



Introduction to Vestibular Laboratory Tests

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Disclosures

No financial disclosures or conflicts of interest.

No relevant non-financial relationship to disclose.

Learning Objectives

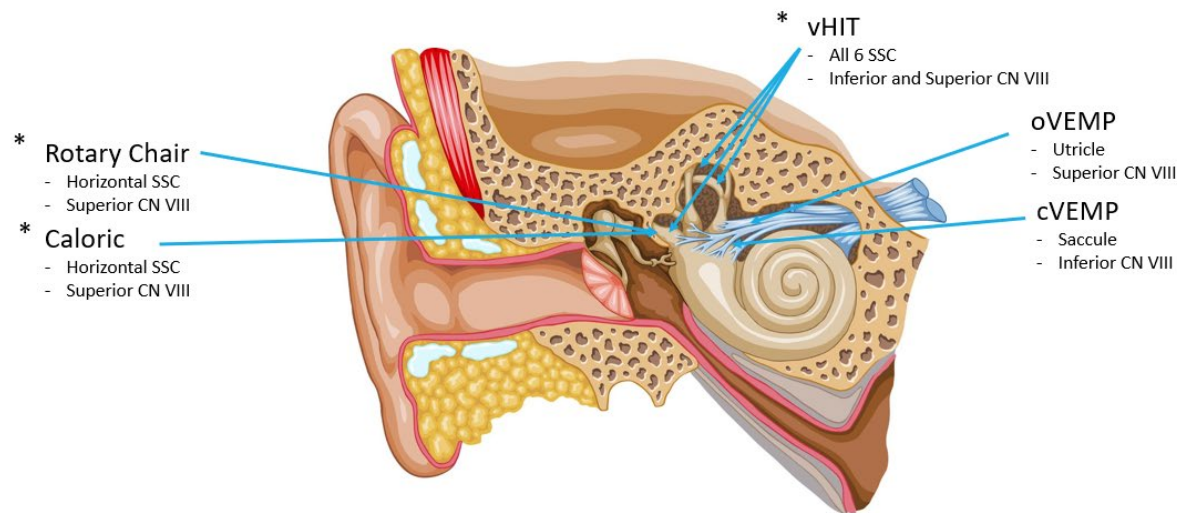
1. Describe vHIT, o/cVEMPs, VNG and Rotary Chair
2. Understand which portion of the system each is testing
3. Have a basic understanding of the results

Vestibular Evaluation

- VNG (or ENG)
- Caloric Irrigations
- Rotary Chair
- vHIT
- VEMPs

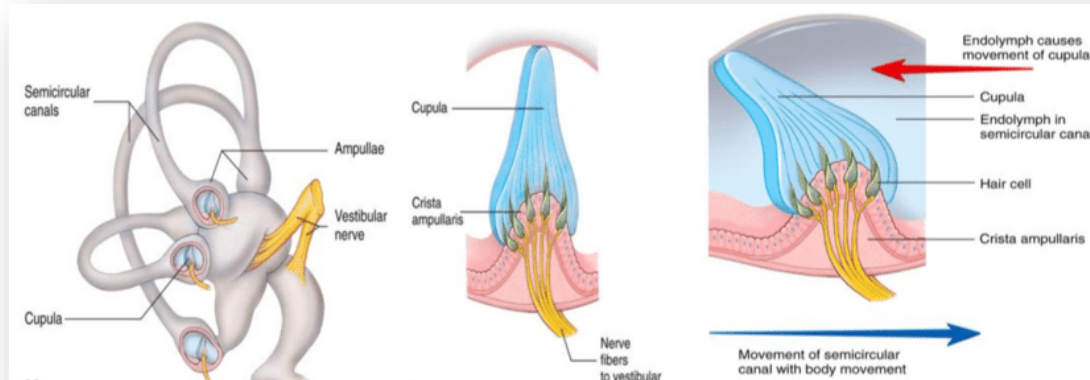
Testing the System

- 8th nerve (inferior and superior portions of the nerve)
- Semicircular canals
- Sacculle
- Utricle



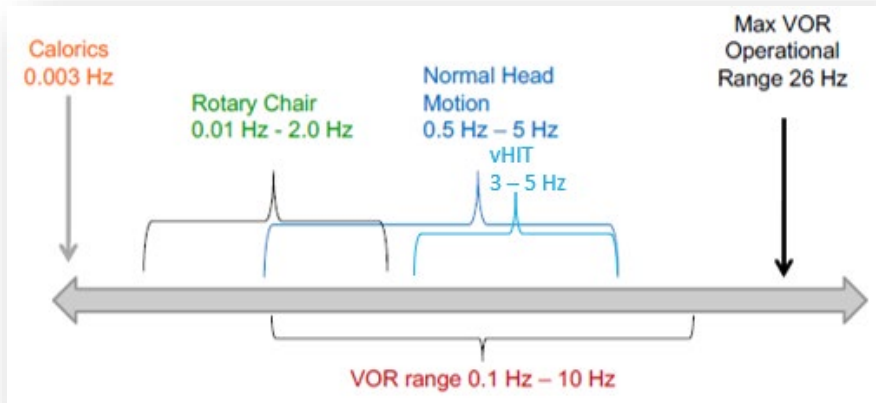
Semicircular Canals

- Responsible for angular head movement
 - Lateral / Horizontal
 - Anterior
 - Posterior
- Work in three matched pairs
 - Right Lateral – Left Lateral
 - Right Anterior – Left Posterior (RALP)
 - Left Anterior – Right Anterior (LARP)

