TRANSLATIONAL PERSPECTIVE

In childhood, a different electrode placement improves the recording of pattern reversal visual evoked potentials

Maria M. van Genderen[1,2]

[1]*Diagnostic Center for complex visual disorders, Bartiméus, Zeist, Netherlands*
[2]*Department of Ophthalmology, University Medical Center Utrecht, Utrecht, Netherlands*

Email: mvgenderen@bartimeus.nl

Handling Editors: Laura Bennet & William Taylor

The peer review history is available in the Supporting Information section of this article (https://doi.org/10.1113/JP284400#support-information-section).

The eyes and visual pathways of children develop over many years. Clinicians and researchers need to be aware of this development, in order to know what can be considered normal at a certain age. For instance, a visual acuity of 1.0 LogMAR (6/60) is normal in a 6-month-old infant, while children older than 4 years with the same visual acuity would be considered severely visually impaired. The increase in visual acuity is secondary to the maturation of the visual system, including the retina, the fovea, the optic nerve and the brain.

Visual electrophysiology is an important tool to objectively assess retinal and optic nerve function. Objective measurements are especially important in children, as they cannot always comply with subjective testing. In paediatric ophthalmology, the most widely used electrophysiology measurements are the full field electroretinogram (ffERG) and visual evoked potentials (VEPs). The ffERG measures generalized retinal function, largely from photoreceptors and bipolar cells, and is recorded with electrodes in contact with the cornea or with skin electrodes attached to the lower eyelids. VEPs are used to assess the function of the visual pathway from the macula to the striate cortex, and consist of visually evoked electrophysiological signals recorded from the scalp overlying the occipital cortex. The VEP stimulus usually is either a flash or a checkerboard pattern. The pattern reversal VEP (prVEP) is clinically the most useful stimulus, as the response is narrowly defined and shows little variation between individuals, between eyes and over time. The International Society for Clinical Electrophysiology of Vision (ISCEV) specifies standards for measuring and interpreting the ERG and VEP, based on a subset of stimulus and recording conditions that provide essential clinical information.

As with visual acuity, the interpretation of electrophysiology results should take age into account. For instance, the ffERG shows significant developmental changes in the first year of life: amplitudes increase and implicit times decrease (Fulton et al., 2003). The maturation of the pattern reversal VEP is reflected in a rapid decrease of latency over the first year of life and more slowly thereafter (Lenassi et al., 2008).

The ISCEV recognizes the need for modified protocols in children to increase the chance of a useful outcome. Modified protocols mainly concern faster procedures to decrease measurement time. Such protocols increase the chance of success without compromising diagnostic accuracy (Marmoy et al., 2022).

To date, no modifications in the protocol have been proposed because of morphological changes in childhood. The ISCEV standards for VEP include electrode placement, and specify for prVEP measurements that the active electrode is placed on the occipital scalp over the visual cortex at the mid-occiput (Oz, which is 10% of the nasion–inion distance) (Odom et al., 2016). These specifications apply to all age groups, although in children the development and growth of the brain and skull results in a different anatomy compared to adults.

In an article in this issue of *The Journal of Physiology*, Marmoy *et al.* (2023) assessed the optimal electrode placement in a very large cohort of healthy children. They found that prVEP amplitudes at a young age are larger for a lower-placed electrode (over the inion, Iz) compared to Oz. They also demonstrated that the larger responses from Iz improved diagnostic accuracy. The difference in amplitude between Iz and Oz decreased with age; for large checks the decrease occurred at a younger age than for small checks. Above 12 years of age, Oz became the preferred electrode position for the majority of children. The researchers explained their findings by age-related anatomical changes altering the cortical dipole, probably in combination with visual neurodevelopmental changes.

To evaluate whether a prVEP amplitude is abnormal, every centre should collect its own reference values and calculate normal ranges, preferably for different age groups. If in young children the recording electrode is placed over the inion, the normal amplitude range probably will shift, resulting in a higher value for the lower threshold compared to the conventional electrode placement. This implies that the proportion of children with abnormally low amplitudes may be similar for both electrode positions. However, in the case of visual pathology resulting in reduced amplitudes, it may be that with the addition of an electrode at Iz, a small response still may be identifiable, while at Oz responses cannot be distinguished from noise. We live in an era of rapid increase in genetic knowledge of inherited ocular disease, leading for the first time to possible curative treatments for childhood blindness. Also, new targeted treatments for other diseases of the optic nerve like optic glioma are being developed. To objectively assess the effects of treatment, visual electrophysiology is essential. If prVEP responses are still recordable with a different electrode placement while with the conventional method they are not, improved follow-up with regard to the effect of gene therapy, surgery or medication becomes possible.

The results of this study may lead to the adaptation of the ISCEV standards for VEP measurements in young children. The addition of an extra electrode over the inion to accommodate the changing morphology of the visual cortex may lead to more reliable outcomes and better follow-up in young children with visual pathway pathology.

References

Fulton, A. B., Hansen, R. M., & Westall, C. A. (2003). Development of ERG responses: The ISCEV rod, maximal and cone responses in normal subjects. *Documenta Ophthalmologica*, **107**(3), 235–241.

Lenassi, E., Likar, K., Stirn-Kranjc, B., & Brecelj, J. (2008). VEP maturation and visual acuity in infants and preschool children. *Documenta Ophthalmologica*, **117**(2), 111–120.

 DOI: 10.1113/JP284400

Marmoy, O. R., Horvat-Gitsels, L. A., Cortina-Borja, M., & Thompson, D. A. (2023). Pattern visual evoked potentials show an inferior-superior topographic shift through maturation in childhood. *The Journal of Physiology*, **601**(10), 1869–1880.

Odom, J. V., Bach, M., Brigell, M., Holder, G. E., McCulloch, D. L., Mizota, A., & Tormene, A. P. (2016). International society for clinical electrophysiology of vision. ISCEV standard for clinical visual evoked potentials: (2016 update). *Documenta Ophthalmologica*, **133**(1), 1–9.

Marmoy, O. R., Moinuddin, M., & Thompson, D. A. (2022). An alternative electroretinography protocol for children: A study of diagnostic agreement and accuracy relative to ISCEV standard electroretinograms. *Acta Ophthalmologica*, **100**(3), 322–330.

Additional information

Competing interests

None.

Author contributions

Sole author.

Funding

None.

Keywords

neuro-ophthalmology, paediatric, VEP, visual evoked potential

Supporting information

Additional supporting information can be found online in the Supporting Information section at the end of the HTML view of the article. Supporting information files available:

Peer Review History