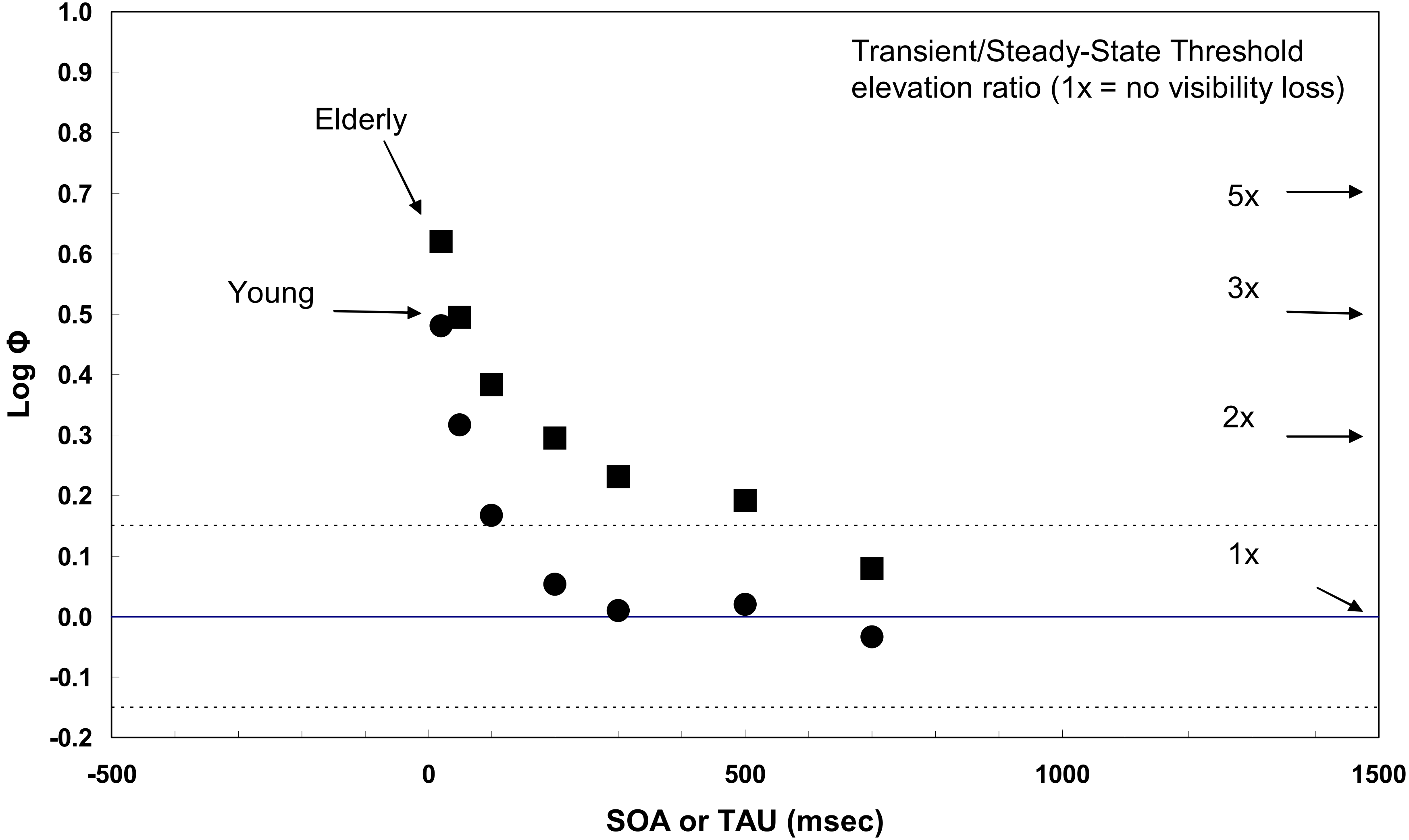
10 Fold AF decrement (1 down to 0.1 c/m²)



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Conclusions

- Thresholds higher for older subjects under all conditions
- Recovery of sensitivity during glare exposure was slower in the older Ss, i.e., transient vision loss larger in older Ss
- Recovery also slower to increments and decrements of a uniform adapting field.

Acknowledgement

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