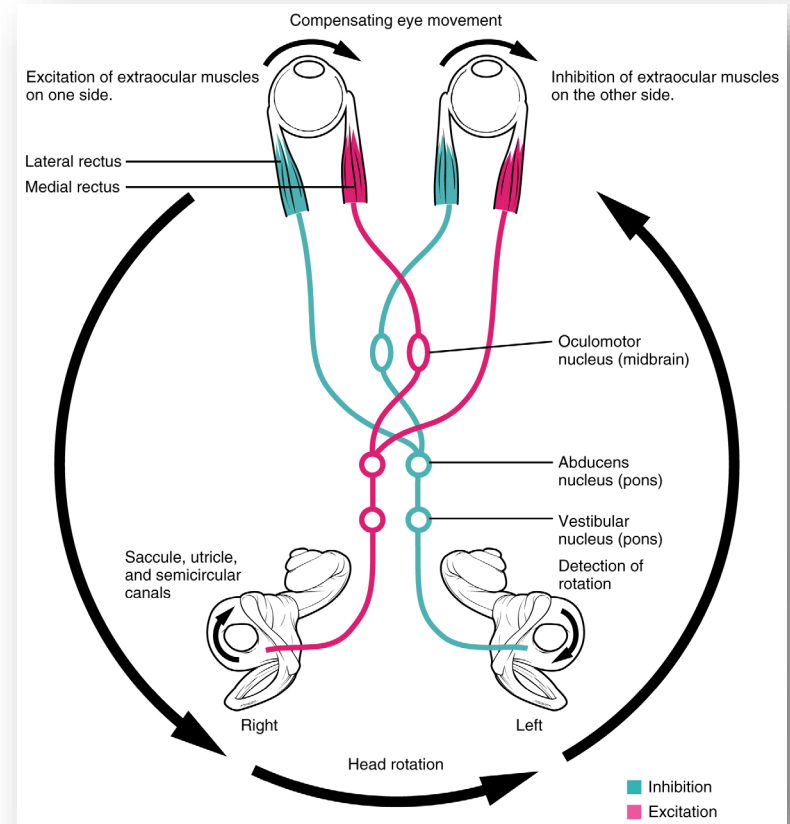


Vestibulo-Ocular Reflex

- Compensatory eye movement
- Stabilization of gaze
- Postural control



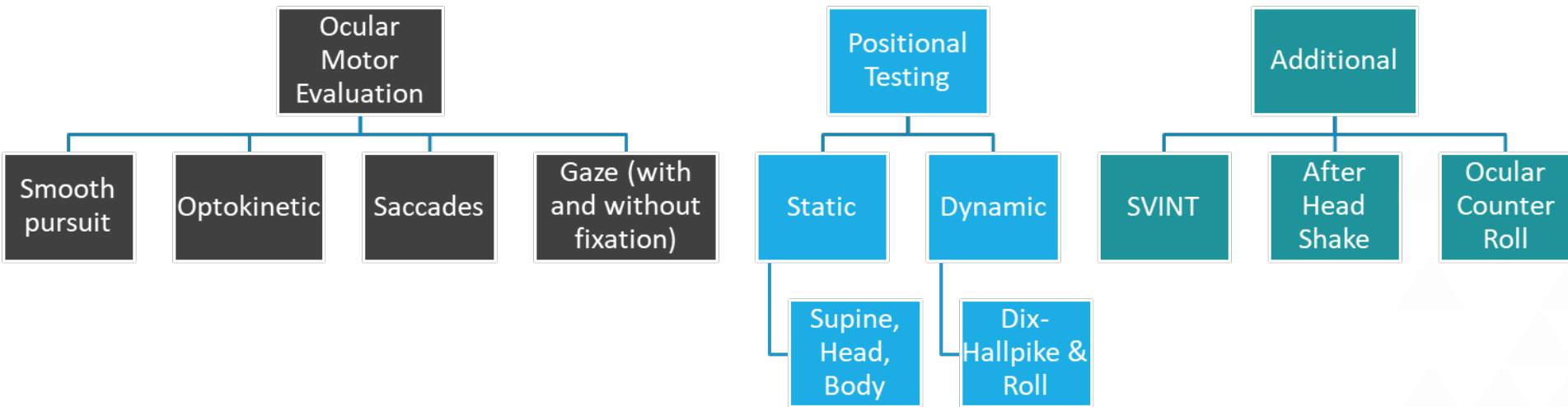
(Leigh & Brandt, 1992)
Zalewski, C. PhD. [2015]. Fundamentals of Rotational Vestibular Assessment [1-28].



Vestibular Evaluation

- **VNG (or ENG)**
- Caloric Irrigations
- Rotary Chair
- vHIT
- VEMPs

Videonystagmography (VNG)

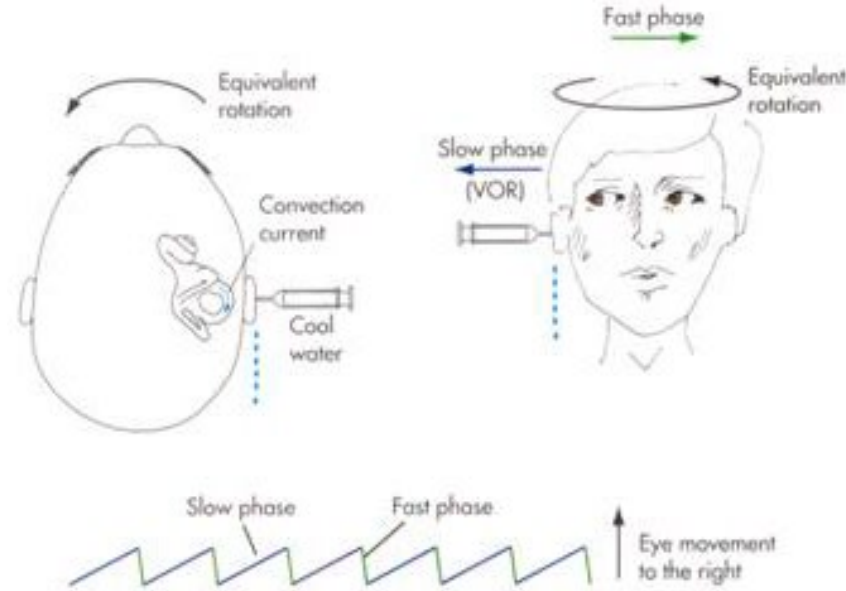


Vestibular Evaluation

- ~~VNG (or ENG)~~
- **Caloric Irrigations**
- Rotary Chair
- vHIT
- VEMPs

Caloric Irrigations

- Testing VOR of the horizontal SSC
- Head is at 30 degrees
- Warm and cool water (or air) presented into the ear canal
- Changes the temperature of the ear which changes the density of the endolymph in the horizontal SSC
- An absent or weak response to caloric irrigations are indicative of a peripheral lesion
- UW (unilateral weakness) or RVR (reduced vestibular response) is calculated
 - ~ 25% or greater is considered a unilateral weakness



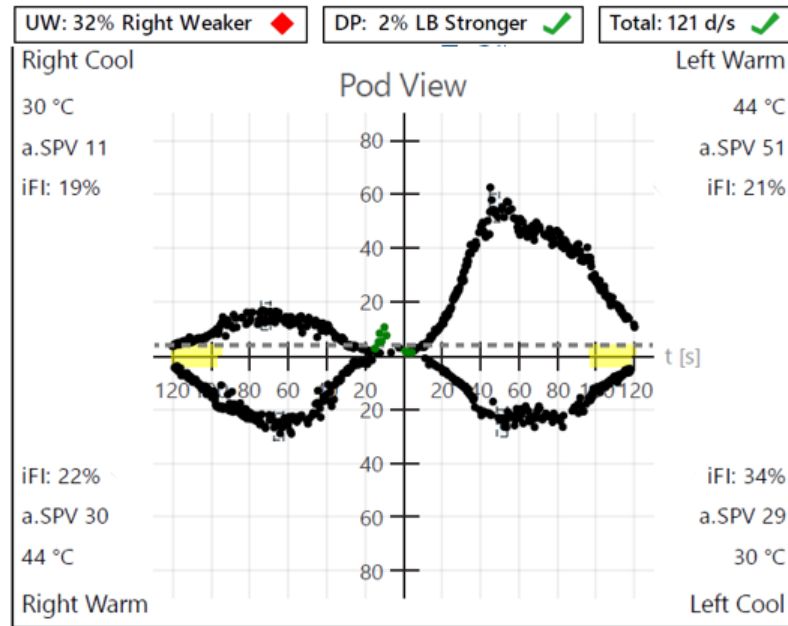
Calorics: The Setup

- Otoscopy prior to confirm TM is visible and intact and ear is dry and healthy
- Head at 30 degrees
- Visor over the eyes (fixation denied)
- Irrigator placed into canal
 - ANSI standards recommend warm water first then cool and to start with the right ear
- Basin/towel under ear to catch water
- Instructions are very important
- Tasking patient necessary

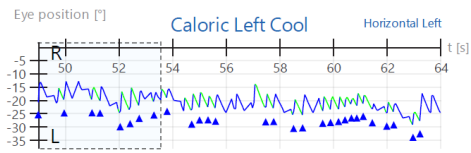
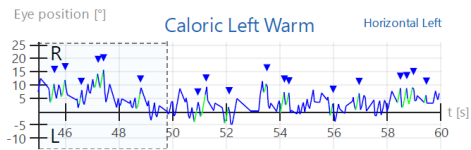
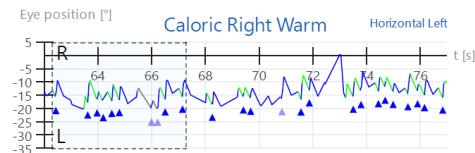
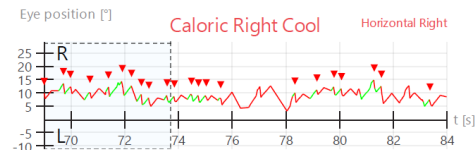


Calorics: The Results

- Nystagmus direction changes with temperature change
- “COWS”
 - Cool - opposite
 - Warm – same
- Peak nystagmus from each irrigation used for calculations

