

Changes in the Human Brain with Vision Loss

Alice Cronin-Golomb, Ph.D.

Department of Psychological and Brain Sciences
& Center for Systems Neuroscience
Boston University



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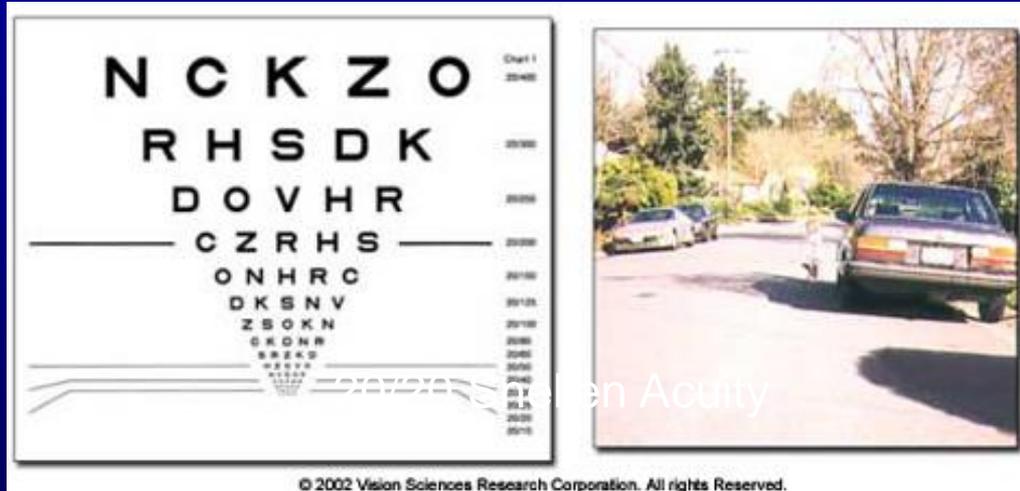
General Agreement:

