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Visual Evoked Potential (VEP) Recording Guideline

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1. PURPOSE

These guidelines have been prepared to offer guidance towards best practice for recording a VEP in the routine clinical setting within Australia.

2. INTRODUCTION

The following guidelines should be considered as minimum standards to record a routine VEP in clinical practice. They have been prepared by a sub committee governed by ANTA and have been presented to stakeholders within the field of Clinical Neurophysiology in Australia (see Appendix 1). A review of international guidelines was made to ensure that this ANTA Inc guideline is consistent with worldwide standards (see reference section).

3. LIMITS OF THE GUIDELINE

This guideline relates to the routine VEP in clinical practice for children and adults only. It does not relate to full term babies and neonates. This guideline does not relate to recording in the operating theatre or non routine setting.

4. ELECTRODES

(i) Recording Electrode Placement

<u>International10:20 System</u>

Electrodes should be placed in accordance with the International Federation of Clinical Neurophysiology (IFCN)[(1)] which is the internationally recognised standard. Recording electrodes should be placed at O1, Oz, O2. T6 and T5 and other midline electrodes can be placed if there are available channels. A reference electrode should be placed at Fz and a ground electrode placed at Cz [(2)].

<u>Queen Square Method</u>

It is recommended to use the Queen Square method of electrode placement for investigation of hemispheric function and half field responses. Recording electrodes should be posteriorly situated at 5 cm anterior to the inion (mid occipital MO) and 5 and 10 cm lateral to the MO electrode (R5,R10, L5,L10) referred to a reference electrode at Fz [(3)].

(ii) Electrode Choice

Electrodes used to record a VEP are the same used for EEG recording [(9)]. The electrodes used should also be of the same material preferably silver / silver chloride (Ag/AgCl), gold plated silver due to the inherent time constant of each material [(3, 4)].

(iii) Electrode Impedance

Electrode impedance should be measured prior to each recording and at any time during the VEP where an electrode has be altered or adjusted. Impedances of all electrodes should measure below 5kohms and of a similar value within no more than 3kohm range of each other [(3,5,9)].

5. MACHINE PARAMETERS

(i) Common Mode Rejection Ratio

For common mode rejection to work effectively the active and reference electrodes should be of near equal impedance [9] and all input electrode impedances maintained below 5Kohms [6].

The amplifier's common mode rejection ratio should be 120dB or greater [5].

(ii) Input Impedance of Pre-amplifiers

The amplifier's input impedance should be at least 100MΩ [5].

(iii) Analogue to Digital Signal Conversion

The sample rate shall be a minimum of 500 samples per second per channel with a minimum resolution of 8bits [3].

(iv) Automatic Artefact Rejection

Automatic artefact rejection should exclude signals exceeding +/- 50-100uV in amplitude and return to baseline rapidly following a high amplitude artefact [3].

(v) Filters

For the purpose of VEP's filters shall be set to the following levels [5] –

Low Pass/High Frequency Filter ≥ 100Hz (-3dB)

High Pass/Low Frequency Filter ≤ 1Hz (-3dB)

A 50Hz 'notch filter' should not be used because the signals of interest fall precisely in this frequency range. Any applicable artefact should be rectified by addressing the source of the interference, such as nearby electrical equipment or the recording electrodes [5].

(vi) Sweep Duration

Generally 250ms post stimulus for adults is sufficient however if major response components are significantly prolonged or delayed a longer analysis time (up to 500ms) may be required to obtain reproducible results [5, 7].

In children an analysis time of up to 400ms post stimulus may be required [3].

(vii) Averaging

At least 100 individual trials to be averaged – more may be required (up to 400) to ensure reproducibility in low amplitude responses and to ensure that a stable waveform is recorded with minimal noise [3]. At least two total runs should be obtained and superimposed to verify reproducibility of waveform morphology, latency and amplitude [3,9].

6. RECORDING

Ensure the patient is relaxed, in a position that ensures patient's comfort and minimises muscle activation. Monitor the quality of the live/raw data while averaging the signal to ensure integrity [5].

