

# Pediatric Vision Testing & Amblyopia

Scott A. Larson MD



# Vision Testing

- **Detection**
  - Response to the presence of a stimulus
    - Behavioral response (e.g. child looks at it)
    - Electrophysiologic response
    - typically easier
- **Discrimination**
  - Identification of a unique optotype
  - Requires more cognitive processing

# Vision testing in Children

- Psychophysical Tests
  - Define a threshold of detection or discrimination
  - results influenced by perceiver's judgement and perception not just optics and neurotransmission.
    - cognition & cooperation

# Visual System Milestones

| Mean Age | Milestone                |
|----------|--------------------------|
| 30 weeks | Pupillary Light reaction |
| 2 months | Fixation                 |
|          | Alignment Stabilized     |
| 3 months | Visual Following         |
|          | Saccades                 |

# Visual System Milestones

| Mean Age            | Milestone                           |
|---------------------|-------------------------------------|
| 4 months            | Accommodation Appropriate to Target |
|                     | Foveal maturation                   |
| 4-7 months          | Stereopsis                          |
| 7 months to 2 years | Optic nerve myelination             |

# Visual Acuity Ranges

(Teller cards)

| Age       | Normal Vision   |
|-----------|-----------------|
| Birth     | 20/400 - 20/800 |
| 2 months  | 20/150 - 20/400 |
| 6 months  | 20/100 - 20/400 |
| 1 year    | 20/50 - 20/80   |
| 2-5 years | 20/20 - 20/40   |

# Normal Visual Acuity By Age Matching or Naming

| Years old | Vision        |
|-----------|---------------|
| 2         | 20/50 - 20/60 |
| 3         | 20/50         |
| 4         | 20/40         |
| 5         | 20/30         |

# Developmental Milestones

| Age      | Behavioral Event                      |
|----------|---------------------------------------|
| Neonatal | Sucking, rooting, swallowing reflexes |
| 4 mo     | Lifts head in sitting position        |
| 6 mo     | Rolls over                            |
| 9–10 mo  | Sits up                               |
| 10–11 mo | Crawls                                |
| 12–15 mo | Walks unassisted                      |
| 18 mo    | Walks up and down stairs holding on   |
| 3 yr     | Can stand on one foot                 |



# Teller Cards

- Well established testing methods
- Often used in large studies



# Teller Cards Testing method

- 15 cards with 12x12 cm gratings (black+white=1 cycle)
- One “low vision card”, One blank card
- All lights on in the room
- Measure testing distance: 55 cm most common



# Teller Cards Testing Method

- Start with blank and low vision card- observe response
- Present card in “masked fashion” two times
- Sort cards in “Seen and not seen piles”
- Record finest spacial frequency and test distance
- Transpose to Snellen equivalent if desired
- Introduces error in interpretation



