Changes in the Human Brain with Vision Loss

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Disclosures

• **Current funding:**
  - American Parkinson’s Disease Association (PI)
  - Boston University Interdisciplinary Biomedical Research Office, Affinity Research Collaborative (PI)
  - National Institute on Aging (co-I)
  - Veterans Administration (co-I)

• **Other financial relationships:** None.

• **Conflicts of interest:** None.
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

Owsley, Ann Rev Vis Sci 2, 2016
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 SNELEN EYE CHART
Manipulate contrast, measure cognition
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, Neargardar & 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.
BAD INPUT  BAD OUTPUT
BAD INPUT \ AMPLIFIED

BAD OUTPUT \ IMPROVED

CLARIFIED
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

Lages et al., Psych Sci 28 2017
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)

(Plow et al., *Neurorehab Neural Repair* 26, 2012)
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