These aspects of vision change with aging, even in the absence of cataract, glaucoma, or macular degeneration, and these changes have functional consequences

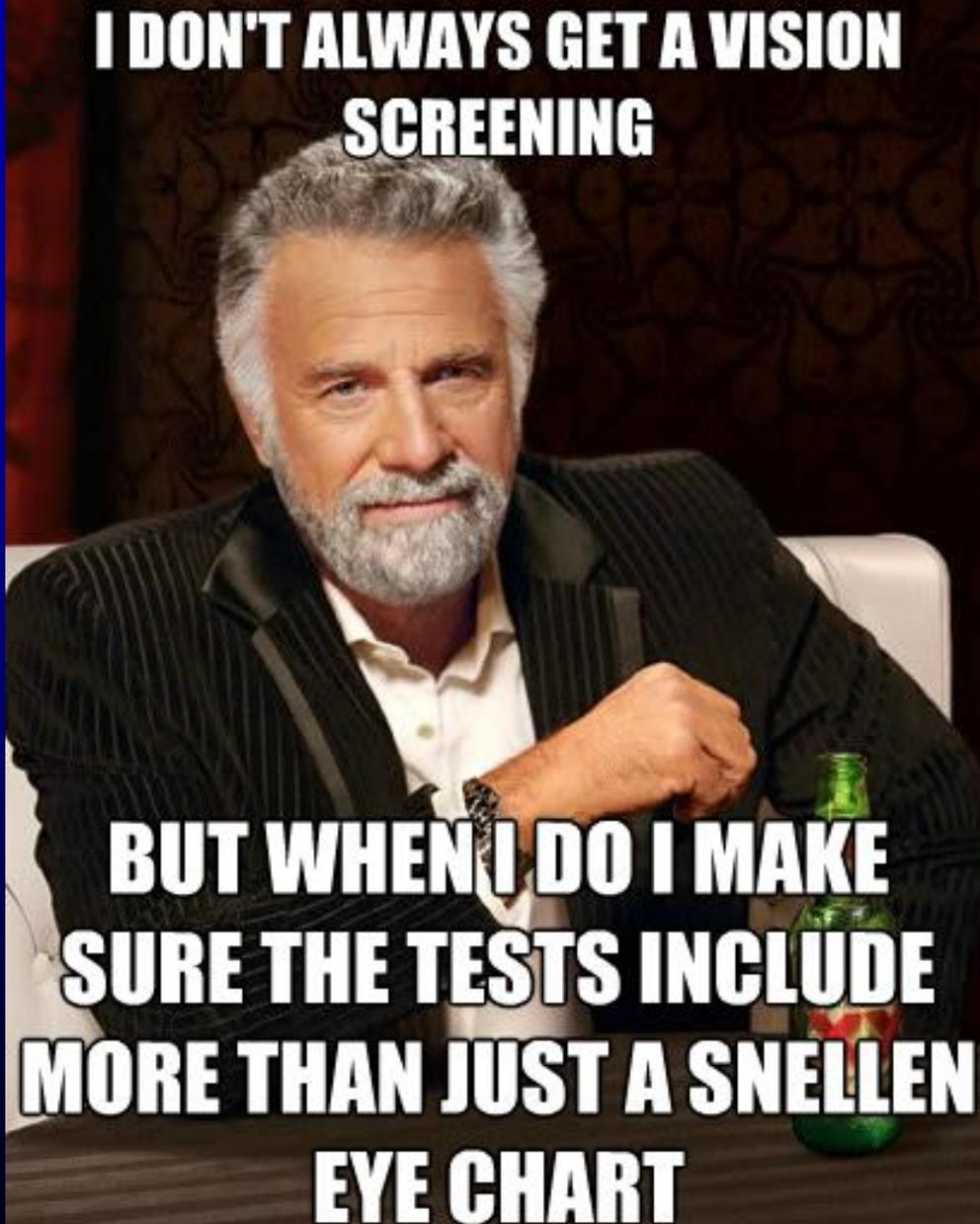
- Acuity
- Contrast sensitivity
- Dark adaptation
- Visual processing speed