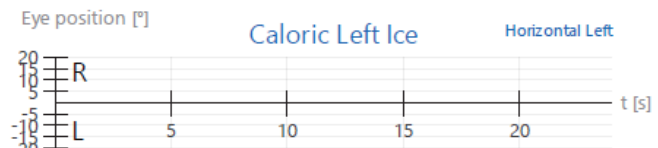
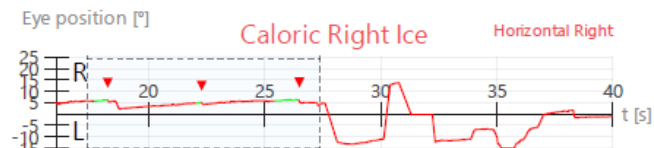
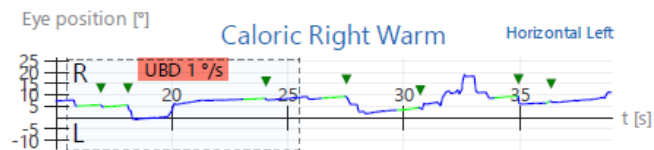
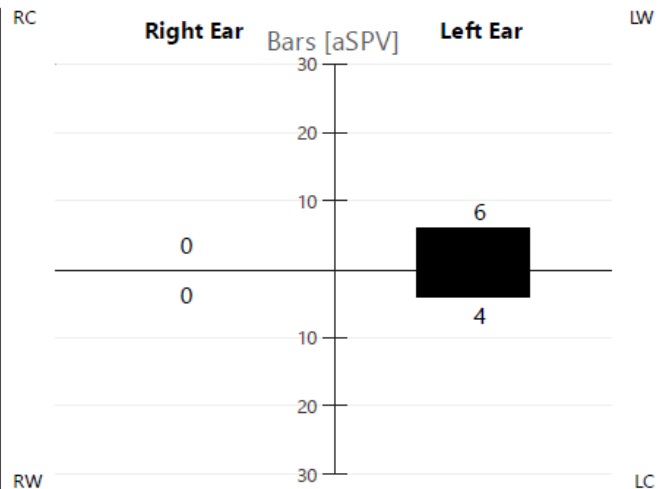
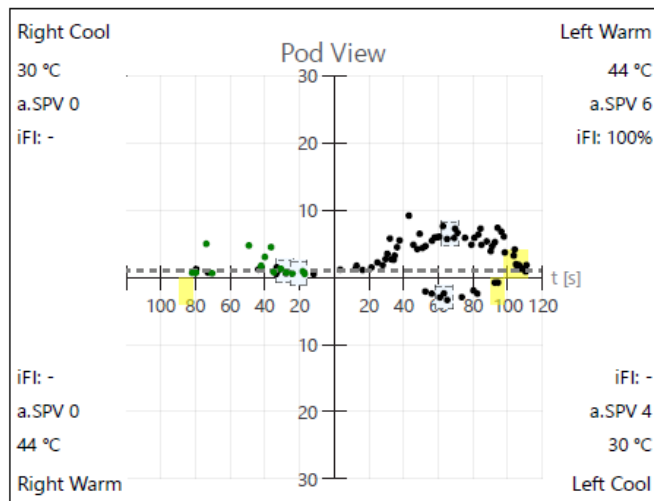


- UW or RVR: is there a weaker ear?
 - $(LC+LW) - (RC+RW) / (LC+LW+RC+RW) \times 100$
- Direction Preponderance: was the nystagmus stronger in one direction?
- Total response RE/LE: useful to diagnose BVH
- Fixation Index: are they able to suppress the response with fixation?



Calorics: BVH

- Total LE <12 d/s & Total RE <12 d/s = BVH (Jacobson and Newman, 1993)
- Debate about BVH criterion
- Be consistent within your clinic



Ice Water

Ice Water Calorics:

- Used when there is no response from caloric irrigations
- Ice-water is used to determine if any residual function

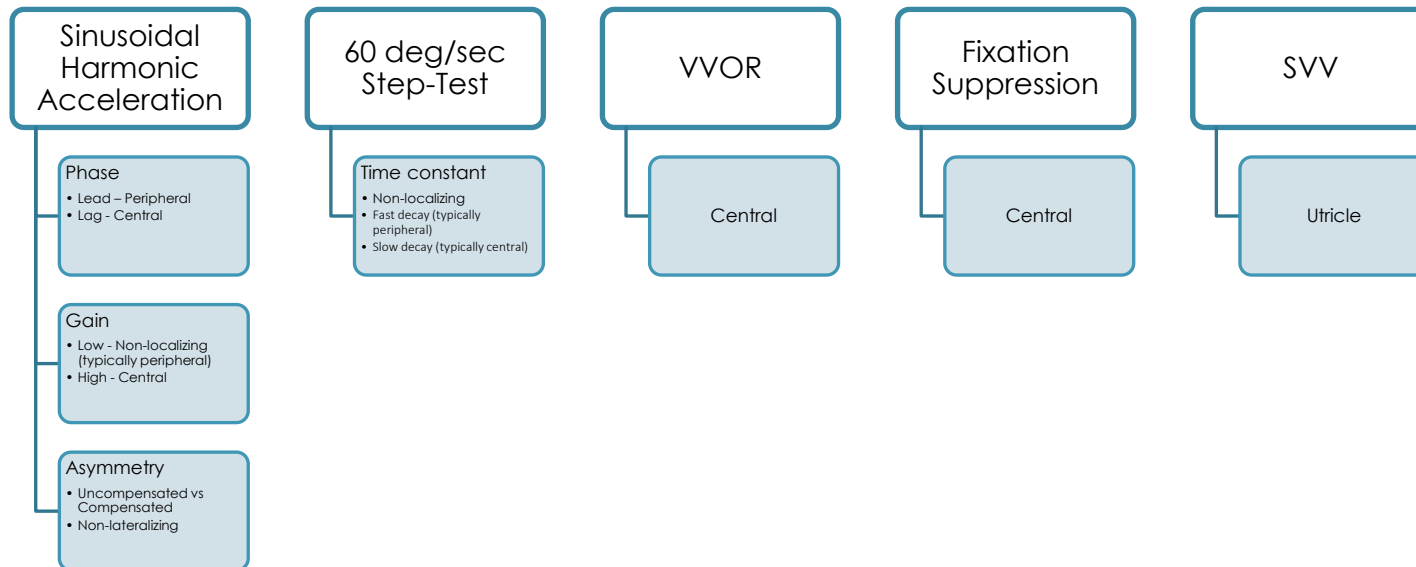
The Setup:

- Use ice made with sterilized water
- Turn head for test ear up
- Inject 2 cc ice water into canal
- After 20 seconds the head is returned to center and ear is emptied onto the towel
- Can be performed two ways:
 - If no spontaneous nystagmus is visualized
 - Head is at 30 degrees to irrigate
 - If spontaneous is present
 - Supine to irrigate – if nystagmus is present patient should be rolled to prone
 - Nystagmus should disappear or change directions

Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- **Rotary Chair**
- vHIT
- VEMPs

Rotary Chair



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- The screenshot displays a video recording interface for eye-tracking. At the top, a title bar reads "Sinusoidal Harmonic Acceleration - .04 Hz 60 dps". Below the title are three control icons: a crosshair, a plus sign, and a double arrow. The main area is divided into two panels, each showing a video feed of an eye and a corresponding data plot.
- The left panel shows a video feed of an eye with a red border. Below it is a plot titled "Horizontal Right" and "Horizontal Left". The plot shows two data series (red and blue) over time, with a red line indicating the right eye's position and a blue line indicating the left eye's position. The x-axis is labeled from 60 to 100.
- The right panel shows a video feed of an eye with a blue border. Below it is a plot titled "Horizontal Right" and "Horizontal Left". The plot shows two data series (red and blue) over time, with a red line indicating the right eye's position and a blue line indicating the left eye's position. The x-axis is labeled from 60 to 100.
- On the right side of the interface, there are two bar charts. The top chart is titled "Gain" and shows two bars: a red bar labeled "24" and a blue bar labeled "21". The bottom chart is titled "Phase" and shows two bars: a red bar labeled "4.4" and a blue bar labeled "4.2".

