

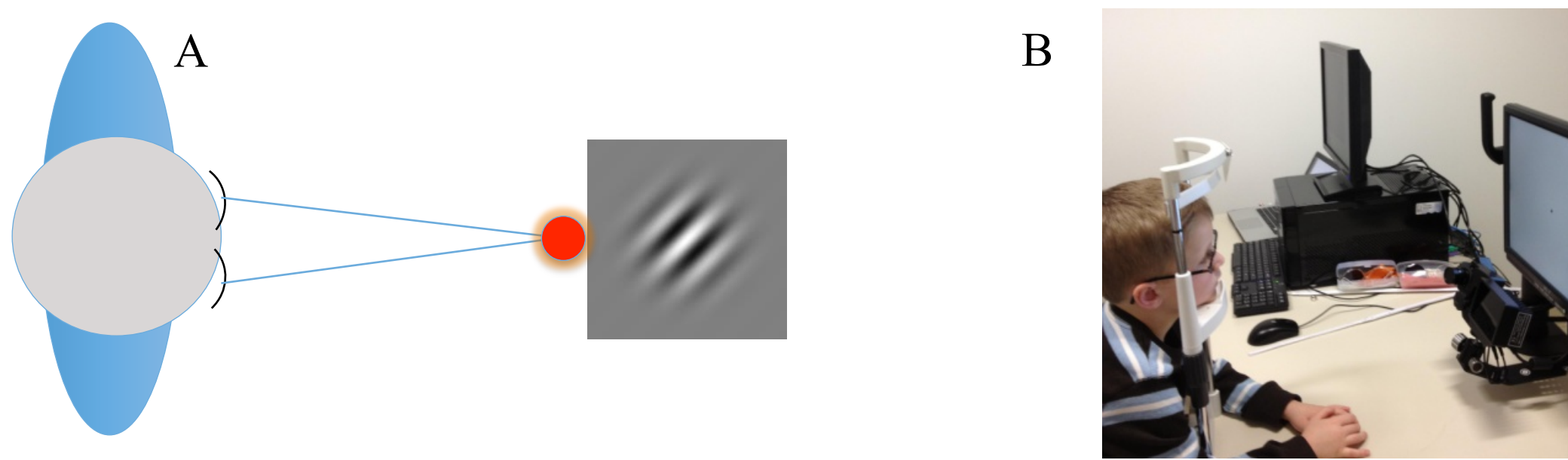
# Binocular Visual Function Deficits in Amblyopic Patients with and without Nystagmus

Cody Dulaney PhD, Palak Gupta MS, Jordan Murray PhD, Fatema Ghasia MD  
Cole Eye Institute, Cleveland Clinic Foundation

## Introduction

- Amblyopia, the leading cause of blindness, has a prevalence estimated at 99.2 million worldwide and can result from congenital cataract, difference between eye refractive errors, or eye misalignment (i.e., strabismus)<sup>1</sup>
- Amblyopia includes compromising deficits such as impaired sensitivities to contrast, depth perception, overriding of the amblyopic eye input (suppression of the amblyopic eye (AE)), and poor fixation<sup>2</sup>
- Daily tasks affected such as reading and environment navigation, therefore effects academics, physical, and social abilities
- Long-term concerns: vision loss in the fellow eye (FE), reduced vocational opportunities, and adverse psychosocial effects<sup>1,2</sup>
- Critical periods are birth to 7 years as treatment is thought to be most effective in this age group<sup>3</sup>
- The most common amblyopia treatment comprises of patching of the FE – despite good compliance recurrence and/or residual amblyopia is seen in 40% of patients<sup>3</sup>

## Methods



**Fig 1a** Subject position setup at distance of 1.5m for spatial frequency testing, **(1b)** and 80cm for FEMs

- Subject Selection:** 22 amblyopes (Anisometropic = 7, Strabismic/Mixed = 15) and 8 healthy control subjects were recruited. Of the amblyopes, 14 subjects had nystagmus and 8 without
- Eye movement recording:** A high-resolution eye-tracker (EyeLink 1000®, SR Research, Ontario, Canada; spatial resolution of 0.01 degree and temporal resolution of 500Hz) was used to quantify fixation eye movements (FEM).
  - Binocular horizontal and vertical eye positions were recorded under binocular, FE, and AE conditions
  - Remote, infra-red video oculo-graphy
  - The data was further processed and analyzed using MATLAB (Mathworks, Natick, MA) to allow for the appropriate identification of nystagmus. We further computed the amplitude and variance of the fast and slow FEMs
- Contrast Sensitivity Function (CSF):** Subjects viewed gabor patches (spatial sigma 1°) at 1, 2, 4, 8, 12, and 16 cycles/degree with a 1-down-1-up adaptive staircase. Further, area under the log CSF (AULCSF) was calculated using MATLAB for each participant. Amblyopes were divided into low contrast group (LCG, AULCSF < controls) or high contrast group (HCG, AULCSF=controls). Additionally, amblyopes were parsed into those with and those without nystagmus
- Analysis:** Repeated measures ANOVA assessed differences across CSF and AULCSF. Independent samples t-test was utilized to assess differences between LCG and HCG of AE and FE of amplitude and variance