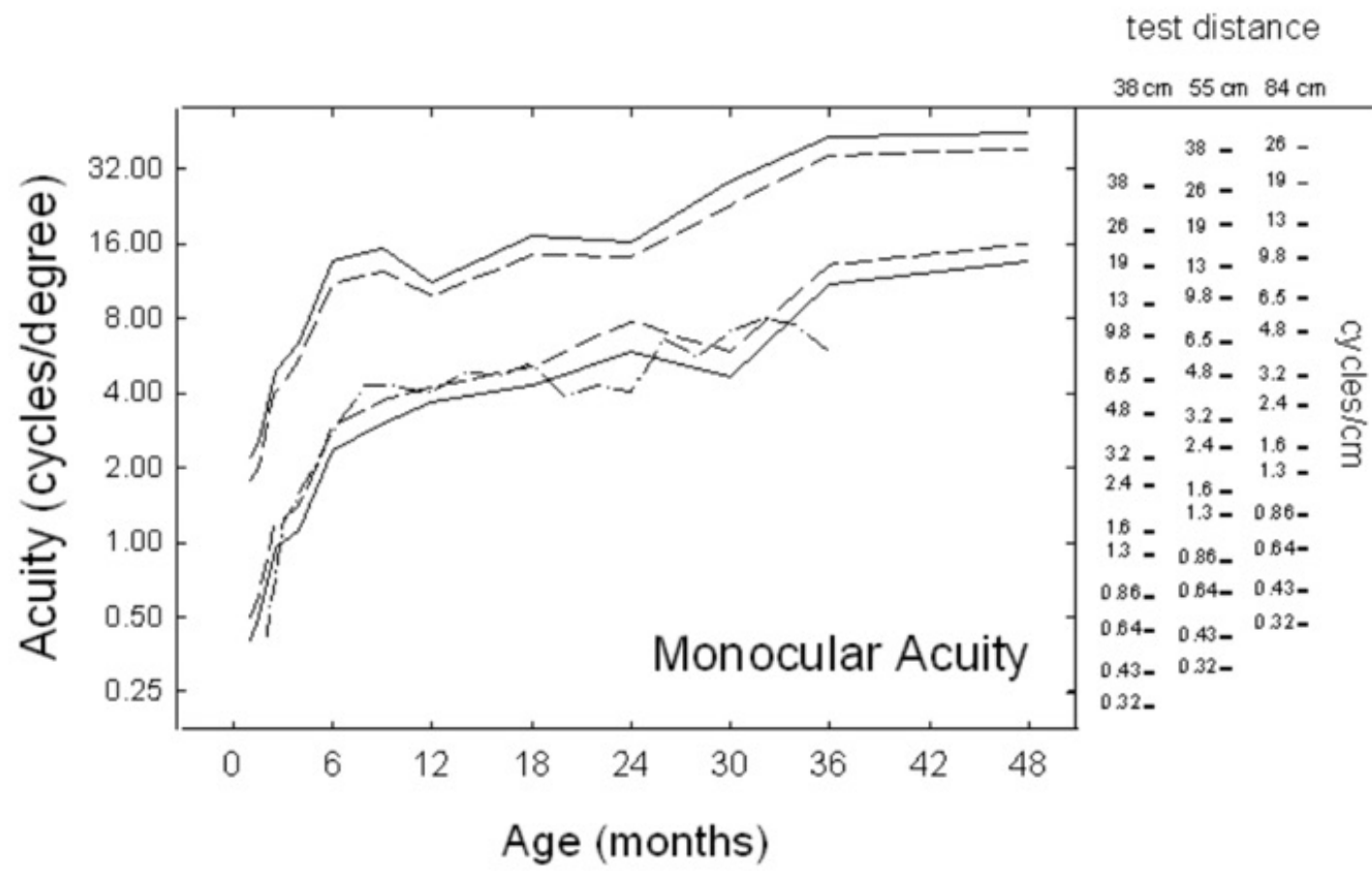
J AAPOS 2006;10:547-551

# Teller Cards

## CONVERSIONS FROM CYCLES/CM TO SNELLEN EQUIVALENTS<sup>®</sup>

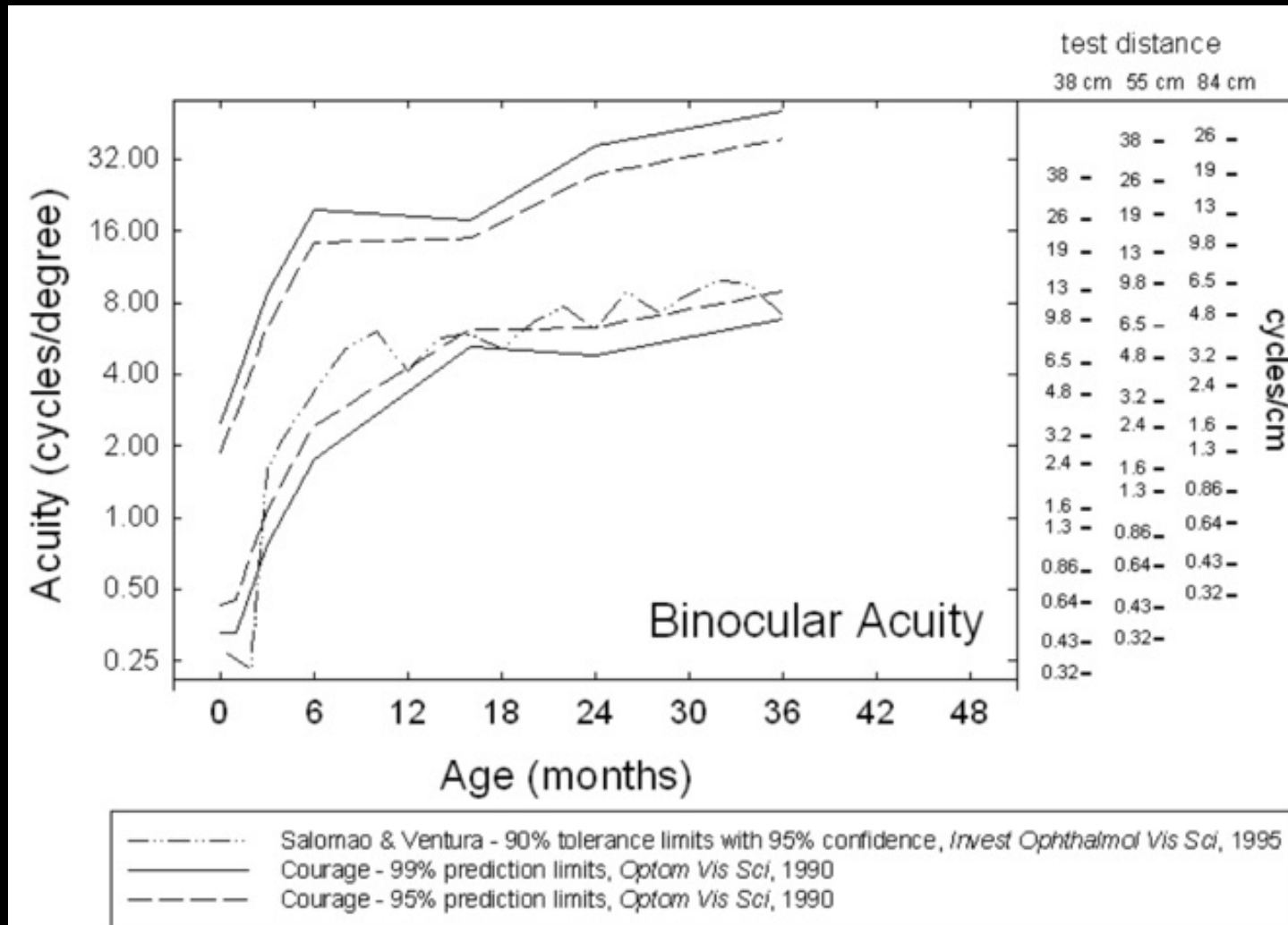
| <u>CYCLES/CM</u> | <u>TEST DISTANCE<sup>+</sup></u> |         |         |         |         |
|------------------|----------------------------------|---------|---------|---------|---------|
|                  | 9.5cm                            | 19cm    | 38cm    | 55cm    | 84cm    |
| 38.0             | 20/57                            | 20/40   | 20/23   | 20/16   | 20/11   |
| 26.0             | 20/84                            | 20/59   | 20/33   | 20/24   | 20/15   |
| 19.0             | 20/110                           | 20/81   | 20/45   | 20/32   | 20/21   |
| 13.0             | 20/170                           | 20/120  | 20/66   | 20/47   | 20/31   |
| 9.8              | 20/220                           | 20/160  | 20/89   | 20/63   | 20/41   |
| 6.5              | 20/340                           | 20/240  | 20/130  | 20/94   | 20/63   |
| 4.8              | 20/460                           | 20/320  | 20/180  | 20/130  | 20/84   |
| 3.2              | 20/680                           | 20/490  | 20/270  | 20/190  | 20/130  |
| 2.4              | 20/910                           | 20/650  | 20/360  | 20/260  | 20/170  |
| 1.6              | 20/1400                          | 20/970  | 20/540  | 20/380  | 20/250  |
| 1.3              | 20/1700                          | 20/1200 | 20/670  | 20/470  | 20/310  |
| 0.86             | 20/2500                          | 20/1800 | 20/1000 | 20/710  | 20/470  |
| 0.64             | 20/3300                          | 20/2400 | 20/1400 | 20/960  | 20/630  |
| 0.43             | 20/4800                          | 20/3500 | 20/2000 | 20/1400 | 20/940  |
| 0.32             | 20/6400                          | 20/4700 | 20/2700 | 20/1900 | 20/1300 |
| 0.23**           | -----                            | -----   | -----   | -----   | -----   |

