Technology in Amblyopia Treatment

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No conflicts of interest

Nothing to disclose
Amblyopia

• Amblyopia is the most common form of unilateral visual impairment in the adult population and results from a disruption to normal visual development early in life
Common causes of amblyopia

• Strabismic
• Refractive
• Deprivation
Technology in detection of refractive error, strabismus and media opacities

PlusoptiX

Spot 2Win
Visual Acuity

- Patching, please kids will peak!!!😊

- Single-surrounded targets work well to detect amblyopia
Amblyopia Treatment Studies (ATS)

- **ATS1** Occlusion versus Pharmacologic Therapy for Moderate Amblyopia
- **ATS2** A Randomized Trial Comparing Part-time Versus Full-time Patching
- **ATS3** An Evaluation of Treatment of Amblyopia in 7 to <18 Year Olds
- **ATS4** A Randomized Trial Comparing Daily Atropine Versus Weekend
- **ATS5** A Randomized Trial to Evaluate 2 Hours of Daily Patching
- **ATS6** A Randomized Trial of Near versus Distance Activities while Patching
- **ATS7** Bilateral Refractive Amblyopia Treatment Study: Response to Treatment of Previously Untreated Presumed Bilateral Refractive Amblyopia
- **ATS8** A Randomized Trial Comparing Atropine to Atropine plus a Plano Lens for the Sound Eye as Prescribed Treatments for Amblyopia in Children 3 to < 7 Years
- **ATS9** A Randomized Trial Comparing Patching to Atropine for Amblyopia in Children 7 to < 13 Years Old Closed 8/24/2005 12/18/2007
- **ATS10** A Randomized Trial Comparing Bangerter Filters and Patching for the Treatment of Moderate Amblyopia in Children 3 to <10 years old
Amblyopia Treatment Studies (ATS)

- **ATS11** A Randomized Trial to Evaluate Combined Patching-Atropine Treatment for Residual Amblyopia
- **ATS12** - A Randomized Trial Comparing Patching with Active Vision Therapy to Patching with Control Vision Therapy as Treatment for Amblyopia in Children 7 to <13 Years Old
- **ATS13** An Observational Study of Optical Correction for Strabismic Amblyopia in Children 3 to <7 Years Old
- **ATS14** A Pilot Study to Evaluate Levodopa as Treatment for Residual Amblyopia in 8 to 17 Year Olds
- **ATS 15** Increasing Patching for Amblyopia Study
- **ATS 16** Augmenting Atropine Treatment for Amblyopia Study
- **ATS17** A Study to Evaluate Levodopa as Treatment for Residual Amblyopia in 8 to 17 Year Olds
- **http://pedig.jaeb.org/Publications.aspx**
Cause of Amblyopia in PEDIG studies

- Combined: 21%
- Strabismus: 28%
- Anisometropia: 51%
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<th>End Date</th>
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Review of current *unilateral* amblyopia treatments

- Correction of refractive error
- Patching
- Atropine
- Bangerter filters
- Levodopa
- Other alternative treatments?
Treatment Effectiveness Factors

- Age of initiation of treatment
Amblyopic Eye at 4 Months

Cumulative Distribution

Amblyopic Eye Visual Acuity

- 2-Hours Patching
  
  - N=92

- 6-Hours Patching
  
  - N=89

4-month Amblyopic Eye Visual Acuity

- >20/16
- >20/20
- >20/25
- >20/32
- >20/40
- >20/50
- >20/63
- >20/80
- >20/100
- >20/125
- >20/160
Amblyopic Eye at 4 Months

Cumulative Distribution

Amblyopic Eye Visual Acuity

- **2-Hours Patching**
  - N=92

- **Daily Atropine**
  - N=77

- **Weekend Atropine**
  - N=83

- **6-Hours Patching**
  - N=89

4-month Amblyopic Eye Visual Acuity
Treatment of Amblyopia in Children 7-<18 Years Old

Compliance?
Some Lessons learned from ATS

• **Patching, bangerter filters, and atropine** are similarly effective

• For **severe** amblyopia, **6 hrs** patching or **nightly** atropine works well

• For **moderate** amblyopia, **2 hrs** patching or **weeknight** atropine works well

• **Refractive correction** alone can improve vision a lot within the first 4 months

• **Age of initial treatment** seems to have an effect on treatment success (a younger child is more likely to succeed)

• **Older** children may require **combined** mechanisms of treatment for improvement
But...Is amblyopia a reduction of visual acuity only?

- Accommodation
- High spatial contrast sensitivity
- Ocular motility
- Detection of motion
- Stereopsis
- Suppression scotomas in VF
- Fine motor skill deficiencies
- Gaze control

More functions need to be improved other than just Visual acuity!

Visual Processing

• Amblyopia is not limited to the eye alone!
• We must take into account the entire process:
  – From the moment the stimulus reaches each eye (and it’s perceived unequally)
  – To the point when it is transmitted and analyzed at the visual cortex
• Important to consider all the sensory aspects of visual processing
• To understand the way that amblyopia treatment can maximize and optimize the binocular stimulus to the visual cortex while there is plasticity.
What are we currently learning from adult brain studies?