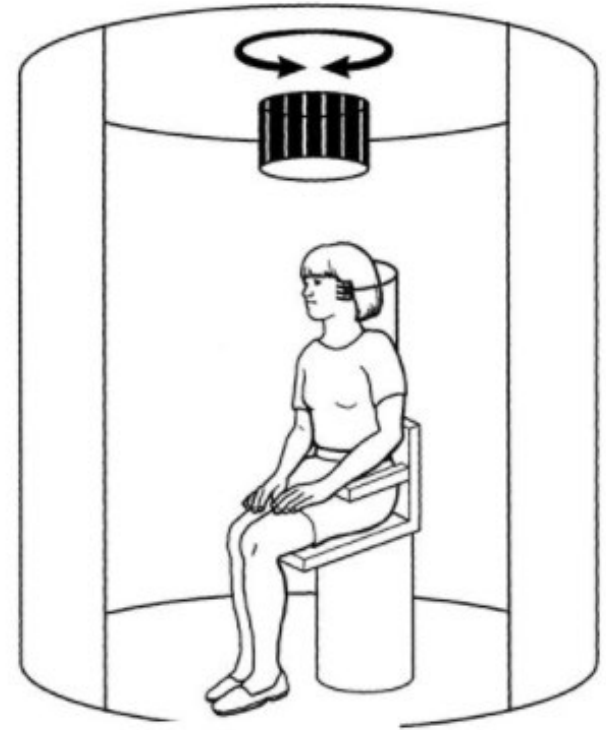
SHA: The Setup

- Seated upright with head pitched forward at 30 degrees to stimulate the horizontal SSC
- Seatbelt, head straps, ankle straps in place
- Vision denied (enclosure or visor)
- Tasking while testing is essential



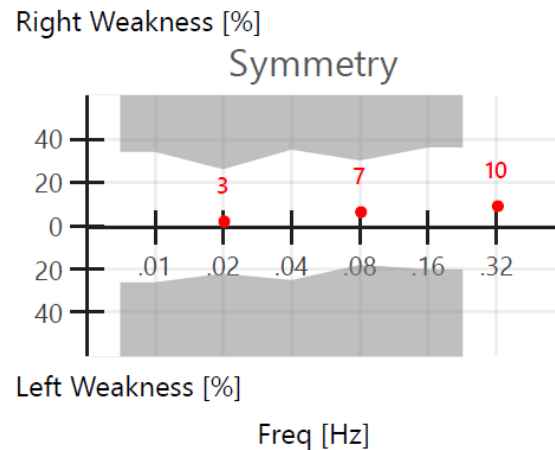
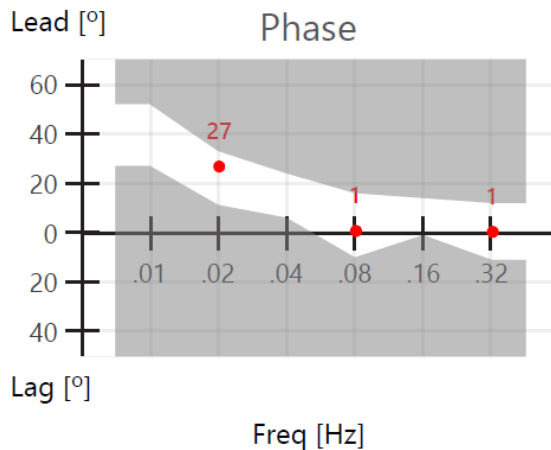
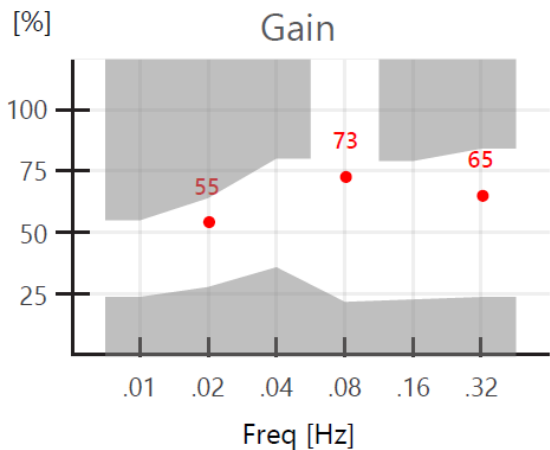
Sinusoidal Harmonic Acceleration (SHA)

Phase	Eye movement in comparison to the head/chair
Gain	Responsiveness of the system
Asymmetry	Ratio of nystagmus in the CW compared to CCW condition

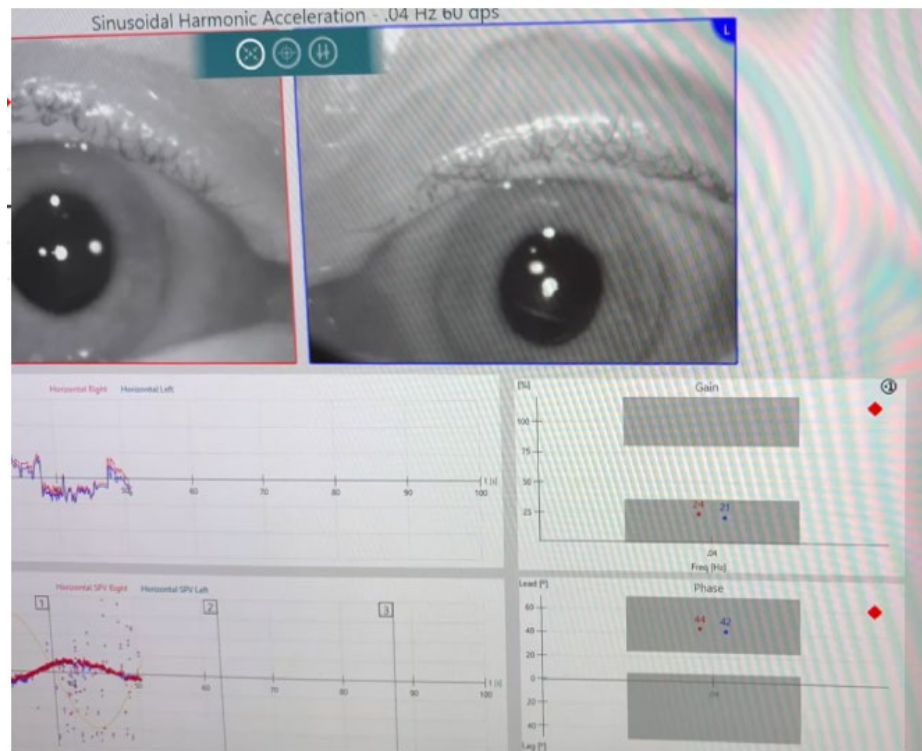
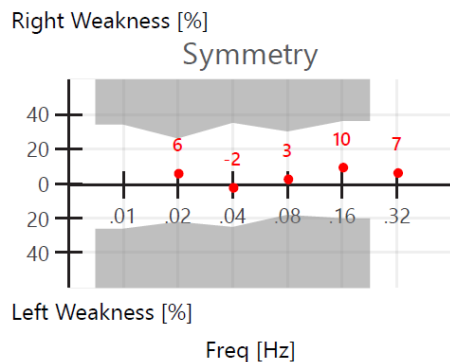
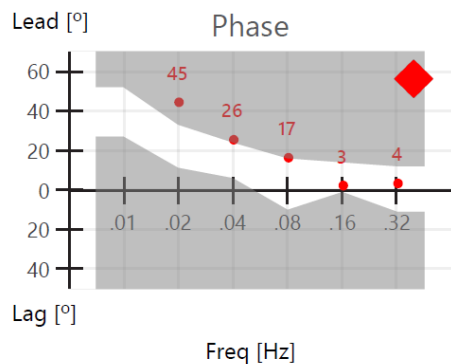
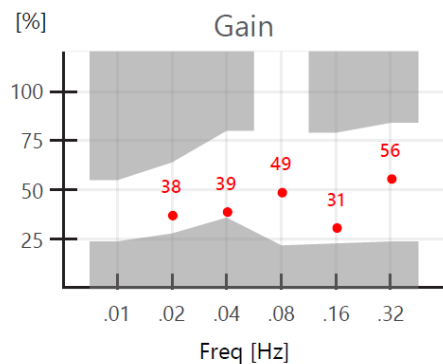