# Teller Cards



- ..... Salomao & Ventura - 90% tolerance limits with 95% confidence, *Invest Ophthalmol Vis Sci*, 1995
- Mayer et al. - 99% prediction limits, *Invest Ophthalmol Vis Sci*, 1995
- Mayer et al. - 95% prediction limits, *Invest Ophthalmol Vis Sci*, 1995

# Teller Cards



# Fixation Preference

- Assumptions:
  - Child will prefer to use the eye with better vision.
  - Child will have no preference if vision is equal.
- Must know where child is fixating
- C, S, M; UC, US, UM
  - Central fixation vs. eccentric fixation
  - Steady: variable fixation or nystagmus
  - Maintained: holds fixation through blink





# Fixation Preference

- Blink = break in fixation
- Unmaintained fixation
  - Immediately switches fixation to preferred eye
  - Holds for 1-3 seconds
  - Holds to a blink
- Maintained fixation
  - Holds through a blink





# Fixation Preference

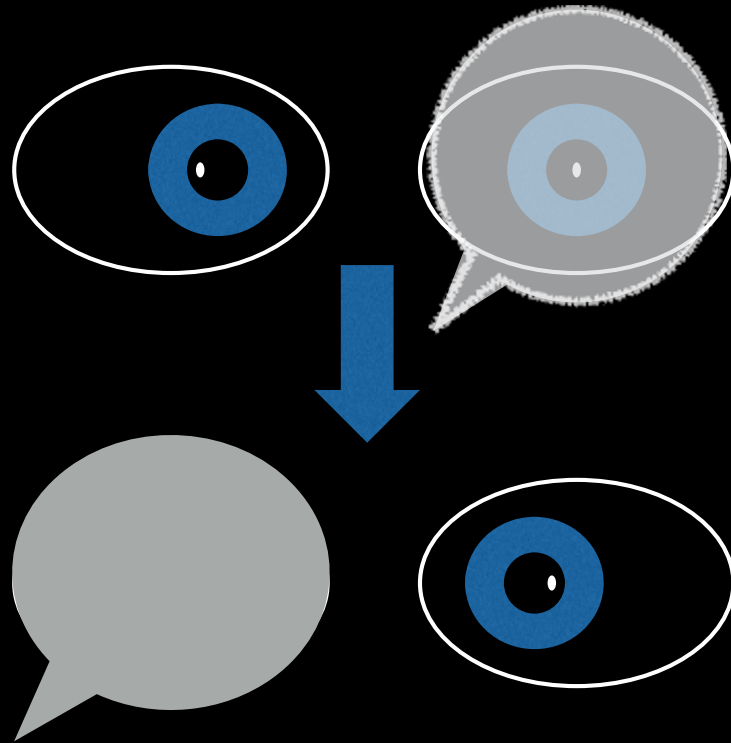
| Visual Acuity    | Fixation Pattern                      |
|------------------|---------------------------------------|
|                  | No fixation                           |
| 5/200 or less    | Eccentric                             |
| 5/200 to 20/300  | Unsteady                              |
| 20/200 to 20/100 | Central but not held                  |
| 20/70 to 20/30   | Central will hold but prefers one eye |
| 20/20 OU         | Alternates spontaneously              |