## References

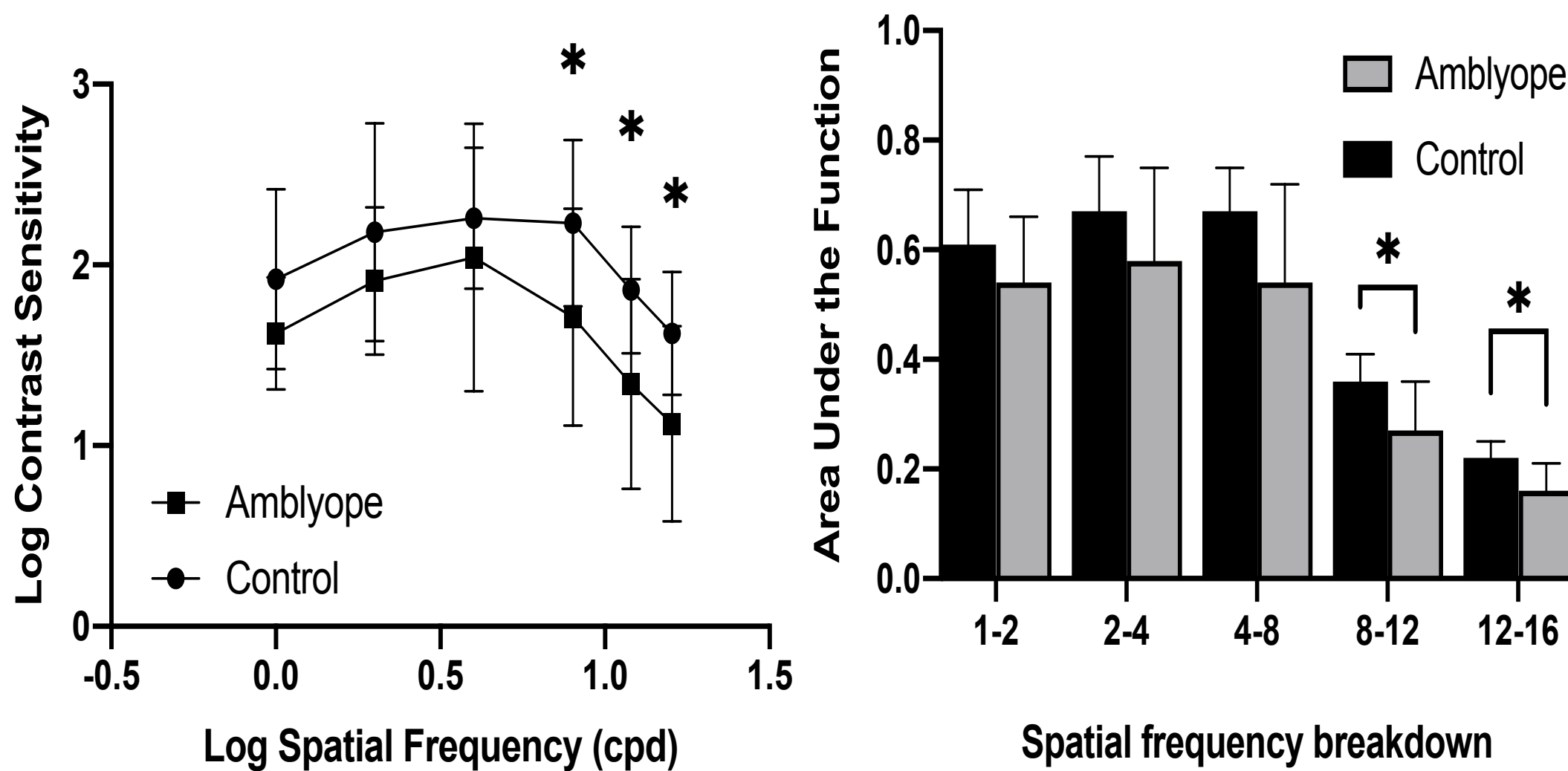
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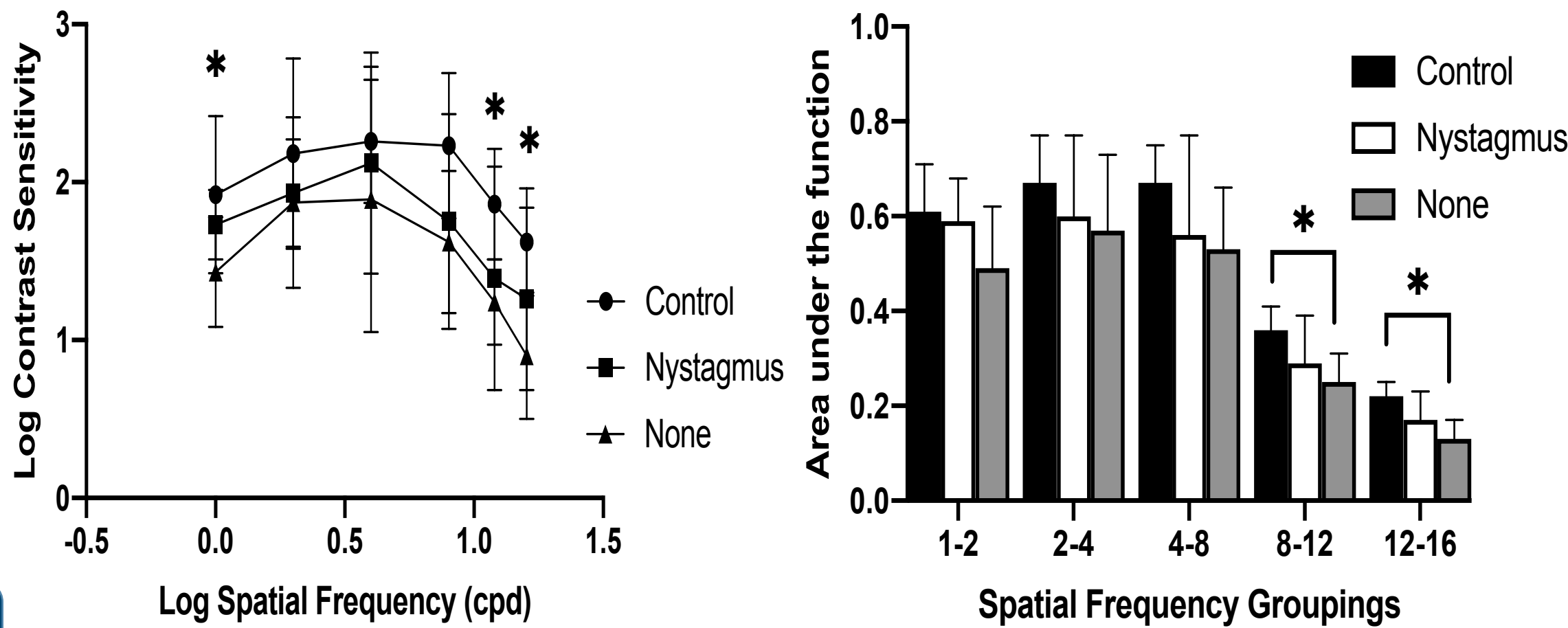
## Results