(i) Patient and Test Information

The following details should be included, as minimum, with any VEP recording:

- Patient name
- Patient identification number
- Date of birth
- Recording date
- Referring doctor
- Recording health professional initials
- Relevant clinical details
- Clinical question to be answered
- Current medications
- Visual acuity
- Time and amplitude scale
- Number of averaged trials
- Montage
- Polarity convention.

The visual acuity of the patient should be determined prior to performing any VEP procedure and preferably corrected if the patient has their glasses or contacts [5].

It is important to make a note of any extreme pupil sizes or any anisocoria. For pattern reversal stimuli the patient must not have any mydriatic or miotic drugs. For flash stimuli the pupils should not be dilated [3, 5].

(ii) Patient Attention

The patient's attention should be monitored throughout the recording to ensure alertness and compliance with the requirements of the test and consistency of the recorded data.

If the patient becomes drowsy and loses the ability to readily fixate on a point, encouragement and interaction may help avoid potentially erroneous responses [7].

(iii) Averaging

If compliance or fixation wanes during the recording, more trials may need to be averaged [2].

(iv) Pattern Reversal Stimulation Settings

If an abnormal VEP is obtained in a patient with visual symptoms, a pattern electroretinogram (pERG) should be performed if available [3].

See Appendix 3 for pERG Guideline.

Stimulus type

Alternating high contrast (black and white) checkerboard [3,5].

Stimulus rate

2 reversals per second (1Hz) [3, 5, 7, 8].

Stimulation phases

Responses to phases are averaged with the opposite phase [8].

Brightness contrast

Contrast between black and white should be greater than 80% [3, 5].

Intensity

Mean luminance of the stimulus should be greater than 50 candela/m^2 (cdm^{-2})and there should be no change in mean luminance during the reversal of the pattern [3,5].

The luminance should be uniform and vary no less than 30% between the centre and periphery of the visual field [5].

Lighting within the recording room should be homogonous with an average room luminance approximately equal to the average stimulus luminance [5].

Stimulation device

Pattern reversal stimulation can be generated using projection, oscilloscope, video monitor or LED array devices. Variability in P100 latency and morphology may occur between devices. The choice of monitoring device should be in accordance with normative data for the department [9, 10].

Stimulation

Monocular stimulation is used to ensure that there is no masking of a unilateral conduction abnormality [3,5].

Check width

Different check sizes can be used separately; large or small [5, 7].

Large checks should measure 60' of arc (1˚ ± 20%); small checks should measure 15' (0.25˚ ± 20%)[3, 5]. Note - see individual field pattern reversal stimulation detail below.

Field size

While it is not necessary to use a square field (i.e. computer monitor displaying the stimulus pattern does not need to be square) the ratio between width and height should not exceed 4:3 and the field size should be at least 15˚ (of visual angle) at the smallest point [5].

Check colour

An equal number of black and white checks should be used [5].

Distance of stimulus from patient:

The distance between the patient and the stimulus can range from 50 -150 cm, dependent on visual arc required [5]. Distance should be measured from the nasion to the fixation point on the screen and be in accordance with normative data for department [7]. (See Appendix 2 for calculating visual arc and distance from screen.)

(a) Full Field Pattern Reversal Stimulation

Fixation point

The fixation point should be located in centre of screen positioned at the corner of 4 checks [5, 7].

Check width

Check width for full field stimulation should be 50-60' [3, 5] for routine practice. Smaller check size of 15' [7] can be utilised in addition to the routine larger check size.

Field Size

Field size for full field pattern stimulation should be no less than 15^{o} [3, 5, 6].

Example of full field recording montage:

10:20 System[3]	Queen Square[3, 7]
Channel 1: O2 to Fz	Channel 1: R5 to Fz
Channel 2: Oz to Fz	Channel 2: MO to Fz
Channel 3: O1 to Fz	Channel 3: L5 to Fz
Ground: Cz	Ground: Cz

Pattern reversal full field markers [7] mid occipital:

Peak latency

- N75 – 1st negative peak
- P100 – 1st positive peak
- N145 – 2nd negative peak

Baseline to peak amplitude P100

(b) Hemi Field Pattern Reversal Stimulation

Each eye is tested separately to both left and right hemi-field stimulation; whereby the pattern is presented to one half of the visual field of each eye.[7].