# Fixation Preference

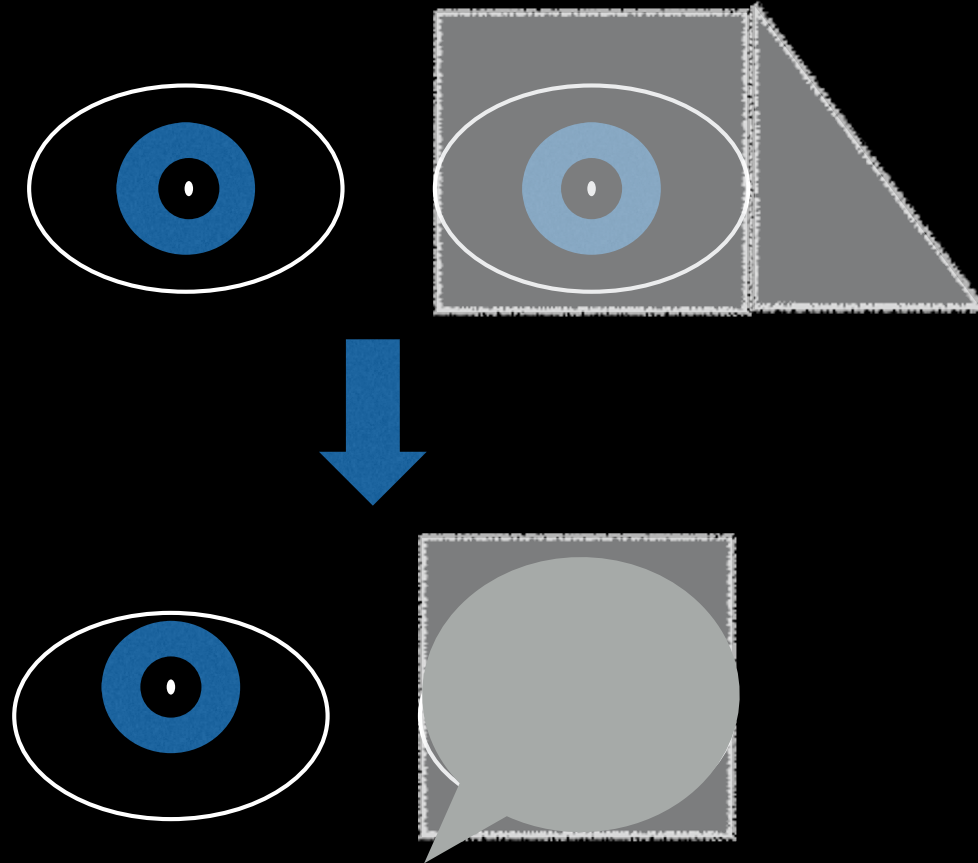
- Strabismus
  - Observe child for preferred eye
  - Make child use non preferred eye
  - Response should be equal for equal vision
- No Strabismus
  - use 16 $\Delta$  Base Down over eye
  - Eyes move up when picking up fixation under prism
  - Repeat for both eyes

# Fixation Preference

- Fixation preference without significant amblyopia (False Positive)
  - More common in small angle esotropia, monofixators
  - Use 16 $\Delta$  Base Down to reduce false positive results in Esotropia < 12 $\Delta$
  - Well treated unilateral aphakia, pseudophakia
- No fixation preference but has amblyopia (False negative)
  - Older children (>4 or 5 yrs)
  - “I see two...”