People with normal acuity can have problems with functional vision

Both of these have 20/20 vision:

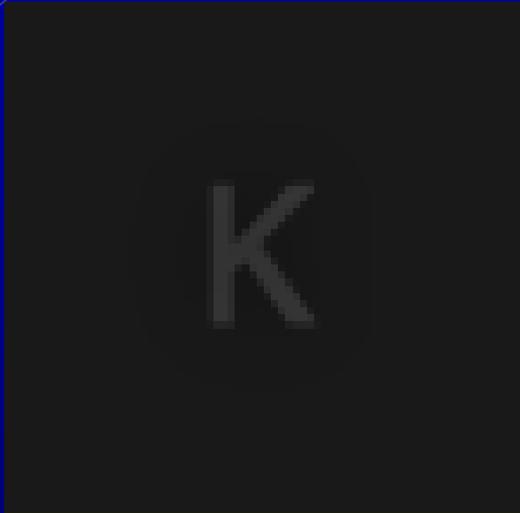


**I DON'T ALWAYS GET A VISION
SCREENING**

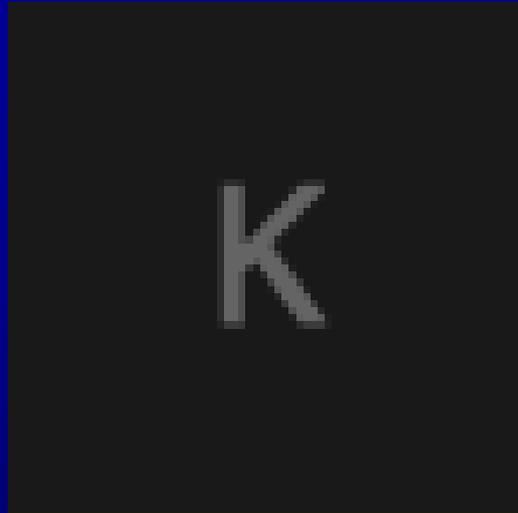


**BUT WHEN I DO I MAKE
SURE THE TESTS INCLUDE
MORE THAN JUST A SNELLEN
EYE CHART**

Manipulate contrast, measure cognition



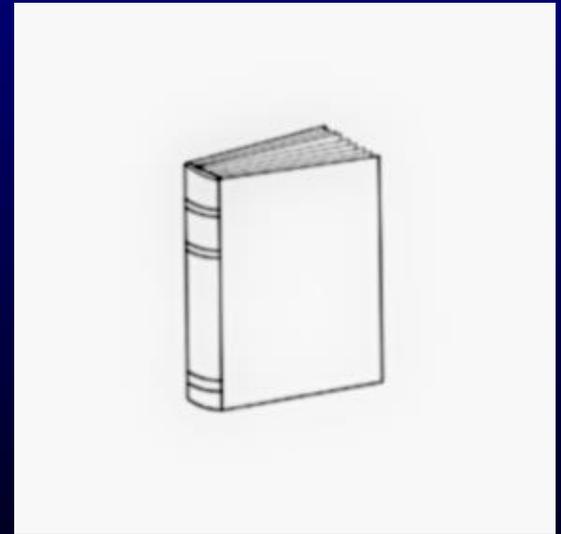
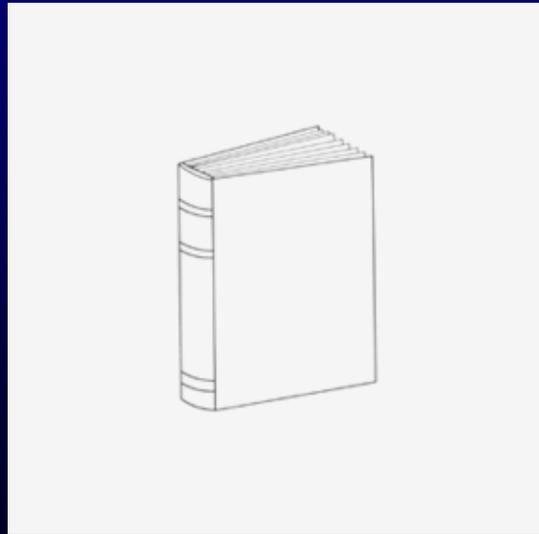
Low Contrast