Fixation point

The fixation point should still be located at the centre of the stimulus screen, however it will only be located in the corner of 2 checks for hemi-field stimulation [7] at the nasal aspect of the stimulus pattern.

Check width

Check width for hemi field stimulation should be 50-60' [3, 5] for routine practice. Smaller check size of 15' [7] can be utilised in addition to the routine larger check size.

Field size

Field size for hemi field pattern stimulation should be no less than 15^{o} [3, 5, 7].

(Example of hemi field recording montage:

10:20 System[3]	Queen Square[3,7]
Channel 1: T6 to Fz	Channel 1: 10R to Fz
Channel 2: O2 to Fz	Channel 2: 5R to Fz
Channel 3: Oz to Fz	Channel 3: MO to Fz
Channel 4: O1 to Fz	Channel 4: 5L to Fz
Channel 5: T5 to Fz	Channel 5: 10L to Fz
Ground: Cz	Ground: Cz

Pattern reversal hemi field markers [7] lateral recording site ipsilateral to stimulus side :

Peak latency

N75 – 1st negative peak

P100 – 1st positive peak

N145 – 2nd negative peak

Baseline to peak amplitude P100

(c) Central Field Pattern Reversal Stimulation

Fixation point

The fixation point should be located in centre of screen positioned at the corner of 4 checks [6].

Check width

Check width for central field stimulation should be 15' [7] for routine practice. Larger check size of 50-60' [3, 5] can be utilised in addition to the routine small check size.

Total field size:
For central field stimulation the field size should be reduced to 2-4° [7].

Central field recording montage
The central field recording montage should not differ from full field recording montage [7].

Pattern reversal central field markers [7] mid occipital:
On central field stimulation the P100 latency will be longer and smaller in amplitude when compared to full field responses [12].

(vi) Flash Stimulation

Flash stimulus for eliciting a VEP is used infrequently and is reserved primarily for infants and other patients that cannot maintain fixation and when reduced visual acuity cannot be rectified [2, 7].

(a) Settings for Flash Stimulation

Stimulus Type/Pattern generator
A white flashing light is the stimulus utilised in flash VEP's. This can be delivered to the patient via a stroboscope lamp or via a Ganzfeld stimulator [3, 5].

Stimulus rate
The stimulus of flashes of white light should occur at 1-2Hz [3,5].

Intensity
Luminance of the flash should be at least 3cdm^{-2} [5].

Stimulation
Monocular stimulation is used to ensure that there is no masking of a unilateral conduction abnormality [8].

Field size
The flash stimulus should subtend a visual field of at least 20° [5].

Distance of stimulus from patient
The distance between the patient and the flash stimulus should be 30 -45 cm [7].

Example of full field flash recording montage:

10:20System [1]	QueenSquare [7]
Channel 1: O2 to Fz	Channel 1: 5R to Fz
Channel 2: Oz to Fz	Channel 2: MO to Fz
Channel 3: O1 to Fz	Channel 3: 5L to Fz
Ground: Cz	Ground: Cz

Flash recording markers:

6 peaks appear in the first 250ms and are labelled as [5,7]:

- I or N1 – 1st negative peak
- II or P1 – 1st positive peak
- III or N2 – 2nd negative peak
- IV or P2 – 2nd positive peak
- V or N3 – 3rd negative peak
- VI or P3 – 3rd positive peak.

7. QUALITY CONTROL

(i) Calibration

Calibration of recording systems should be carried out on a regular basis [7]. Please refer to:

'Guidelines for calibration of stimulus and recording parameters used in clinical electrophysiology of vision', Calibration standard committee of the International Society for Clinical Electrophysiology of Vision (ISCEV), 2003. Documenta Ophthalmologica 107: 185-193.

(ii) Normal Values

Each lab should establish its own normative data using standard stimuli and recording parameters because of the large range of normal values depending on recording parameters such as ambient light, pattern luminance and contrast [5]. These should be the same for all patients tested and for all subjects from which normative data is obtained [7].

Note that normative values may be influenced by age, gender and differences in visual acuity; and that acquired normative data for adults must be in a given age range[3, 5, 7]. Additional normative data may need to be acquired for elderly (>60) or paediatric (<5) populations [2, 5].

