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Technical Note

Adjustments to Stimulation Frequency and Duration of STEP VEPs in Paediatric CVI

Alison M Mackay [1,2]

[1]Flex Clin Sci Ltd. 27 Dock office, Furness Quay, Salford, Manchester, UK
[2]Faculty of Biology, Medicine and Health, University of Manchester, UK
Email Address: **alisonmackay@live.co.uk**

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Abstract:
Recent research has demonstrated that the agreement between VEP and subjective Visual Acuity is influenced by both technical and clinical factors.
We are still learning about the manifestations of Cortical Visual Impairment; large variations in the three functional pathways may have contributed to relatively slow transient VEPs having the strongest relationship with subjective VA in this cohort. It is also concluded, in hindsight, that preferential looking cards are not necessarily the gold standard subjective test for CVI.

For the ssVEP-based Step VEP, poor consistency and reduced SNR delays test statistics in reaching the detection threshold, necessitating longer recording periods for the particularly small responses of paediatric CVI. Reducing stimulation frequency to five reversals per second is the slowest that would elicit the steady state response necessary for automated analysis. This should also preserve consistency and amplitude so that less signal averaging is required. Increasing the maximum duration of stimulation to 35 seconds will match the original STEP VEPs number of stimuli, and therefore opportunities to respond, should this be required.

Recent research has demonstrated that the agreement between VEP and subjective VA is influenced by both technical and clinical factors [1-3]. In normal visual development, spatial resolution threshold is limited by the density of retinal bipolar cells [4] which initiate three distinct functional pathways; magnocellular, parvocellular, and koniocellular [5]. Ophthalmological pathology during development before the LGN *and* resulting in moderate or severe visual impairment [6] may preferentially preserve the magnocellular pathway, making steady state VEPs the ideal assessment. We are still learning about the manifestations of congenital damage further down the visual pathway (Cortical Visual Impairment) [7]; large variations in each functional pathway may have contributed to slower transient VEPs having the stronger relationship with subjective VA in this cohort [8].

The specific challenges of subjective VA testing in CVI, and its resulting relationship with VEPs were discussed in a recent commentary [9]. In addition to the overarching challenge of maintaining attention and cooperation in children, motor comorbidity and eye movement limitations in CVI [idem] affect both electrophysiology and subjective tests. In hindsight, PL cards are not the gold standard VA test for paediatric CVI, even though they are nearly always used, and subjects may appear to cooperate [10]. As a Medical Physicist, proposal of the most appropriate subjective test is outside my scope of practice, however, I can suggest a compromise between existing electrophysiological tests by slowing down the stimulus rate of steady-state VEPs. This should support ocular motility limitations and enhance the collective contribution from different pathways. Closer relationships between modalities would verify this and even better estimates of functional VA may be possible in those who can only complete VEPs. Five reversals is the slowest rate allowing objective analysis and control by the STEP VEP algorithm.

The amplitude of an electrical response measured at the Occiput should also be considered. In normal adults and children, VEP amplitude reduces significantly near the threshold of spatial resolution [11-12], and for children with CVI, these amplitudes are even smaller [13,14]. VEP detection using circular T^2 statistics depends on the consistency of the response, and all methods depend on signal to noise ratio (SNR) [14] (which depends on amplitude). Poor consistency and reduced SNR delays test statistics in reaching the detection threshold [idem] necessitating longer recording periods for the particularly small responses of paediatric CVI.

The STEP VEP algorithm has a maximum stimulation period of 22.6 seconds for each stimulus-calculated from a normative paediatric study [idem]. This maximum period is rarely needed in practice, though elongated detections times are associated with a threshold response. For the stimulation frequency of 7.78 reversals per second, 175 opportunities for response detection exist if the full stimulation period is utilised. Reducing stimulation frequency to five reversals per second would hopefully elicit large and consistent responses that require less averaging; in addition, 35 seconds of stimulation will match the original STEP VEPs opportunities to respond.

The existing spatio-temporal combination has been effective in finding correlates of subjective tests in a paediatric neuroophthalmological group. [1,3], with adequate relationships in the focussed CVI cohort. As the latter are less likely to be able to complete subjective tests, they are more in need of accurate electrophysiological assessment, especially given the proven benefits of intervention [15]. They were the original reason that a new electrophysiological test was desirable (Bill Good, Personal Communication). Extending the maximum stimulation period might increase the overall test duration, and whether this affects success should be evaluated alongside the VA relationship with a validated subjective test.

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