1. Shifts back immediately
2. Holds for a small time
3. Holds up to a blink
4. Holds through a blink



1. Shifts back immediately
2. Holds for a small time
3. Holds up to a blink
4. Holds through a blink

**Distance Visual Acuity Test (E Game)**  
 (Read in good light at 10 feet.)




**Line 1**  
 20/200



**Line 2**  
 20/100



**Line 3**  
 20/40

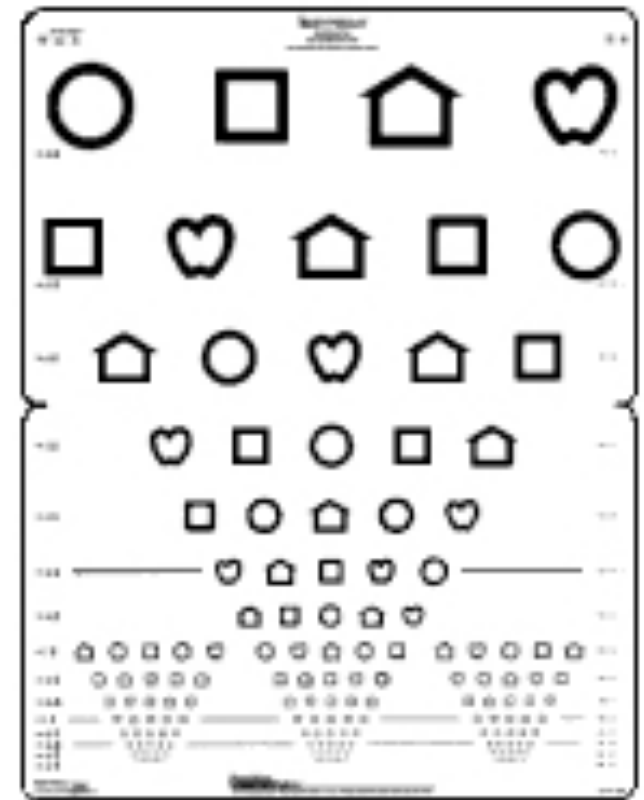


**Line 4**  
 20/20



---

 100 Millimeter Calibration Bar  
 (If not 100 mm, see text of visual acuity page.)

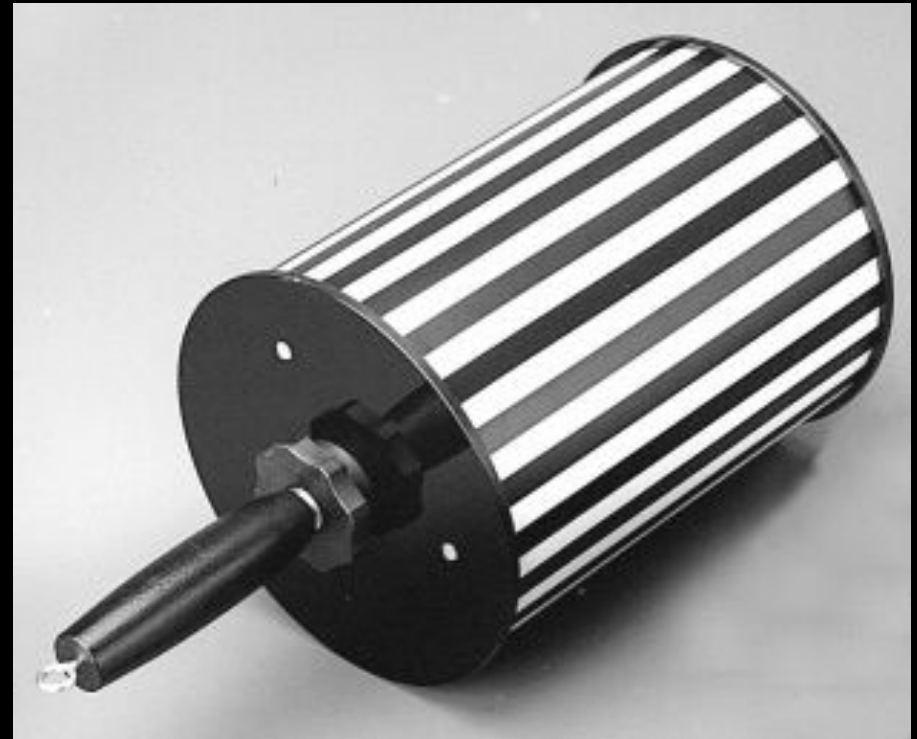


# Vision Testing

- HOTV
- Snellen letters
- Numbers
- Always test with full line and pointing device or crowding bars
  - Amblyopes will do artificially better with single optotypes
- Test distance and near vision