SHA: The Results

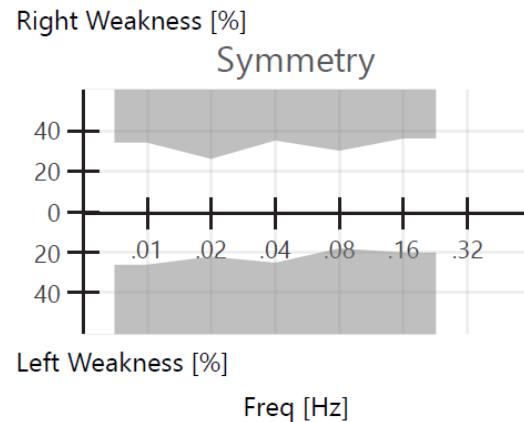
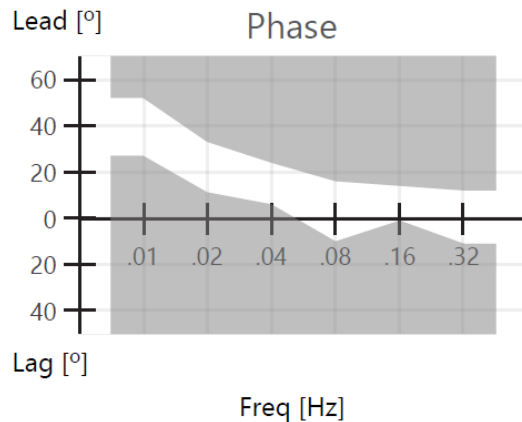
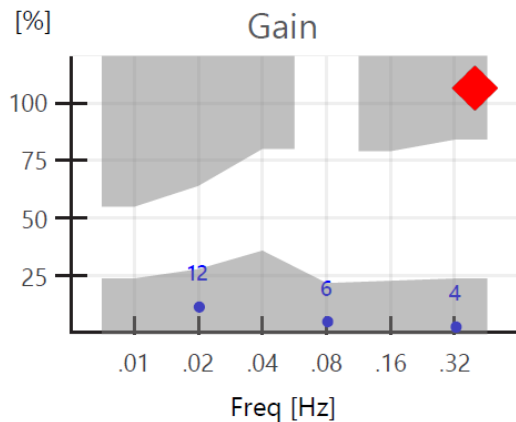
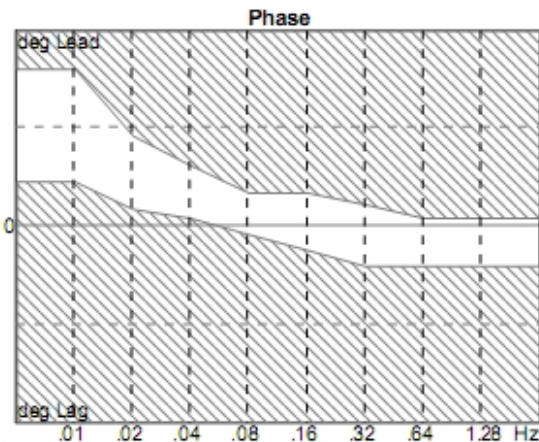
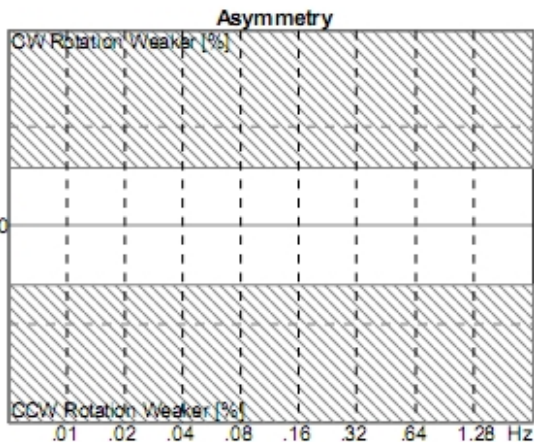
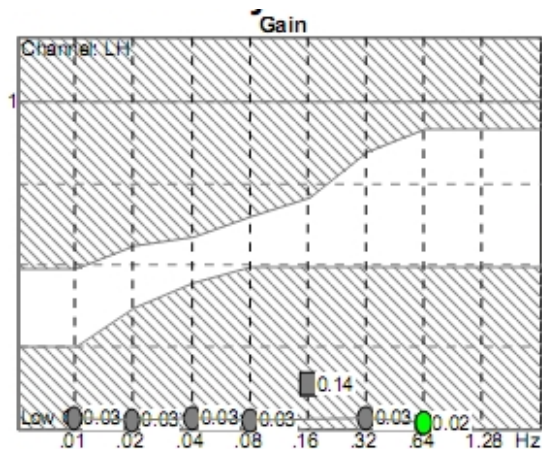
Sinusoidal Harmonic Acceleration



SHA: Unilateral Peripheral Weakness



SHA: BVH



Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- ~~Rotary Chair~~
- **vHIT**
- **VEMPs**

Video Head Impulse Test (vHIT)

- VOR of all 6 semicircular canals
 - Testing lateral, RALP and LARP planes
- Quick test with minimal contraindications
- Eye and head movement should be equal and opposite
- Looking for corrective eye movements



vHIT: The Setup

- Goggles with high-speed camera placed
 - Need to be tight to avoid slip
- Target is visualized
 - Earth-fixed
- Head is turned 20-30 degrees off target
 - Passive and unpredictable
 - 150 degrees/sec or greater head velocity
- Patient instructed to keep gaze on target the entire time
 - Or return to target if lost



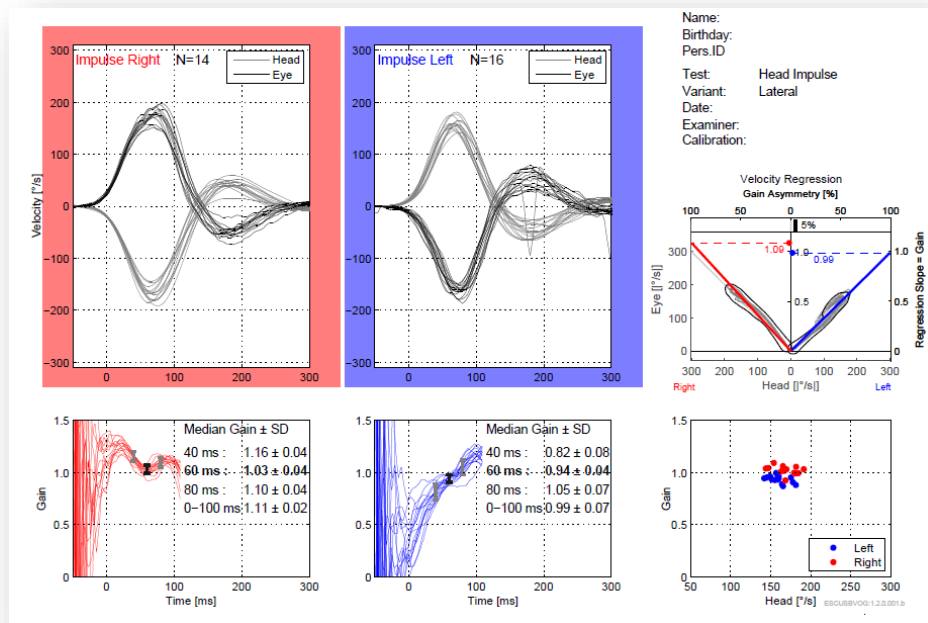
vHIT: The Results

- Normal:

- Gain is $\sim 0.75 - 1.2$ (clinic norms may vary)
- No corrective saccades

- Abnormal:

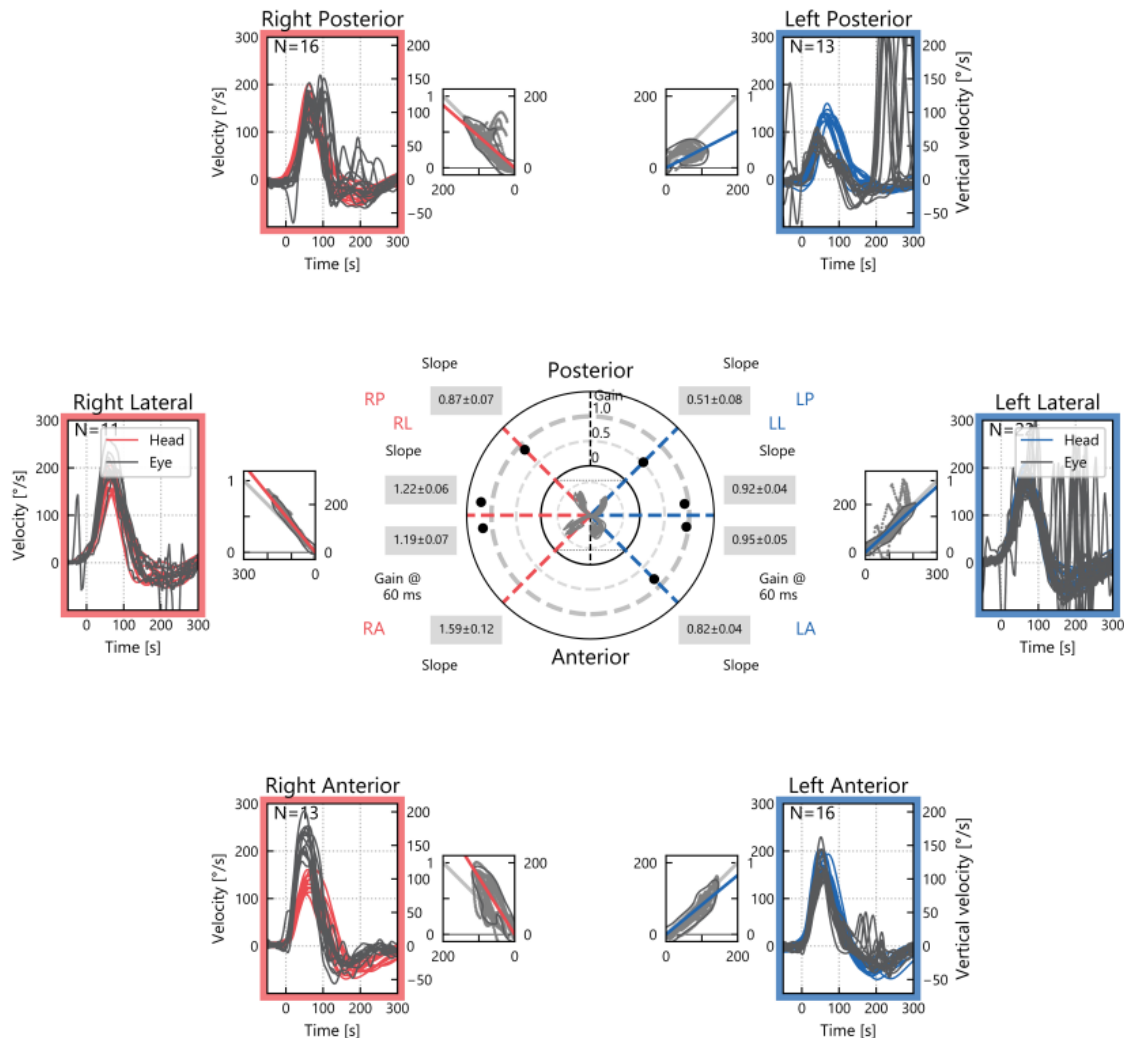
- Gain < 0.75
- Corrective saccades
 - Covert (during head movement)
 - Overt (after head movement)



vHIT: Unilateral

- Gain:
 - Low gain in LP (0.51)
- Saccades:
 - Large overt saccades in LP
 - Large covert and overt saccades in LL

vHIT for EyeSeeCam - EyeSeeSix



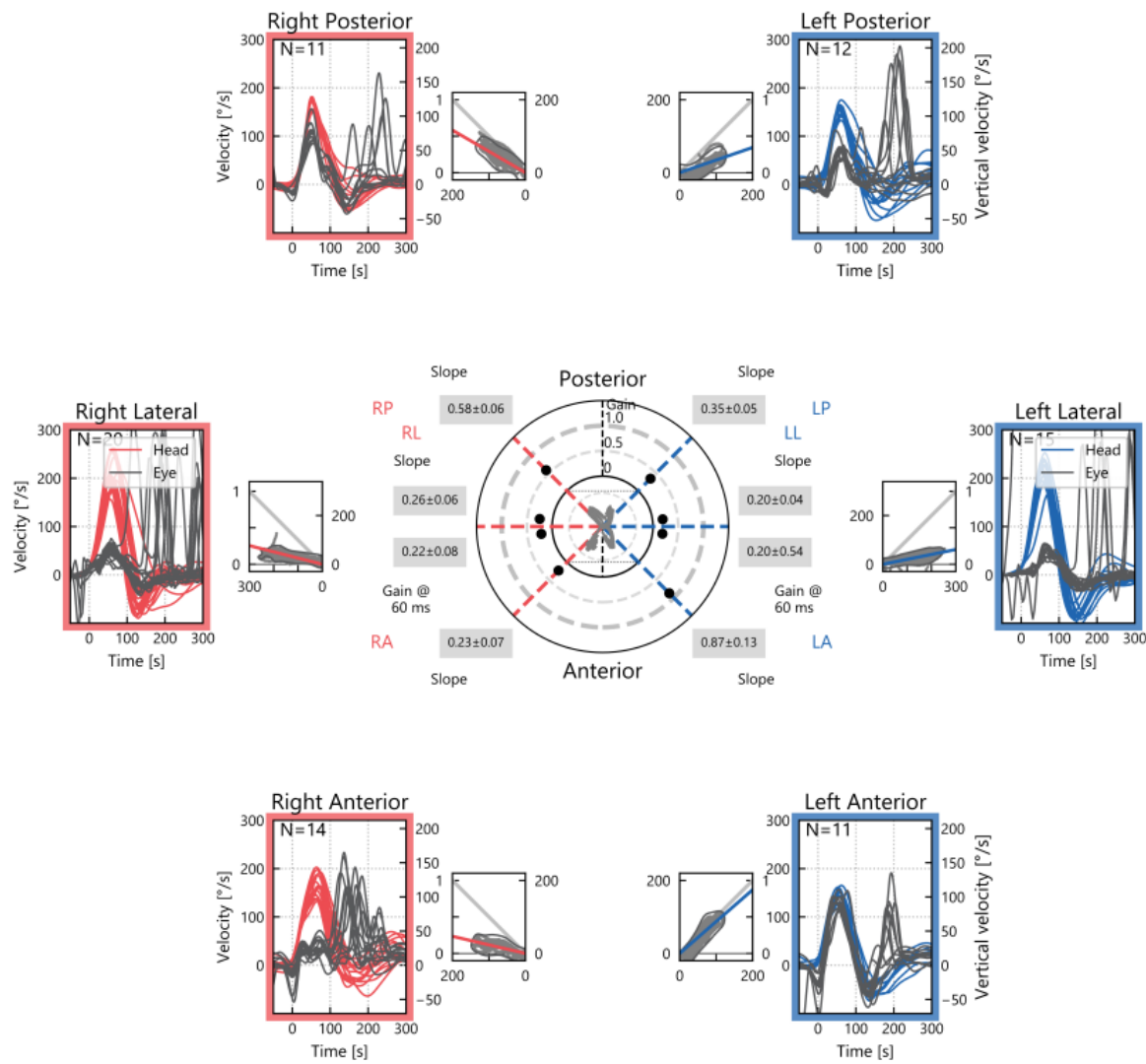
vHIT: BVH

- Gain:

- Low gain in LP, RP, RL, LL, and RA

- Saccades:

- Large overt saccades in RP, LP, LL, LA
- Large covert and overt saccades in RL, RA

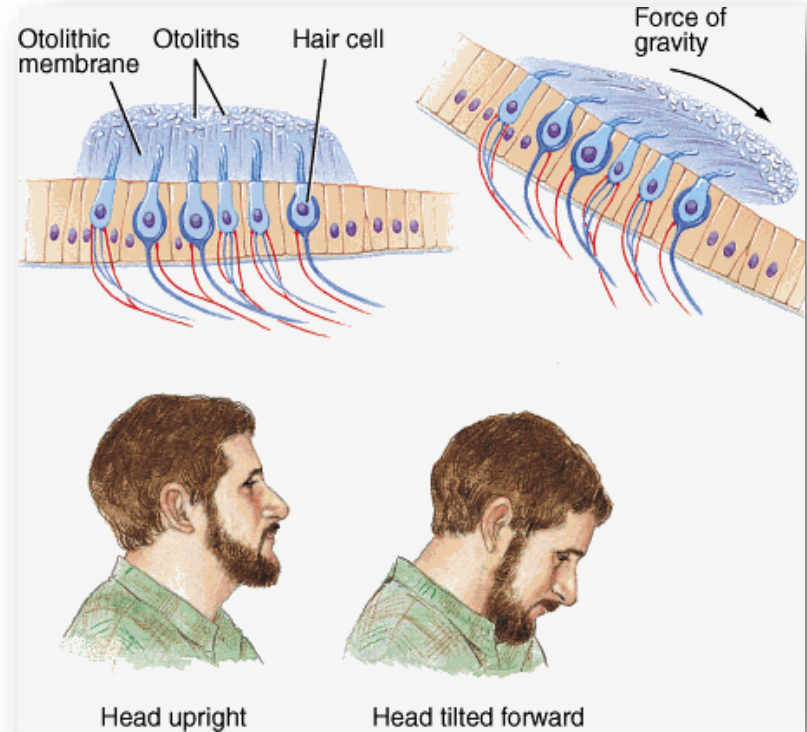


Vestibular Evaluation

- ~~VNG (or ENG)~~
- ~~Caloric Irrigations~~
- ~~Rotary Chair~~
- ~~vHIT~~
- **VEMPs**

Vestibule

- **Responsible for linear movements**
 - Saccule – up/down
 - Utricle - forward/backward

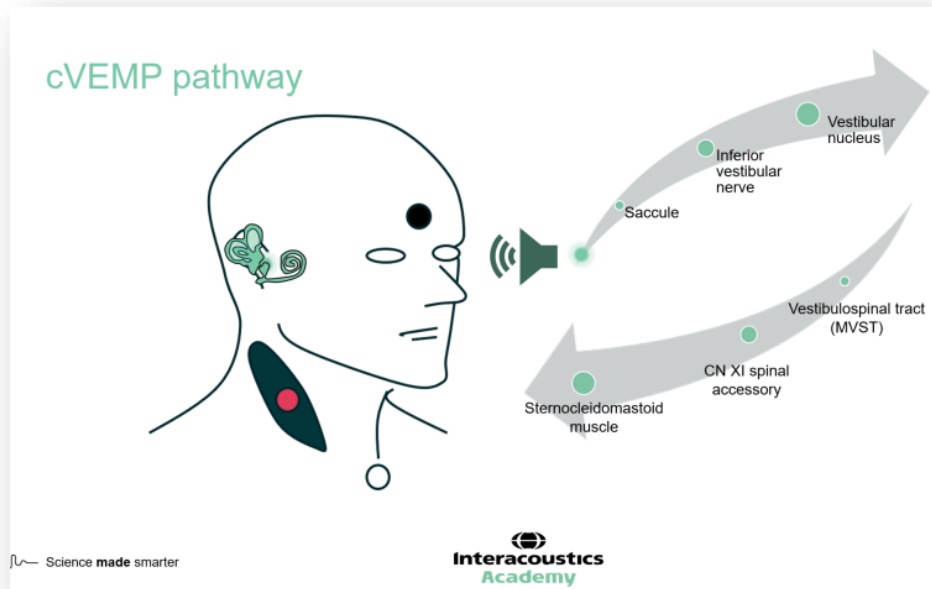


VEMPS

- **V – VESITBULAR**
 - Originates from the inner ear
- **E – EVOKED**
 - Elicit a response (by a stimulus)
- **M – MYOGENIC**
 - Measuring from the muscle
- **P – POTENTIAL**
 - Change in state (muscle activity)

Cervical VEMP (cVEMP)

- Testing saccule and inferior vestibular nerve
- Measure from the Sternocleidomastoid (SCM) muscle
- Ipsilateral response



<https://www.interacoustics.com/academy/evoked-potentials/vemp/vestibular-evoked-myogenic-potentials>

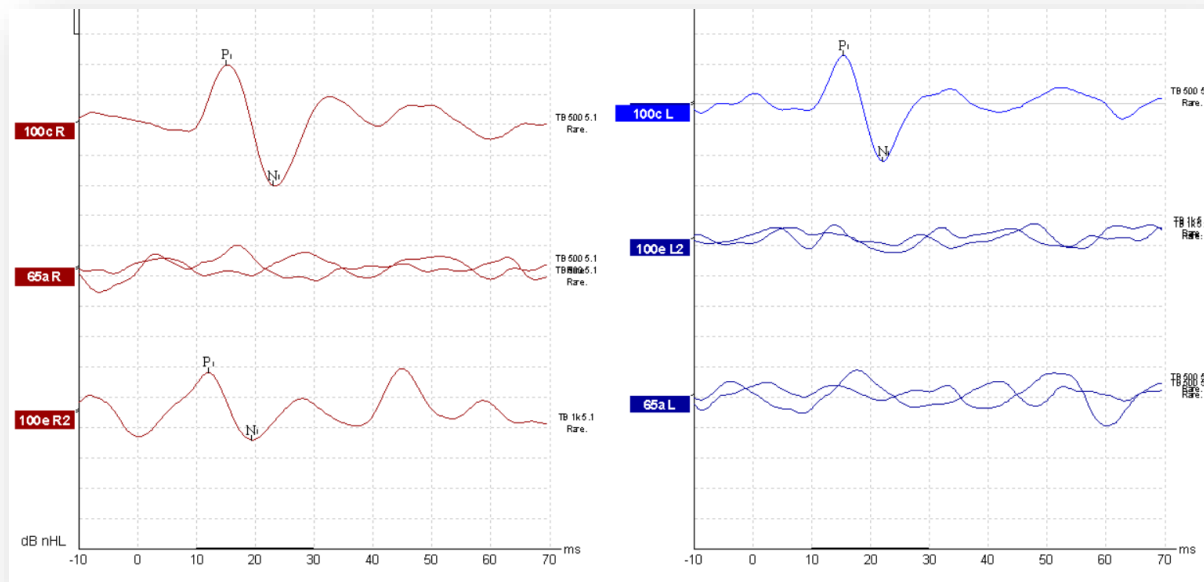
cVEMP: The Setup

- Normal middle ear function is needed for air conduction
 - If abnormal tympanograms or air-bone gaps on audiogram BC should be used
- Skin is cleaned and prepped for electrode placement
 - Confirm good impedances (<5kohms)
- SCM electrodes places symmetrically
 - Top 1/3rd of the muscle
- Head is turned away from stimulus and tuck chin to shoulder to contract the SCM
 - Muscle activity is monitored throughout



