Rapid assessment of core visual deficits in Amblyopia

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INTRODUCTION

Amblyopia (lazy eye) is defined as optically uncorrectable loss of vision, usually in one eye, without any known pathology[1]. Two major amblyogenic factors include ocular misalignment and unequal refractive errors (Fig. 1). Amblyopia is one of the leading cause of monocular vision loss in children in the US[2].

A wide range of visual deficits are associated with amblyopia (Fig. 2), but currently acuity is the only outcome measure for amblyopic treatment. This is a widely recognized limitation but inefficacy of psychophysical assessments, such as long testing time, has been a major obstacle in resolving this limitation.

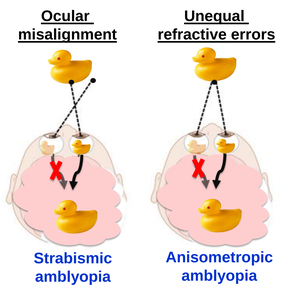


Fig. 1. Two major amblyogenic factors

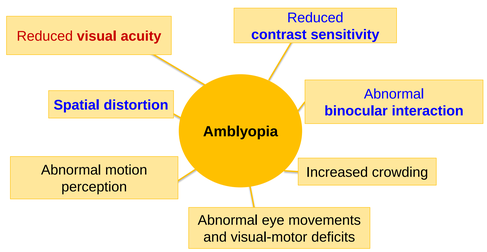


Fig. 2. Various amblyopic deficits and **three core deficits** of amblyopia

AIMS

- **To develop efficient methods to rapidly assess core deficits in amblyopic vision.**
- **To validate the efficacy of these methods in characterizing amblyopic deficits.**

METHODS

Participants

- Testing was carried out in an ophthalmology clinic.
- 4 subject groups: strabismic amblyopia, anisometropic amblyopia, strabismus and normal.
- Subjects, age 5-60 (mean age 20).
- Completion of all 3 tasks took ~20-30 minutes.
- Subjects were tested with best corrected vision.

1: Assessing *Contrast Sensitivity* Function (CSF)

- Quick CSF method[3].
- Letter recognition task using band-pass filtered Sloan letters.
- Both binocular and monocular viewing with each eye were tested, taking ~4-5 minutes.

Contrast sensitivity was quantified as the area under the curve (AULCSF) (Fig. 4).

Fig. 3. iPad retina display

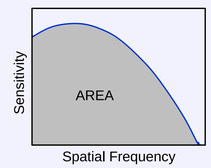


Fig. 4. Quantification of contrast sensitivity: area under the curve (AULCSF)

2: Assessing *Binocular Interaction*

- Dichoptic matching task[4].
- Supra-threshold sinewave gratings of the same spatial frequency (1 cpd) were presented to two eyes, but differing in spatial phase by 90˚.
- Subjects were asked to align the reference line with the center of the dark stripe in the combined percept (Fig. 5).

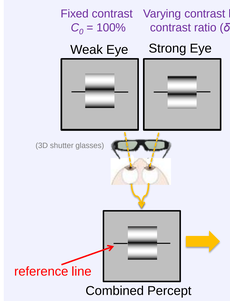


Fig. 5. Dichoptic matching task

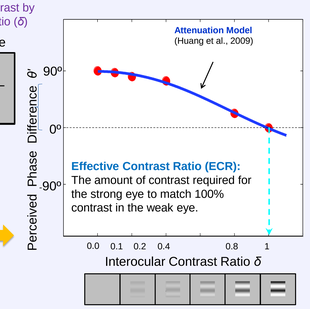


Fig. 6. Estimating effective contrast ratio

3: Assessing *Spatial Distortion*

- Dichoptic pointing task.
- Subjects were asked to fixate on center white dot while moving green cross hair to capture red dot (Fig. 6).