# Optokinetic Nystagmus

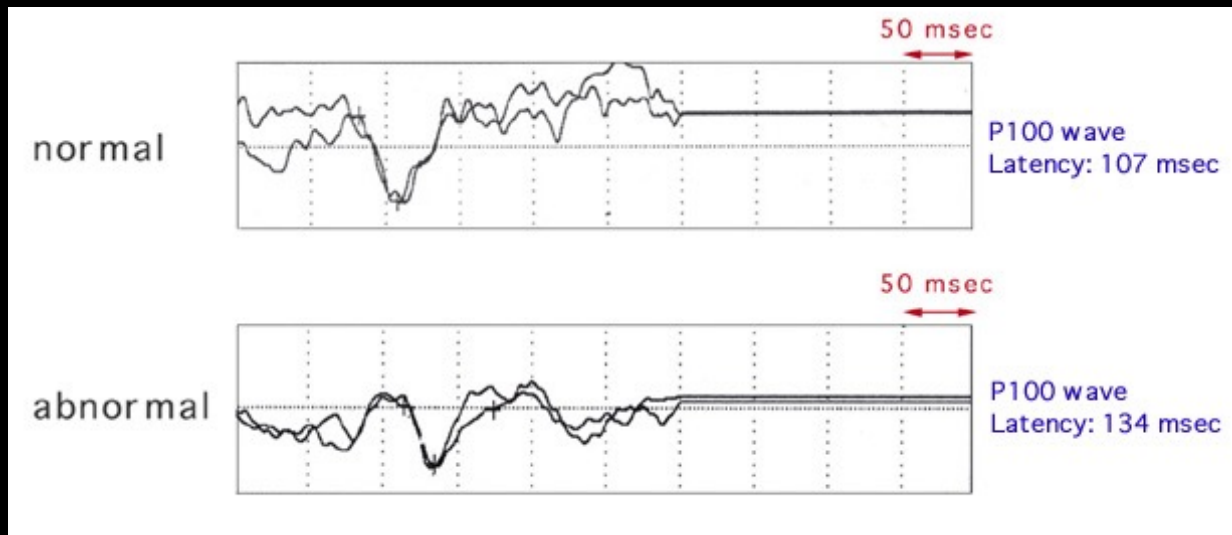
- OKN response
  - Gross vision depending on distance
- Can use Vestibular ocular response





# Visual Evoked Potential

- Measure occipital lobe response to visual stimuli
- Flash or Patterns
- “Sweep”



# Amblyopia

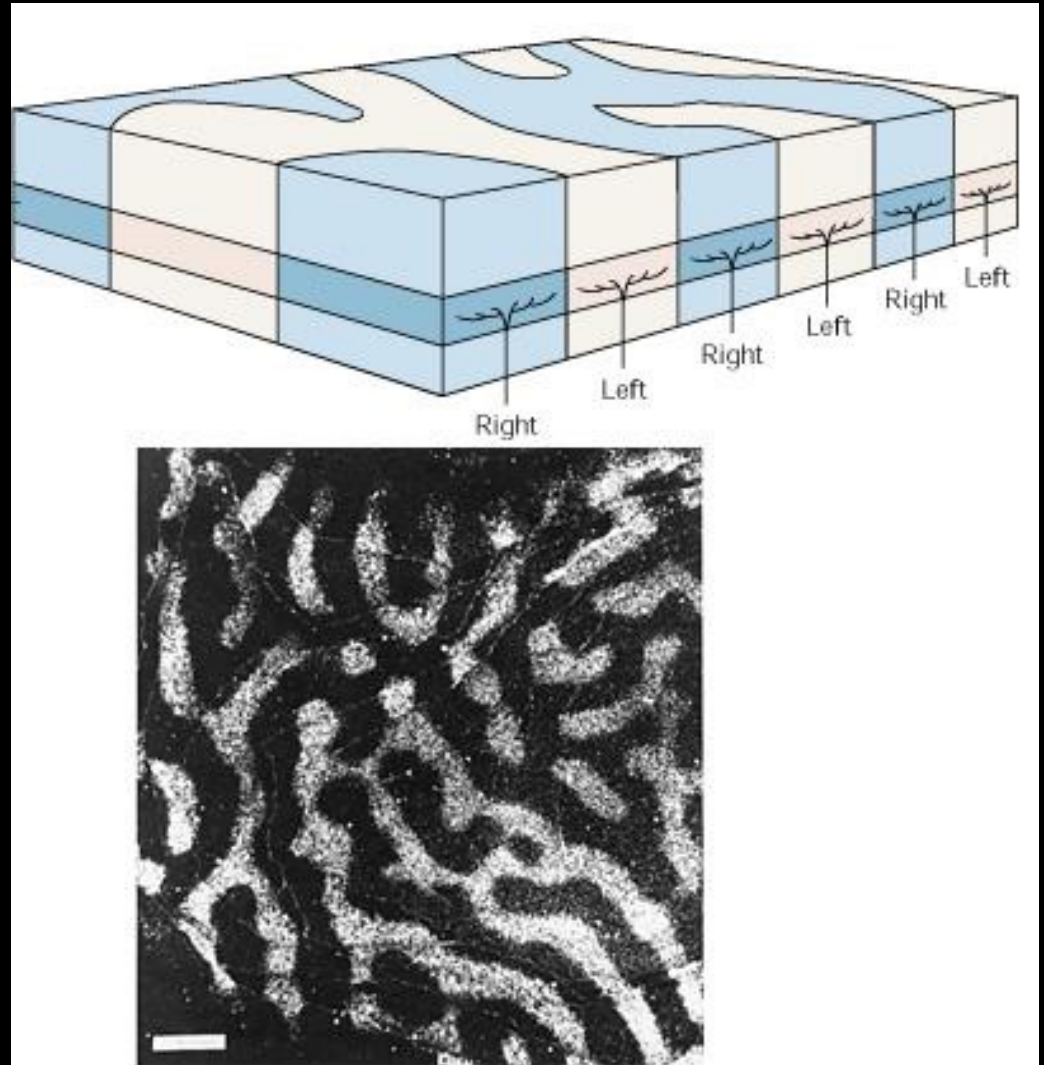
- Poor vision due to abnormal visual stimulation leading to abnormalities in visual centers in the brain
- Affects 2-4% of children
- Most common cause of decreased vision in childhood and young adulthood