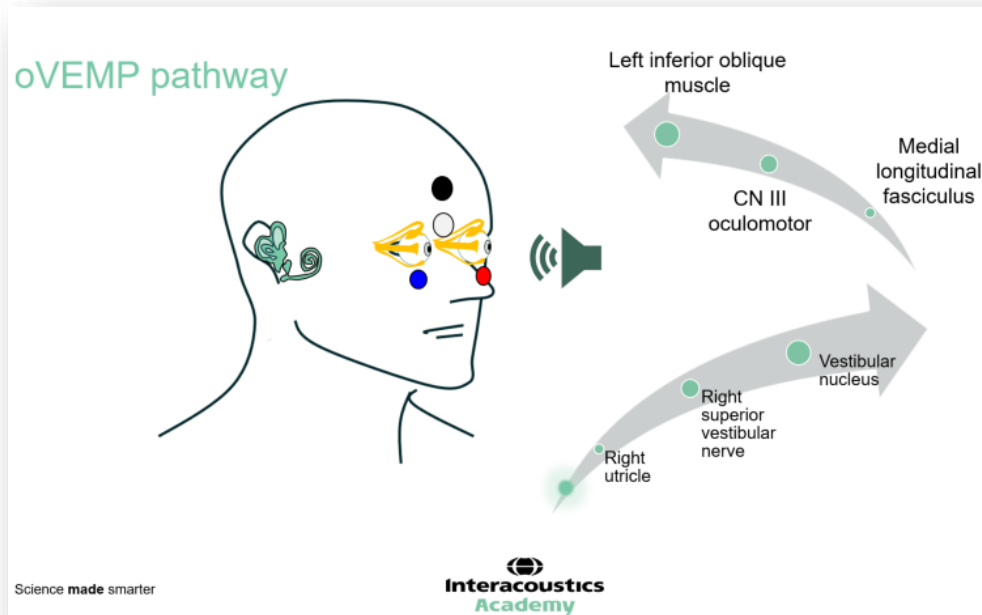
cVEMP: The Results

- **Amplitude**
 - 50 – 300 μ V
- **Latencies**
 - P1 ~15 ms
 - N1 ~23 ms
- **Asymmetry**
 - calculated with the amplitude of the L/R responses at the maximum intensity
 - $AR = ((\text{larger response} - \text{smaller response}) / (\text{larger response} + \text{smaller response})) \times 100$
 - >36% (Young et al, 2002)



Ocular VEMP (oVEMP)

- Testing utricle and superior vestibular nerve
- Measure from the inferior oblique muscle under the eye
- Contralateral response



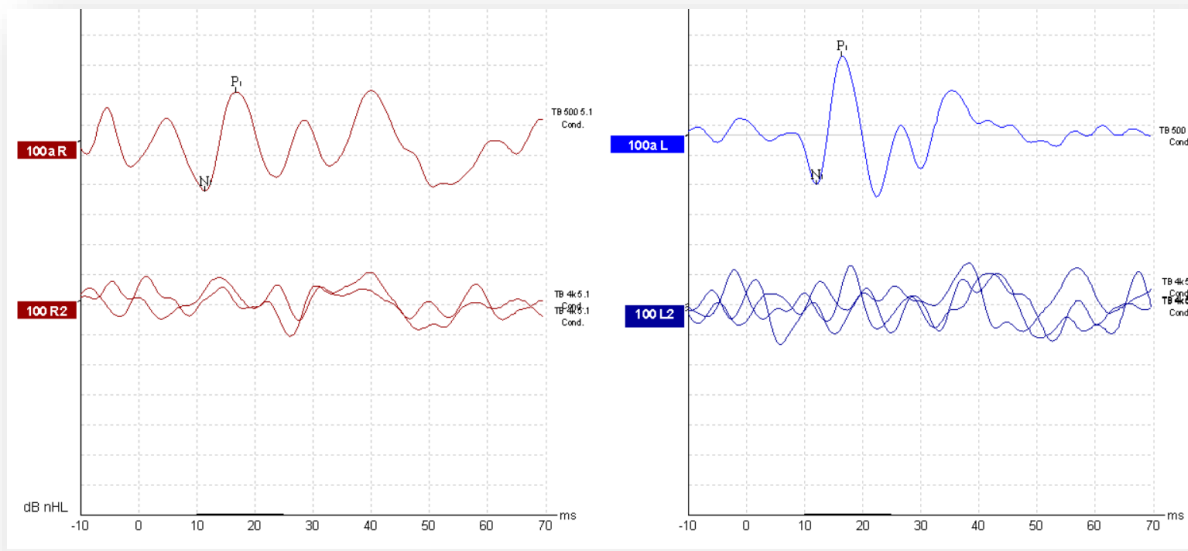
oVEMP: The Setup

- Normal middle ear function is needed for air conduction
 - If abnormal tympanograms or air bone gaps on audiogram, BC should be used
- Skin is cleaned and prepped for electrode placement
 - Confirm good impedances (<5kohms)
- Headphone placed in test ear (contralateral response)
- Gaze upward 30 degrees to contract the inferior oblique muscle



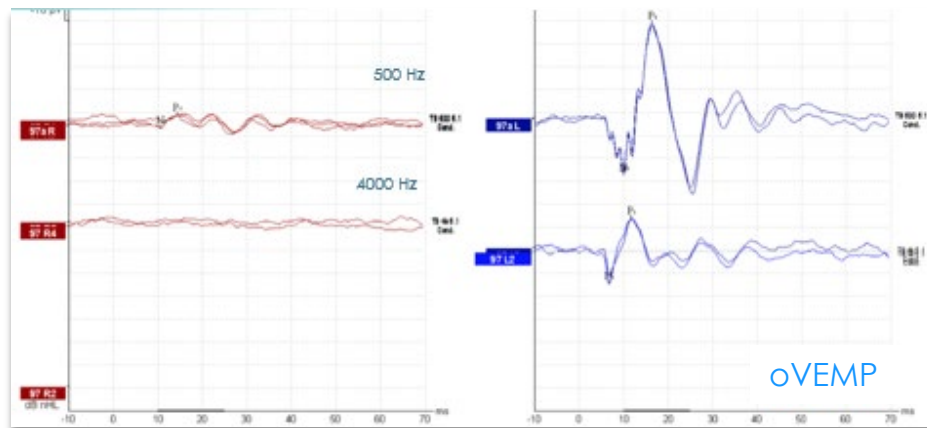
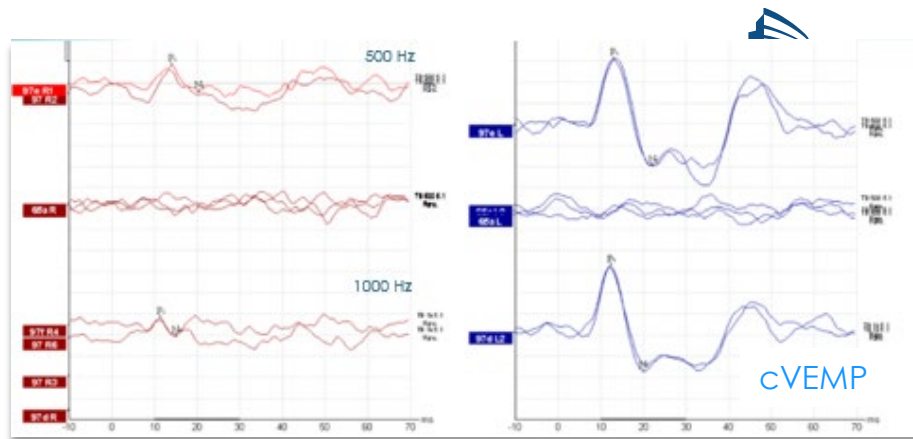
oVEMP: The Results

- **Amplitude**
 - 7 μV
- **Latencies**
 - N1 ~10 ms
 - P1 ~15 ms
- **Asymmetry**
 - Calculated with the amplitude of the L/R responses at the maximum intensity
 - $AR = ((\text{larger response} - \text{smaller response}) / (\text{larger response} + \text{smaller response})) \times 100$
 - >34% (Piker et al, 2011)



VEMP: SSCD

- **Amplitude**
 - May see larger amplitudes
- **Asymmetry**
 - Larger response from SSCD ear
- **Threshold**
 - present reduced intensity (cVEMP)
- **Frequency Tuning**
 - 4k Hz response (oVEMP)



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