### Contrast Sensitivity Function: Controls versus Amblyopes



**Fig 2** (A) Average ( $\pm$  SD) log CSFs of, amblyopic patients ( $n = 22$ ) versus controls ( $n = 8$ ). Circle points denote controls while squares denote amblyopes. Single asterisks denotes significant ( $p \leq 0.05$ ) difference relative to controls versus amblyopes. (B) Average ( $\pm$  SD) area under the curve of amblyopic patients ( $n = 22$ ) versus controls ( $n = 8$ ). Black bars represent controls while grey represent amblyopes. Single asterisks denotes significant ( $p \leq 0.05$ ) difference relative to controls versus amblyopes.

### Contrast Sensitivity Function: Per Type of Amblyopia



**Fig 3** (A) Average ( $\pm$  SD) log CSFs of, amblyopic patients per FEM (Nystagmus = 14, None = 8) versus controls ( $n = 8$ ). Circles represent controls, squares; nystagmus, and triangles; none. Single asterisks denotes significant ( $p \leq 0.05$ ) difference relative to controls versus none groups. (B) Average ( $\pm$  SD) area under the curve of amblyopic patients per FEM (Nystagmus = 14, None = 8) versus controls ( $n = 8$ ). Black bars represent controls, white bars; nystagmus, and grey; none. Single asterisks denotes significant ( $p \leq 0.05$ ) difference relative to controls versus none groups