Monocular Perceptual Learning?

• Adults with normal vision can improve their contrast sensitivity, visual crowding, and visual attention through playing **ACTIVE** video games (i.e. Medal of Honor: Pacific Assault)

• For amblyopic adults...the less plastic brain of the adult requires “**attention and action** using the amblyopic eye, supervised with feedback” in order to provide effective treatment

• Fewer total hours of therapy needed

• Boredom with other tasks as a factor?

http://www.youtube.com/watch?v=71RML96XxCI

Why ‘Active’ treatment?

• Attempts to improve treatment effectiveness by adding active monocular treatment
• To not only ‘penalize’ the dominant eye, but also to improve other visual abilities of the amblyopic eye
• Also, motor biofeedback loops?
So...we know that amblyopia originates from an abnormal binocular experience

- We have known that: it is caused by a **reduction in the stimuli to binocular neurons** in the visual cortex during the critical period
- Recently, there has been some scientific evidence that the damage may be reversible in some cases.
- There are adult studies evaluating the cortical activity in amblyopic patients, using electrodiagnostic techniques...
What happens in the brain when you patch one eye of a binocularly normal subject?

It strengthens that eye's contribution to the binocular percept when the patch is Removed!!!

So... in amblyopic subjects would the dominant eye become ‘stronger’ when the patch is removed?

Inbalance of the monocular signals
Then...maybe it’s more important to strengthen FUSION to avoid SUPPRESSION

• Since amblyopia is a binocular dysfunction
• ‘The ‘affected’ may not be “lazy” but it may actually be a victim of active inhibition of the neurological impulses of the ‘dominant’ eye’
• The recovery of visual functions can take weeks and could result from the establishment of new and/or stronger synaptic connections in the primary visual cortex
• The brain's potential for change exists for all types of amblyopia?

Neural mechanisms of amblyopia

• Amblyopia, a monocular vs. a binocular issue?
  – Patching produces *strengthened* contribution of patched eye after patch is removed
  – After patching there is still a *mismatched* image from each eye
• Binocular plasticity-Where does ‘binocularity’ happen?
  – Higher order neurons in visual cortex dedicated to binocularity
• Does plasticity stop? *Critical period*?
  – Older patients being able to improve?
  – Shorter time for treatment?
• Motion stereopsis vs Static stereopsis
  – Movement and feedback mechanisms enhance improvement
Stereopsis

- Nil stereoacuity was associated with risk for poor response to amblyopia treatment. Children with no stereo have more unstable fixation in the amblyopic eye, disrupting bifoveal fusion.

- Children with anisohyperopia and nil stereo are more likely to develop microtropia.


Tests of suppression

• Worth four dot
• Bagolini striated lenses
• Psychophysics toolbox
Lazy Eye Treatment: Video Game Can Help Correct Amblyopia, Say Researchers

The patients treated using Tetris showed a four-fold improvement in vision in their lazy eye compared with those who were patched, said ophthalmologist Dr. Robert Hess, director of vision research at the McGill University Health Centre and principal investigator of the study.

"The game itself is sort of incidental in a way," Hess explained "It just provides us with a platform to administer this training that we need to do in a way that's enjoyable.

“We know the eye itself is fine; we know it's all in the brain," said Hess. "We're now beginning to realize that it's just the software that's gone wrong."

http://www.huffingtonpost.ca/2013/04/22/video-game-lazy-eye_n_3134354.html
Effective binocular treatments incorporate...

• A task that requires information to be combined between the two eyes and begins with a patient-specific interocular contrast offset that overcomes suppression and allows for the task to be completed

• Reducing contrast to the fellow eye to equate the visibility between amblyopic and fellow eyes can allow binocular contrast summation

Bi-ocular Techniques being evaluated

• Red-green or cyan (anaglyph)
• Lenticular overlay screens
• 3D games
3D games


Garganti A. Using Stereoscopic 3D Technologies for the Diagnosis and Treatment of Amblyopia in Children-3D4AMB-NVIDIA
Equipment being evaluated

• PC (with Cyberscope)
• Binocular head-mounted viewers
• 3D monitor
• iPad
• iPod
• Nintendo
• Wii
• Others?

PEDIG- Study of Binocular Computer Activities for Treatment of Amblyopia

- Strabismic or anisometropic 5-17 yo
- Able to align nonius cross (fixation disparity test)
- Contrast differences:
  - Amblyopic at 100%
  - Non-amblyopic eye at 20%
iPad Tetris Binocular
Challenges of at-home treatments

• On-line compliance monitoring
• Updates for intraocular contrast
• Dichoptic presentations may require a specific head posture
Home-based vs office-based treatment

- Current studies have demonstrated improvements with in-office treatments even in adults
- Smaller studies with at-home treatments are showing some success
- Upcoming research directions
- How to implement the current findings in your practice
Necessary correction during treatment

• Refractive correction
• Prismatic correction for deviation?
• Contrast adjustment?
• http://pedig.jaeb.org/Studies.aspx

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