Objective measures of visual improvement following amblyopia therapy in children

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INTRODUCTION

Amblyopia is a binocular visual condition that occurs when the input to one eye is disturbed during development, but where and how the neural problems arise is still unclear.

Neuroimaging techniques like electroencephalography (EEG) are ideally suited for objectively measuring visual improvements, due to the good signal-to-noise ratio (SNR) in steady-state visual evoked potentials (SSVEPs) and avoiding issues of practice and response bias (Baker et al., 2015; Lygo et al., 2021)

The aim of this study was to use a dry-electrode EEG system to objectively measure visual improvements in children whilst undergoing treatment for amblyopia

METHODS

Participants

Thirty two children (9 females; mean age = 4.39, ±0.49) who had been referred for treatment for strabismic amblyopia were recruited from the Hull Royal Infirmary Eye Clinic (UK).

Participants were tested at three timepoints: before treatment (N=32), during (N=16; 6-8 weeks after session 1) and after (N=11, 6-12 months after session 1) treatment.

EEG

SSVEPs were recorded from six occipital electrodes (O1, O2, Oz, POZ, P01, P02) with additional electrodes at FZ and CZ, using a dry-electrode EEG system (g.tec, Sahara model).

Stimulus presentation and binocular separation was achieved using an Oculus Rift DK2 virtual reality headset

Stimuli

4 x horizontal sinusoidal gratings (3 c/deg, 4Hz on/off flicker) presented in a circular aperture (4° of visual angle) on a binocular fusion-lock background

Stimuli were presented monocularly to each eye at 6, 24 and 96% contrast (x3 repetitions)

RESULTS

SSVEPs revealed better SNRs for the fellow eye compared to the amblyopic eye but improvements in visual function between testing sessions fell outside of significance.

Visual acuity measures showed significant improvements in the amblyopic eye after 6-8 weeks of treatment.

This suggests that the treatment was effective in improving vision between the sessions but any neural changes between the eyes were not reflected in the SSVEPs measured using the dry-electrode EEG system.

It is likely that the low sample size caused by high attrition rate (N=11 at the final session), combined with highly variable measurements, reduced the statistical power.

Various improvements could be made to the protocol to eliminate noise (e.g. shorter blocks to give children more breaks, inco...

DISCUSSION

The combination of a dry-electrode system and young participants led to a high noise baseline, consequently results are presented as SNRs, rather than amplitudes.

Each SNR was calculated by dividing the amplitude at the signal frequency by the mean amplitude in the surrounding frequency bins (5 bins above and below with a frequency resolution of 0.1Hz; 1 = no measurable signal).

For each individual, responses were taken from the electrode that produced the largest SNR in the 96% contrast condition for the fellow eye. Responses were first coherently averaged across trials and then the absolute SNRs were averaged across participants.

Overall, this study provides a first step in designing a paradigm to objectively measure neural responses quickly and effectively within a clinical setting.