## Results

|                   | Low Contrast  | High Contrast |         | Low Contrast  | High Contrast |         |
|-------------------|---------------|---------------|---------|---------------|---------------|---------|
|                   | NVE (AE)      |               | p value | VE (FE)       |               | p value |
| Amplitude         |               |               |         |               |               |         |
| 5 <sup>th</sup>   | 0.281 ± 0.162 | 0.202 ± 0.082 | 0.168   | 0.263 ± 0.210 | 0.174 ± 0.062 | 0.196   |
| 10 <sup>th</sup>  | 0.341 ± 0.202 | 0.244 ± 0.100 | 0.169   | 0.316 ± 0.239 | 0.216 ± 0.080 | 0.204   |
| 25 <sup>th</sup>  | 0.506 ± 0.266 | 0.345 ± 0.170 | 0.107   | 0.455 ± 0.300 | 0.310 ± 0.102 | 0.143   |
| 50 <sup>th</sup>  | 0.710 ± 0.355 | 0.477 ± 0.212 | 0.076   | 0.706 ± 0.392 | 0.431 ± 0.142 | 0.041*  |
| 75 <sup>th</sup>  | 1.09 ± 0.543  | 0.623 ± 0.282 | 0.019*  | 0.977 ± 0.571 | 0.562 ± 0.190 | 0.033*  |
| 90 <sup>th</sup>  | 1.45 ± 0.727  | 0.838 ± 0.314 | 0.018*  | 1.45 ± 0.900  | 0.762 ± 0.272 | 0.024*  |
| Variance Position |               |               |         |               |               |         |
| 5 <sup>th</sup>   | 0.002 ± 0.001 | 0.001 ± 0.001 | 0.049*  | 0.002 ± 0.001 | 0.001 ± 0.000 | 0.006*  |
| 10 <sup>th</sup>  | 0.003 ± 0.002 | 0.001 ± 0.001 | 0.053   | 0.003 ± 0.002 | 0.001 ± 0.001 | 0.037*  |
| 25 <sup>th</sup>  | 0.007 ± 0.005 | 0.003 ± 0.003 | 0.085   | 0.007 ± 0.005 | 0.002 ± 0.002 | 0.013*  |
| 50 <sup>th</sup>  | 0.017 ± 0.012 | 0.008 ± 0.008 | 0.037*  | 0.017 ± 0.012 | 0.006 ± 0.005 | 0.010*  |
| 75 <sup>th</sup>  | 0.045 ± 0.029 | 0.022 ± 0.017 | 0.032*  | 0.043 ± 0.031 | 0.016 ± 0.010 | 0.013*  |
| 90 <sup>th</sup>  | 0.087 ± 0.056 | 0.050 ± 0.030 | 0.067   | 0.082 ± 0.059 | 0.030 ± 0.017 | 0.011*  |

**Table 1** Percentile Amplitude and Variance Position in VE condition (FE) and NVE condition (AE) of Amblyopic subjects in with either low contrast (contrast spatial frequency cumulative area under the curve  $\leq 2.2$ ) or high contrast (contrast spatial frequency cumulative area under the curve  $\geq 2.2$ ).

- Fig 2a – Controls had significantly higher log contrast sensitivity across 8, 12, and 16 cpd spatial frequencies ( $p = 0.043, 0.030, 0.022$ ; respectively) compared to amblyopes
- Fig 2b – Controls had significantly higher AULCSF across spatial frequencies 8-12 and 12-16 ( $p = 0.017, 0.006$ ; respectively) compared to amblyopes
- Fig 3a – Controls had significantly higher log contrast sensitivity across 1, 12, and 16 cpd spatial frequencies ( $p = 0.023, 0.045, 0.016$ ; respectively) compared to none
- Fig 3b – Controls had significantly higher AULCSF across spatial frequencies 8-12 and 12-16 ( $p = 0.033, 0.007$ ; respectively) compared to none
- Table 1 – Disparity between HCG and LCG of NVE (AE) and VE (FE) at 50<sup>th</sup>, 75<sup>th</sup> and 90<sup>th</sup> percentile data for amplitude. Disparity between HCG and LCG of NVE (AE) for 5<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentile and VE (AE) for all percentiles of variance position. See Table 1 for  $p$  values.

## Conclusion

- Amblyopia is not only a monocular problem but has important implication in binocular viewing
- Our data indicates that contrast sensitivity deficits are more pronounced in patients without nystagmus more so than those with nystagmus
- Rational for this may be that a majority of patients with nystagmus also presented with mixed and/or strabismic classifications. This subset of amblyopes are known to have better contrast sensitivity than anisometropic amblyopes for a given level of visual acuity deficit
- FEMs abnormalities were more pronounced which include increase in amplitude of fast FEM and increased of variance of slow FEM in patients with low contrast sensitivity function
- Evaluation of FEM abnormalities may help predict varying contrast sensitivity deficits seen in amblyopia

## COI & Funding

- The above authors note no conflict of interest in the study described (CD, PG, JM, and FG)
- Funding for this study is in part to Research to Prevent Blindness Disney Amblyopia Research Award, Blind Children's Center (FG), Artificial Intelligence Lerner Research Institute (FG), Heartwell Foundation Fellowship (CD), and National Eye Institute T32 (JM)