# Amblyopia

- Most definitions: at least 2 lines of visual loss between eyes
- Visual development critical period
  - 1 week to 3 months of age
- Children susceptible between birth and age 7

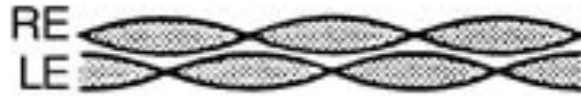
# Visual Cortex

- Cells arranged in highly organized columns
- “Cross-talk” between columns needed for binocular and stereovision

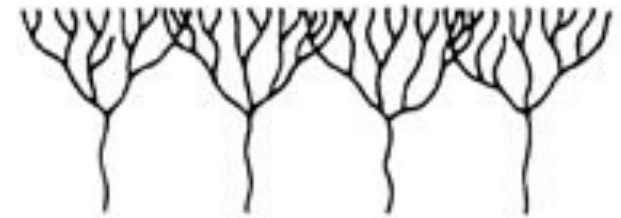
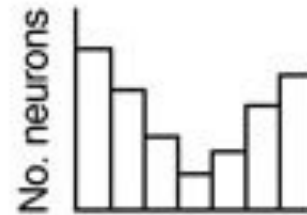


# Visual Cortex

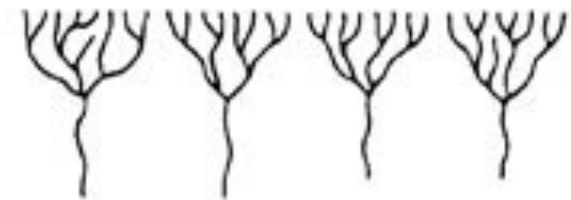
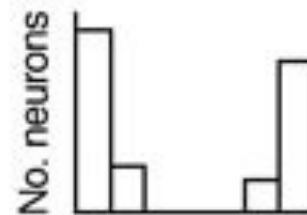
Birth



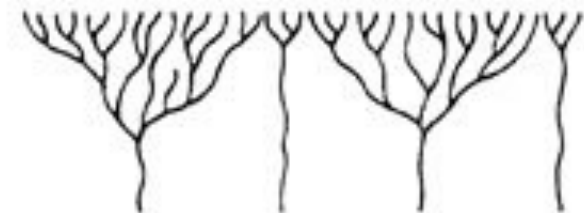
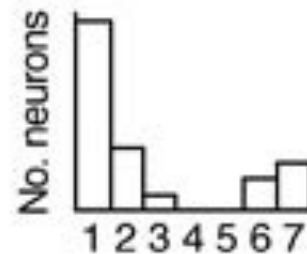
Normal  
6-month-old



Strabismus



Amblyopia



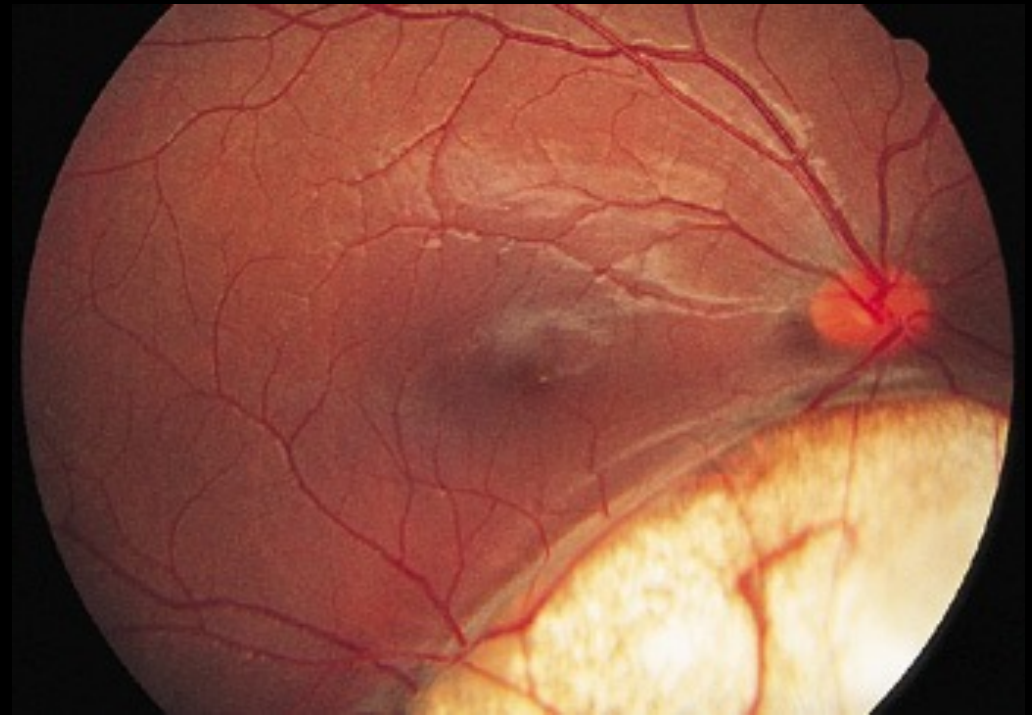
1 2 3 4 5 6 7

# Amblyopia Causes

- Strabismus
  - Esotropia: 60%
  - Intermittent Exotropia: rare and if present usually mild
  - Vertical deviations: rare (head tilt)
- Deprivation: media opacities
- Anisometropic:  $> +1.00$ ,  $-2.00$  or  $+1.50$  cyl
- Ametropic: bilateral high refractive error (not myopia)

