Visual Evoked Potentials

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Outline

• Visual Pathway Anatomy
• Basic VEP principles
  - VEP Definition
  - Types of VEPs
  - Waveforms and generators
• VEP Techniques
  - Patient/Testing Conditions
  - Stimulation Parameters
  - Recording Montage
• Interpretation
  - Evaluation of the P100
  - Variables affecting the P100
• Example VEPs
Visual Pathway Anatomy

VEP

• **Definition:** An electrophysiologic response time locked to a visual stimulus

• VEPs can be categorized by stimulus characteristics:
  1. Stimulus type: patterned (usually checkerboard) vs. unpatterned (flash).
  2. Field stimulated: monocular full field vs. hemi-field
  3. Stimulus Frequency: transient VEPs vs. steady state VEPs

• **Clinical use:** most often used to evaluate optic nerve function, but can detect abnormalities at any point in the visual pathway
Neural Generators of the VEP

- **P100**: Generators within occipital cortex (striate and extrastriate cortex)
- **Pattern VEP**: is dominated by central (macular) vision serving the central 8-10 degrees of the visual field
- **N100**: separate generator in the frontal region
P100

• A middle latency, near field potential
• It is the most consistent component of the VEP and thus used for interpretation
• Assesses the conduction of neuronal activity from the retina to the occipital cortex
• Typically maximal amplitude is in the mid-occipital region, but can be displaced above or below (normal variant)
VEP Testing:
Patient Assessment and Test Conditions

- Assess and record visual acuity of each eye (corrected)
- Assess alertness and ability to fixate
- Assess pupils and ensure no cycloplegics
- Conduct test with appropriate corrective lenses
- Conduct test in ordinary room illumination
VEP Testing: Stimulation Parameters

- **Pattern Reversal**
  
  Full field - Better for detecting lesions anterior to the chiasm
  
  Hemi-field - Used for detecting lesions posterior to the chiasm (Limited utility overall)

- **Flash**

  Use if subject unable to fixate or has very poor visual acuity

  Responses are complex and variable

  Interpretation largely limited to “all or none”
## Stimulus Parameters: Pattern Reversal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Size</td>
<td>30 min checks</td>
</tr>
<tr>
<td></td>
<td>can use 15’ and 60’ as needed</td>
</tr>
<tr>
<td></td>
<td>Visual Angle=arctan(width/distance)</td>
</tr>
<tr>
<td>Intensity</td>
<td>Photopic</td>
</tr>
<tr>
<td>Contrast</td>
<td>50-100%</td>
</tr>
<tr>
<td></td>
<td>Difference in luminance between bright and dim portions of pattern</td>
</tr>
<tr>
<td></td>
<td>Lmax-Lmin*100/(Lmax+Lmin)</td>
</tr>
<tr>
<td>Luminance</td>
<td>MUST KEEP CONSTANT</td>
</tr>
<tr>
<td>Distance</td>
<td>&gt;70 cm from screen</td>
</tr>
<tr>
<td>Reversal Rate</td>
<td>&lt; 4 rev/ second</td>
</tr>
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</table>
Effect of Check Size

• Checks too small
  False positives due to refractive error

• Checks too large
  Decreased sensitivity
  Antagonistic effects of peripheral/foveal responses

• Using multiple check sizes can be helpful
  If visual acuity is 20/50 or better:
    use 30 min and 15 min checks
  If visual acuity is <20/50:
    use 30 min and 120 min checks (+/- flash)
<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Passband</td>
<td>1-100 Hz</td>
</tr>
<tr>
<td>Sweep</td>
<td>250msec</td>
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<tr>
<td></td>
<td>500msec (flash)</td>
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<tr>
<td>Number averaged</td>
<td>100-200</td>
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<tr>
<td>Replications</td>
<td>at least 2</td>
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<tr>
<td>Sampling Rate</td>
<td>&gt;2000/s</td>
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</table>
“Queens Square” electrode positions

MO = 5 cm above Inion
LO, RO = 5 cm lateral to MO
MF = Midfrontal, 12 cm above nasion

Midline Montage

Fz – M1
MPz– M1
Oz – M1
Oz – Fz

20 msec/div  3 uv/div
Single Channel

Oz-Cz

25 msec/div  2 uv/div
Patient Factors affecting VEPs

• Visual Acuity (ability to resolve pattern stimulus)
• Visual Field defect
• Ocular Factors
• Cooperation: lack of focus/fixation
• Pupil Size
• Age
• Gender
Interpretation

