Arch Clin Ophthalmol. 2022;3(1):3-4.

Archives of Clinical Ophthalmology Commentary

Assessment of Visual Function for Education: A Commentary on 'VEP Visual Acuity in Children with Cortical Visual Impairment'

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Received date: February 27, 2023, **Accepted date:** March 20, 2023

Citation: Mackay AM. Assessment of Visual Function for Education: A Commentary on ' VEP Visual Acuity in Children with Cortical Visual Impairment'. Arch Clin Ophthalmol. 2023;3(1):3-4.

Commentary

Last year's article In the International Journal of Clinical and Experimental Ophthalmology [1] highlighted that Cortical Visual Impairment (CVI) is now the leading cause of visual impairment in the developed world [2]. It also provided a definition of CVI [3,4], and summarized its functional deficits, and methods of assessment. Different sources report vastly different incidence of Visual Acuity (VA) reduction in CVI, ranging from 83% [5] to just a small minority [6]. However, the implication is the same- screening of many aspects of vision may be required in infancy, not just VA.

In American electrophysiological studies of this cohort, a vernier onset pattern provided higher signal to noise ratios than grating reversals [7]. My own study implied that slower temporal frequencies would optimise the correlation between VEP and subjective VA [1]. Sweep VEP VA and Contrast Sensitivity (CS) thresholds were optimal with an Oz-Fz recording montage in children under five [8]. This is in keeping with our own ssVEP study of normal children [9], however the sweep VEP study extends this finding to a vernier stimulus [8]. Unsurprisingly, both thresholds and signal amplitudes were particularly reduced in CVI, for both grating and Vernier stimuli. In addition, the amplitude of the CS function (CSF) allowed differential diagnosis of perinatal hypoxia [8].

Single Cell voltage recordings from Lateral Geniculate Nucleus (LGN) and striate cortex in macaques have shown disparate responses to specific stimuli [10] given their different receptive field mechanisms, and non-invasive probes based on this could locate damage in children with CVI in a healthcare setting.

All VA measurements in this cohort tend to be made binocularly, and subjective VA is often estimated in an ad-hoc manner given co-morbidity like cerebral palsy, nystagmus, and attention span limitations. Typically, stimuli are brought closer than normal to attract fixation, and may also be held at an asymmetrical tilt in any plane. It is now known that objects appearing larger in one near field than the other can result in switching of eye dominance [11], and it follows that this could add variability to the agreement between VEP and subjective VA.

The shape of the CSF varies at different luminance levels in health and disease and has a monophasic morphology at low luminance [12]. The shape of this function is mirrored by the spatial frequency amplitude function in normal children and those with CVI [8] and it's unambiguous slope at low luminance enables a clear-cut extrapolation of VEP amplitudes. This could explain why electrophysiological and subjective test methods agreed so well in this cohort.

An early MRI study showed that VA was correlated with a quantitative imaging grading, and even more so with the degree of damage to the optic radiations [13]. A decade long study of 229 patients included anatomical and functional brain categorization as well as genetic information [14]. Hypoxic-ischemic Encephalopathy (HIE), Epilepsy, and Cerebral Palsy (CP) suggested that visual improvement over time was unlikely; more positively, interventions using physical therapy, occupational therapy, and refractive correction were associated with long-term visual improvement [14]. Early diagnosis is crucial [15] to allow for these interventions, and its standardization is necessary given the array of tests in current use. Five particularly important parameters are 1) Medical

History; 2) Ophthalmological and Orthoptic assessment; 3) Neuropsychological assessment; 4) Neuroradiology and MRI; 5) Genetic Assessment. Although it can provide unique information in some cases, electrophysiology is a very small piece of the larger puzzle [16].

Attempting VEPs in high-functioning children with CVI of all ages should identify the technical parameters best representing subjective VA test thresholds. Each permutation of luminance, rate, pattern, contrast and spatial frequency would create a data set to be compared to subjective VA and CS using regression analysis. A method for comparing two linear regression lines, presented in the textbook 'Statistics with Confidence' [17], could be used to exclude the poorest agreements. A multivariate regression provides the most statistically powerful comparison but it requires knowledge of biostatistics, and significant technical expertise to compute.

This commentary [18] has elaborated on historical and current electrophysiological recordings from the striate cortex in the animal lab and the pediatric clinic, as well as considering the broader context now necessary for the diagnosis and prognosis of CVI. If assessment and intervention can happen early enough in childhood then subsequent education is much more likely to be effective. The focused nature of a commentary article means that confirmation bias is likely to be present here [19], though this should be negated by the duration of the authors experience in VA measurement, statistical modelling, and evidence-based medical research.

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