# Amblyopia Causes

- Organic
  - Structural abnormalities that are not treatable
    - Optic nerve hypoplasia
    - Macular scar
    - Coloboma



# Amblyopia Vision

- Crowding phenomenon
  - Better seeing single optotypes
  - 1-2 lines better
  - May represent the difference in receptive field of cortical neurons
- Neutral Density Filter effect
  - More resistant to decrease in luminance



# Amblyopia Vision

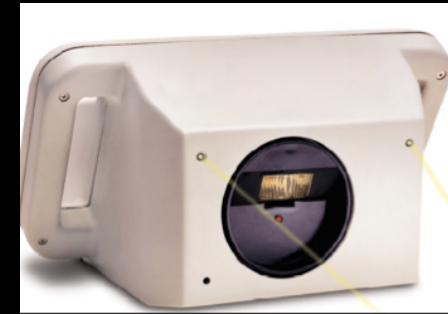
- Extrafoveal fixation
  - More apparent in those  $>20/200$
  - Use a large parafoveal area for fixation
  - More subtle in eyes with better vision
  - Used in one type of screening device

# Screening

- Test vision directly
- Test for risk factors
  - Refractive Error, anisometropia, strabismus

# Screening

- Photo Screening
- Autorefractors
- Stereovision testing
- Acuity Testing
- Other Testing (Light reflex, cover test, ophthalmoscopy, VEP)



# Amblyopia Treatment

- Clear Retinal Image
  - Spectacles
  - Correct anisometropia
  - May under-correct hyperopes up to +2.00
  - Cataract surgery
  - Corneal surgery
- Strabismus surgery more effective if amblyopia treated first

# Amblyopia Treatment

- Patching
  - Occlusion of better seeing eye
  - Can reverse cortical abnormalities
  - Most effective treatment for severe amblyopia (>20/80)
  - Compliance problems
  - Associated with “occlusion amblyopia”
    - Best vision were in those who had occlusion amblyopia in Iowa series

# Amblyopia Treatment

- Full time occlusion
  - Follow-up one week for every year of age up to 4 weeks
    - 2 year old, follow up in 2 weeks
    - 4 year old, follow up in 4 weeks
    - $\geq 5$  year old, 4 weeks
- Part time occlusion
  - Follow up every 6 to 8 weeks.



# Amblyopia Treatment

- Penalization
  - Atropine 1%
    - Cheap
    - Safe in once daily dosing
      - Side effects: flushing, tachycardia, behavioral changes, pupil dilation up to 10 days
    - Improved compliance
    - Equivalent to ~2 hours of patching/day
    - Blurs to about 20/100 at best
    - Augmented with removal of optical correction
    - Follow up every 6-8 weeks

# Amblyopia treatment

- Tape or Bangerter foil over glasses lens
  - Peaking!
- Blurring contact lens
  - High plus lenses
  - Rub them out easily
- Too radical for normal people:
  - Sewing eyelid: peaking
  - Botox to eyelid: hold up lid
  - Sewing plastic to face:





# Amblyopia Treatment

- Amblyopia treatment studies
  - Pediatric Eye Disease Investigator Group (PEDIG)
  - Multi-centered, controlled trials
  - Showed benefit from patching up to age 17
  - Showed benefit from atropine
  - Showed benefit from refractive correction
  - Better information about recidivism

# Amblyopia Treatment Studies (PEDIG)

- Success = 3 lines of improvement or 20/30 Vision
- Found 12 hours/day = 6 hours/day = 2 hours/day = Daily atropine = Weekend atropine
- Unable to accurately monitor compliance
- No association with age or time of patching

# Amblyopia Treatment

- Monitored Occlusion Treatment for Amblyopia Study
  - “Kinetics” of therapeutic response
  - Cumulative number of hours needed to gain improvement
    - Age dependent
    - 2 line improvement in VA
      - 170 hours for 4 year old
        - » 14 days of patching (12hrs/day)
        - » 85 days of patching (2hrs/day)
      - 236 hours for 6 year old
  - Treatment most effective within first few weeks of treatment



# Amblyopia Treatment – future?

- Asymmetric Binocular Stimulation
  - Binocular suppression may be a factor limiting vision improvement
  - Anaglyphic glasses
  - Leverage difference in images between eyes



# Amblyopia treatment- future

- Improving compliance
  - Socioeconomic factors
  - Using smart phones