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Additional Readings

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Appendix 1 – Stake Holders

Stakeholders

- ANTA Inc. Members
- Document development committee
- Document development committee Advisory Group
- Other interested parties

Original Document

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Dr Steve Vucic.
ANTA Inc Executive: Stephanie Brooks, Angela Borbelj, Anna Exley, Justin Stent 2009
Endorsed by ANTA Inc Members (2010).
First Revision – 2012

Document Development Committee

Mary Lynch, Joanne Wex, Holly Campbell, Anna Exley, Santhi Chigurupati, Malcolm Corkhill, Kate Martin, Emma Fetherston, Amy Lofts, Fred Tremayne.

Advisory Committee

The document development committee identified a group of key stakeholders to view the draft documents for feedback. The advisory group was made up of technologists, scientists and neurologists working in the neurophysiology industry around Australia. The comments from this group were considered, compared against the reference material and included where appropriate.

Members Feedback

On completion of the final draft the document was put out to all members of ANTA Inc. for feedback. The comments from members were considered, compared against the reference material and included where appropriate.

Guideline Acceptance

This Guideline was accepted by members in July 2014.

Amendments

2016 May Disclaimer and Copyright statements added.

Appendix 2 – Calculating the visual angle for pattern reversal VEP [5, 11]

To calculate the visual angle (Θ) for check size or screen size

1. Measure the width of the check or width or height of the screen (w)
2. Measure the distance from the patient's eye to the centre of the screen (d)
3. Divide the check size or screen width or height by the distance measured
4. Determine the angle whose tangent is that value ($\tan^{-1}$)

$x = w/d$

Θ = angle whose tangent is x ($\tan^{-1}x$)

To calculate the distance from the screen for pattern reversal VEP for a desired screen angle

1. Measure the width of the check or screen (w)
2. Calculate tan of the desired angle (Θ)
3. Divide the check size by tan Θ

$d = w/\tan \Theta$

APPENDIX 3 – Pattern Electroretinogram (pERG)

The PERG (if available) shall be used in a patient with an abnormal visual evoked potential to establish whether a retinal (macular) disorder is present, and thus differentiate between macular and optic nerve dysfunction as a cause for the VEP abnormality [11].

For the purpose of incorporating the ERG in the VEP test set up the VEP stimulating visual arc, luminance, contrast and reversal rate parameters are used.

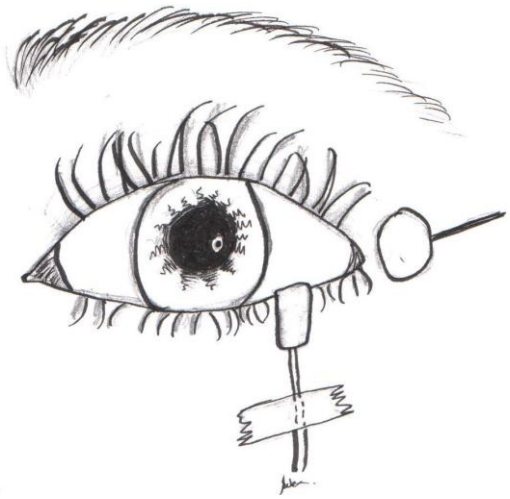
Suggested montages for full field or flash stimulation incorporating ERG channel

10:20 System	Queens Square
Channel 1: iERG - iOC	Channel 1: iERG - iOC
Channel 2: O2 to Fz	Channel 2: R5 to Fz
Channel 3: Oz to Fz	Channel 3: MO to Fz
Channel 4: O1 to Fz	Channel 4: L5 to Fz
Ground: Cz	Ground: Cz

Electrodes

A number of different types of electrodes can be used but the most practical and less invasive type is a leaf electrode that can be placed on the lower eyelid and tethered at the nasal canthus or lower outer canthus of the eye [11].

Reference electrodes are placed at the ipsilateral outer canthus (iOC) of each eye [11].



A ground electrode can be placed anywhere on the head.

Impedances of the reference and ground electrodes should be less than 5KΩ and equal. It is recommended not to measure impedance in situ of the actual recording electrode unless explicitly specified by the particular electrode manufacturer [11].

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