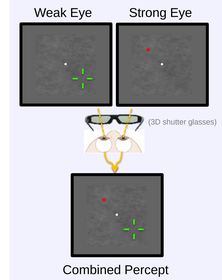


Fig. 7. Dichoptic pointing task

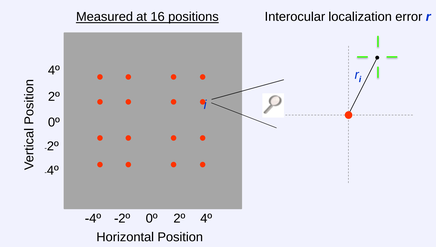


Fig. 8. Interocular localization error

Spatial distortion was quantified using interocular localization errors:

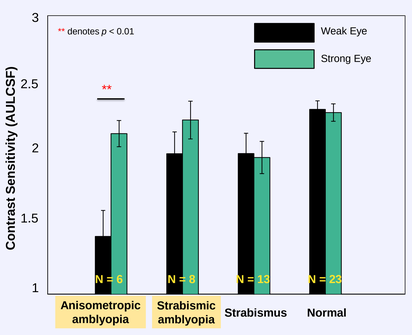
1. Global Error = $\frac{1}{n}\sum_{i=1}^{n} r_i$ ➔ **overall ocular deviation**

2. Local Error = $\frac{1}{n}\sum_{i=1}^{n}(r_i - global\ error)$ ➔ **overall local distortion**

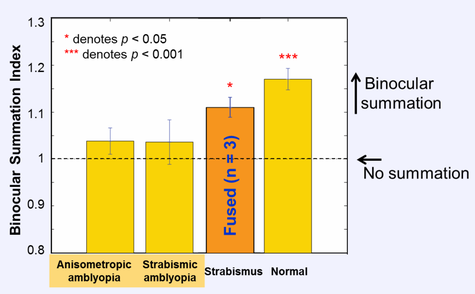
RESULTS

1. *Contrast Sensitivity*

Reduced Contrast Sensitivity in the Amblyopic eye



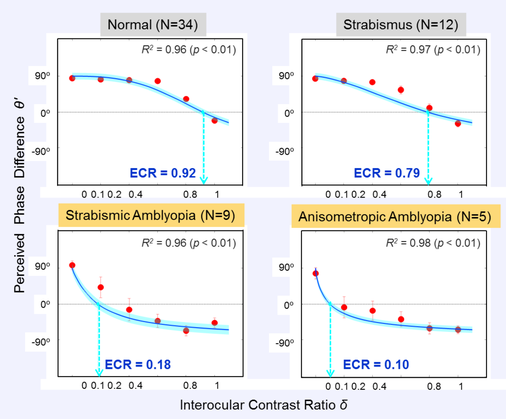
Lack of Binocular Summation in Amblyopia



Binocular Summation Index = $Sensitivity_{Binocular} / Sensitivity_{StrongEye}$

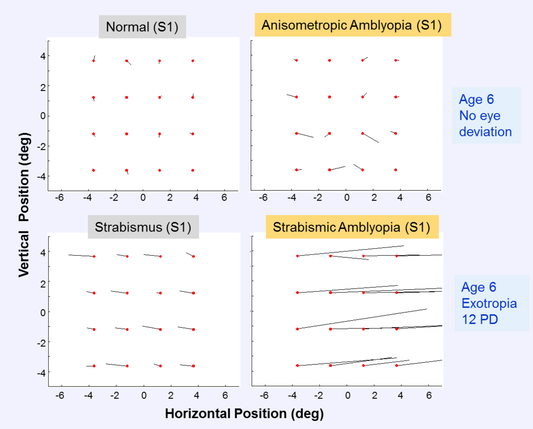
2. *Binocular Interaction*

Effective contrast of the amblyopic eye was considerably attenuated in supra-threshold combined percept

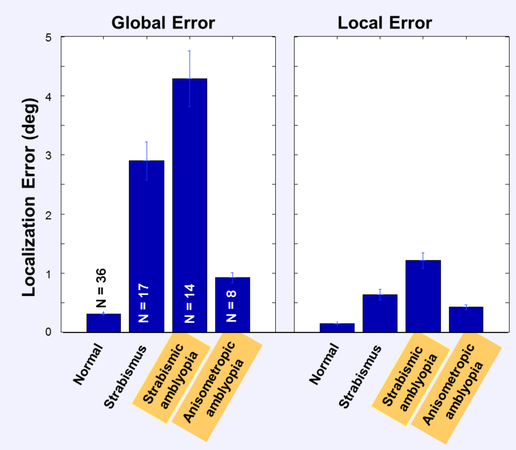


3. *Spatial Distortion*

Larger Localization Errors in Amblyopia



Larger Global and Local Errors in Amblyopia



CONCLUSIONS

- Despite short testing time our methods are as effective as laboratory assessments for quantifying the core deficits of amblyopia.
- Our efficient and comprehensive approach to characterize the broad range of amblyopic deficits are believed to facilitate diagnosis and treatment of amblyopia.

ACKNOWLEGEMENTS

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