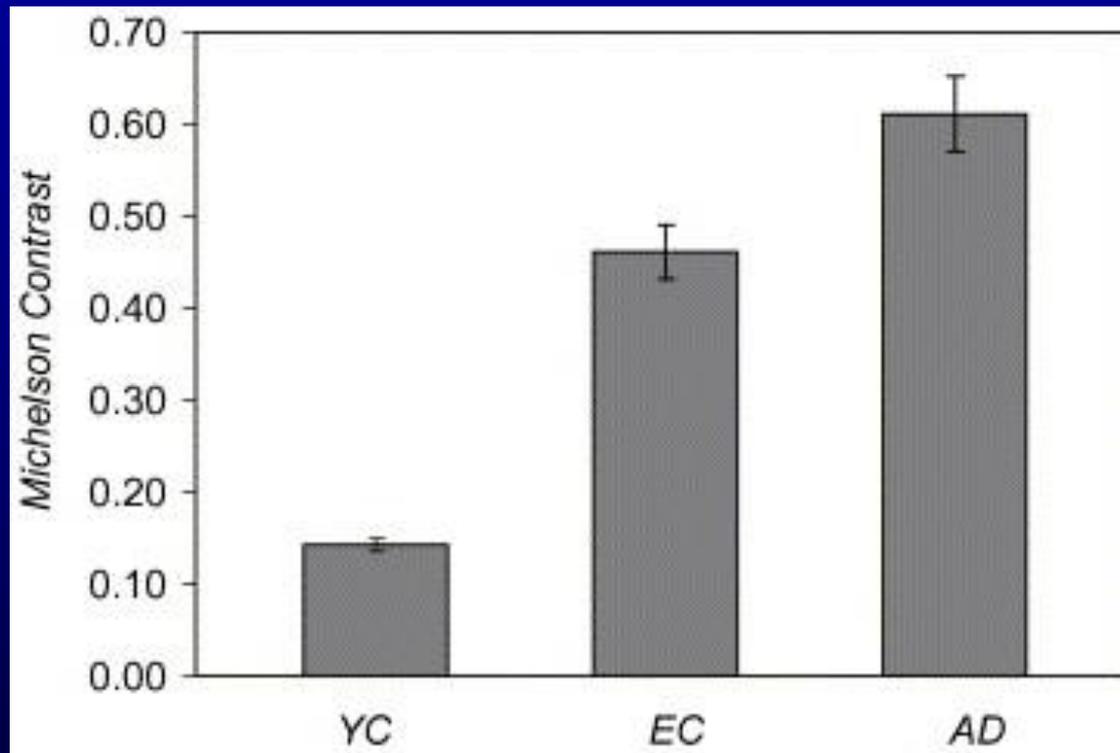
Medium Contrast



High Contrast



Letter Reading, AD vs Elderly Control vs Younger Control, accuracy at 80% criterion



AD (n=21) required more contrast than EC (n=29) ($p < .004$), and EC required more contrast than YC (n=54) ($p < .001$) to perform this task.

(Gilmore, Cronin-Golomb, Neargarder & Morrison, *Vis Res* 2005)

Implications

A visually-fair test can compensate for age-related changes in contrast sensitivity that affect object identification or visual search and reveal the cognitive difficulty “uncontaminated” by perceptual impairment.

It also suggests targets for interventions.

| B | I | N | G | O |
|----|----|------------|----|----|
| 5 | 30 | 38 | 48 | 70 |
| 7 | 22 | 40 | 56 | 63 |
| 9 | 18 | FREE SPACE | 58 | 72 |
| 15 | 23 | 32 | 51 | 67 |
| 13 | 26 | 43 | 50 | 69 |

BAD INPUT  **BAD OUTPUT**

BAD INPUT



BAD OUTPUT

**AMPLIFIED
CLARIFIED**

IMPROVED

Some methods of input amplification and clarification I:

- Contrast enhancement of stimuli
- Environmental improvement (e.g., lighting for contrast, decluttering of visual environment)
- Surgical repair (e.g., cataract removal; Project Prakash)

Some methods of input amplification and clarification II:

- Visual deprivation followed by release from deprivation, e.g., low-vision goggles:
 - adaptation; pre/post see ↓ contrast thresholds and ↑ fMRI BOLD response in V1 & V2



Kwon et al., *J. Vis.* 9, 2009;
see also Legge et al., *Ann Rev Sci* 2, 2016

Some methods of input amplification and clarification III:

- Visual adaptation with after-effects, e.g., improved letter acuity after perceived radial contraction