- Identify major waveform components: N75, P100, N145
- Measure the P100 latency for each eye
- Calculate the latency difference between eyes: interocular latency difference
- Measure the mid occipital P100 amplitude for each eye: peak to peak (N75-P100) or (P100-N145)
- Calculate the interocular amplitude ratio
- Evaluate the topographic distribution of the P100. If using lateral electrodes, is P100 laterally displaced? If so, do hemi field stim.
Interpretation

Major Criteria for abnormality:

• P100 absolute latency prolongation
• P100 interocular latency difference
• Absent waveform (using analysis times as long as 500ms and multiple recording sites)

Minor criteria for abnormality:

• P100 interocular amplitude difference (>2.5:1)
• Abnormal topography
• Abnormal waveform morphology (if monocular)
Interpretation: Localization

Asymmetric Abnormality = anterior to chiasm (optic nerve or ocular)

Bilateral Abnormality = non localizing
Each lab must use its own normative data

<table>
<thead>
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<th>Age</th>
<th>MALE mean</th>
<th>FEMALE mean</th>
<th>MALE + 3 s.d.</th>
<th>FEMALE + 3 s.d.</th>
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<td>80</td>
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<td>123</td>
<td>120</td>
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46 year-old man with episodes of “visual spots”

20 msec/div  3 uv/div
46 y/o woman with episode of dizziness

**OS**

- Fz-A1
- Mpz-A1
- Oz-A1
- Oz-Fz

20 msec/div  7 uv/div
52 year-old man with headache and visual disturbance

Oz-Cz

Oz-Pz

25 msec/div  5 uv/div
52 year-old man with headache and visual disturbance

25 msec/div  5 uv/div
78 y/o woman with visual complaints

OS

OD

Fz-A1

Mpz-A1

Oz-A1

Oz-Fz

20 msec/div 3 uv/div
26 year-old woman with tingling in arms and leg
No visual symptoms
36 year old woman with right weakness, paresthesia
No visual symptoms

20 msec/div  3 uv/div

OS 122ms
OD 105ms
OS-OD 17
Mean +3sd=113ms
Fz-A1
Mpz-A1
Oz-A1
Oz-Fz

OS 140ms
OD 120ms
Mean +3sd=113ms
23 year old man with ataxia, vertigo, r/o MS
No visual symptoms
13 year-old with left eye pain and blurred vision
Acuity OS 20/80 OD 20/20

Oz-Cz Oz-Cz

Oz-Cz

30 min checks

Flash

25ms/div
2µv/div
28 year old with dizziness, r/o MS

Oz-Cz

30 min checks
OS 102
OD 115
>3s.d 114

Oz-Cz

15 min checks
OS 125
OD 125

25ms/div
2µV/div
48 y/o cocaine abuser, dysarthria, blurred vision

OS

OD

Fz-A1
Mpz-A1
Oz-A1
Oz-Fz

20 msec/div  3 uv/div
11 month-old with head trauma

Oz-Cz Flash

25ms/div
2µV/div
35 y/o man with MS

Oz-Cz

Flash

OS 120 ms
OD 143 ms
OS-OD 23
Retrochiasmatic Pathology: Hemifield stimulation Technique

• Imaging modalities have replaced this technique
• Technically difficult. Even small eye movement (one degree!) can lead to large contamination of hemifield responses.
• Arises from projections/activation of the peripheral visual field rather than just the area of the macula
  • -larger check sizes
  • -lateral recording electrodes: LT and RT
Hemifield Stimulation

Recall that LEFT hemifield stimulation projects to the LEFT occiput!!!

P100 response over **ipsilateral** occipital temporal leads
N105 over **contralateral** occipital temporal leads

ACNS Guideline 9B: Visual Evoked Potentials.
American Clinical Neurophysiology Society,
2008: 10.
VEPs after right hemispherectomy

Summary

• Full Field Pattern VEPs reliably assess the pre-chiasmal visual pathway, but can also detect lesions elsewhere.

• Responses may be affected by a variety of patient factors and test conditions.

• Evaluation of the P100 latency must be based on laboratory specific normative data.

• Other stimulation techniques (flash and hemifield) can provide additional information, though their utility is more limited.