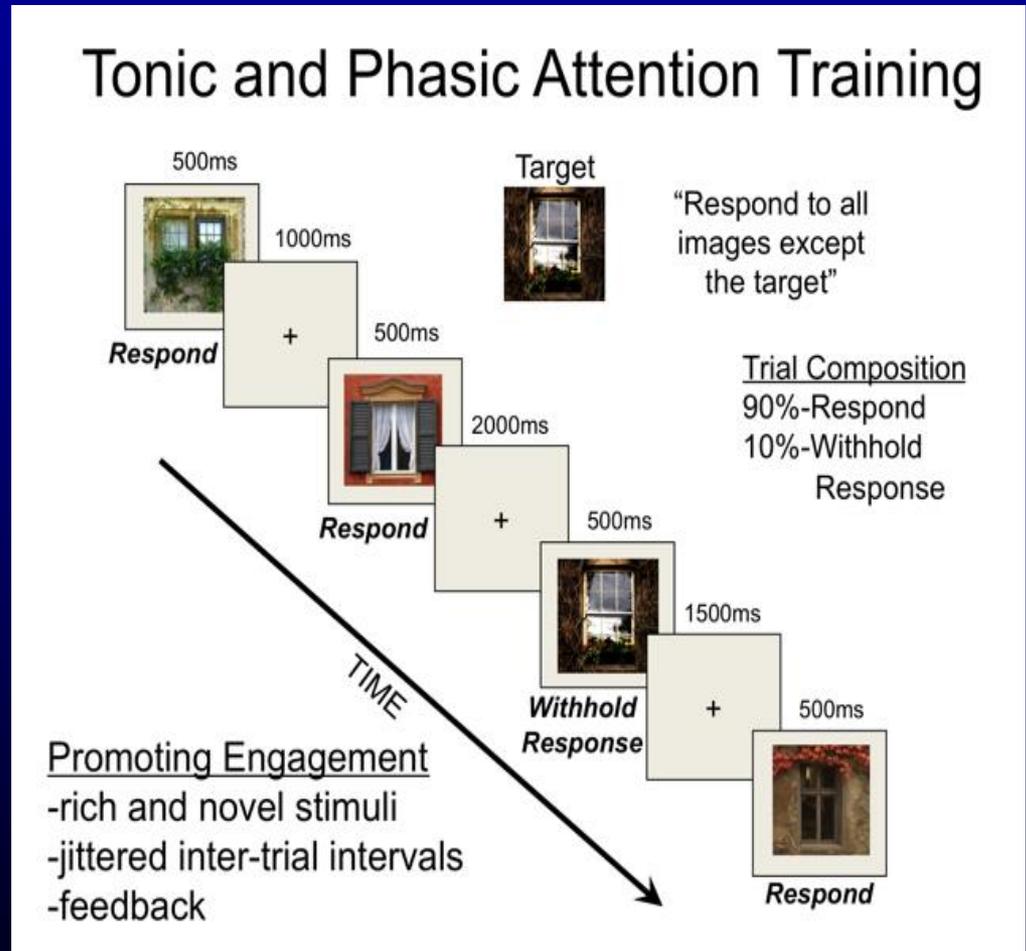


Some methods of *field* amplification and clarification I:

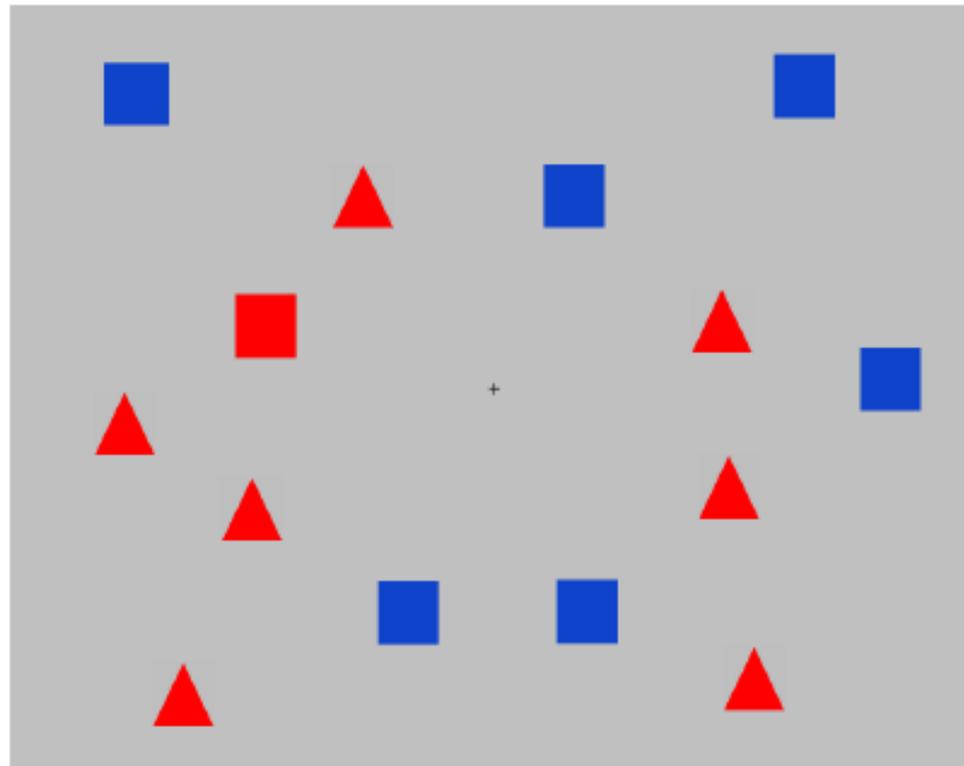
- Perceptual/attentional training (intensive repetition) (insert your favorite training task here)

Visual Attention Training

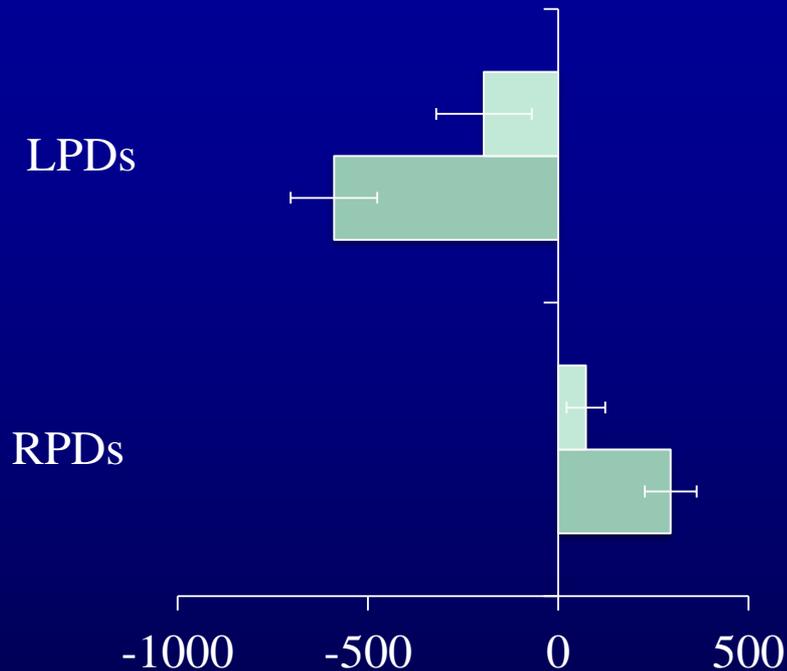
- Sustained attention training; target vs non-target discrimination
- 40 min/day, 4 days/week, 4 weeks
- Assessments at pre-training, post, and post + 4 weeks



Conjunction Search Task



Reduced Spatial Bias on Conjunction Search



- Right minus left display duration (ms) to attain 75% detection accuracy
- Negative (*positive*) numbers indicate worse performance on left (*right*) side of display.

- 5 LPD, 2 RPD with spatial bias pre-training (light green bars), reduced post-training (white bars)
- *Results indicate improvement in the spatial allocation of goal-directed attention*

LPD: left body onset PD; RPD: right body onset PD

(DeGutis et al., *Neurocase* 22, 2016)

Some methods of field amplification and clarification II:

- Perceptual training with brain stimulation (following occipital lesions)
 - Vision Restoration Therapy (3 month), training across visual field (detect light flash)
 - With tDCS to occipital lobe, or sham
 - Outcome: VF perimetry. Trend toward improvement with (but not without) tDCS (but without subjective improvement)

Though sensory-cognitive interactions (types and extents) are likely to be different across normal aging and age-related disorders, they may share a responsiveness of cognition to amplification and clarification of visual input.

Knowledge Gaps

- How aspects of vision besides acuity and contrast sensitivity relate to cognition, and through what mechanisms (*retina? brain?*)
- How cognitive change affects visual perception (*top-down effects*)
- Input/output relations may be different in *normal aging vs. age-related disorders* (e.g., Alzheimer's disease, Parkinson's disease)

Research Opportunities

- Amplification/clarification of input, beyond “proof of concept”. Devise studies to:
 - Compare multiple tried techniques
 - Develop or apply new ones (augmented reality? fNIRS?) (Look for patterns, not nec. for ROIs)
 - Assess longevity of effects
 - Assess responsiveness of various groups (normal and clinical) to individual techniques