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Vanderbilt Audiology's Journal Club with Devin McCaslin, Ph.D. Topic: The Current Status of the Video Head Impulse Test

Devin McCaslin, Ph.D., Vanderbilt University

Welcome

Host:
Gus Mueller, Ph.D.

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JOURNAL CLUB

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Today's Journal Club:

- **A little about cochlear implants**
- **An article about bilateral hearing aid fittings**
- **And, of course, our keynote topic:**

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The Current Status of the Video Head Impulse Test

Devin L. McCaslin, Ph.D.
Associate Professor
Vanderbilt Bill Wilkerson Center

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What They're Reading At Vanderbilt

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René Gifford, PhD

- Increasingly younger children (< 12 months) are receiving cochlear implants as research has shown that a younger age at implantation is associated with higher levels of word learning, vocabulary, auditory pathway maturation and speech recognition.
- On the other end of the life spectrum, as our nation ages and life expectancy rises, more older individuals are being affected by significant hearing loss. Thus there has been increasing interest in recent years about the efficacy of implanting older individuals with cochlear implants. The main questions have been centered on whether or not older recipients:
  - Demonstrate reduced benefit
  - Have greater risk of adverse surgical events

Three articles have recently caught my interest on this topic:

- Carlson et al. (2010). Cochlear implantation in the octogenarian and nonagenarian. Otol Neurotol. 31(8):1343-9.
- Lin et al. (2011). Hearing loss and cognition in the Baltimore Longitudinal Study of Aging. *Neuropsychology,25(6):763–770*
- Lin et al. (2011). Hearing loss and incident dementia. *Arch Neurol. 68(2):214–220*

Carlson et al. (2010)

- N = 258 (50 recipients > 79 years)

This particular article came to three primary conclusions:

- The octo- and nonagenarians demonstrated the same levels of speech recognition as individuals aged 18 to 79 years .
- The older subjects demonstrated no greater risk of adverse surgical events.
- But, the older subjects demonstrated greater risk of perioperative anesthetic complications and hospital admission.

A couple of teaching points:

- Older CI recipients will derive similar benefit to younger patients—an important counseling point in the clinic (see Lin et al papers)!
- Anesthesiologists are already at heightened alert for older surgery patient—not within our scope for counseling, but something to consider.

Lin et al. (2011a, b)

- Though these studies did not examine cochlear implantation in older adults, the findings are relevant to rehabilitative audiology:

These particular articles pointed out the following:

- Presbycusis is linked to poorer cognitive functioning
- Older individuals with severe+ hearing loss have a 5-fold increased risk of developing dementia
- Though the underlying mechanisms for the presbycusis/dementia link are not known, there are several possibilities including hearing loss affecting:
  - hearing loss affecting cortical processing
  - Increased cognitive load
  - social isolation

Check out René's excellent 20Q articles

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Gus's Pick Of The Month

Brought to you by AudiologyOnline

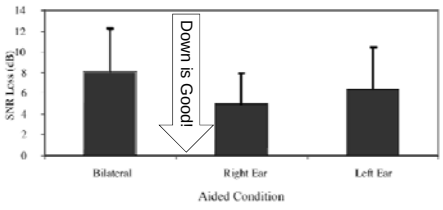
What you think you know about bilateral versus unilateral hearing aid fittings:

For understanding speech in background noise, most patients will do better with two versus one hearing aid.

This is because of:

- Binaural redundancy (the brain gets "two looks" at the signal of interest)
- Binaural squelch (brain uses phase and amplitude differences between the two ears to improve the SNR)

And then, a few years back, this study came along . . .



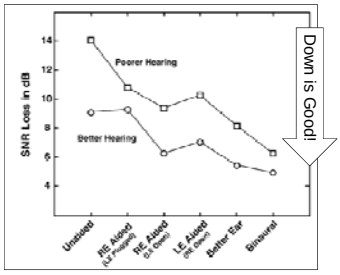
Walden T, and Walden B. Unilateral versus bilateral amplification for adults with impaired hearing. *JAAA*, 2005, 16: 574-584.

Reasons why there maybe wasn't a binaural advantage observed:

(Note: Presentation level used by Walden and Walden was 70 dB HL ~80-85 dB SPL)

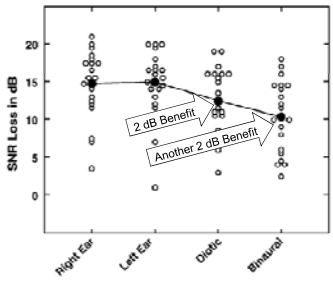
- Speech and noise presented from same loudspeaker—minimizes binaural phase and amplitude differences
- At these high intensity levels, non-test ear may have been responding.
- At these high intensity levels, only minimum gain would be delivered from hearing aids
- At these high intensity levels, hearing aids could be in saturation, minimizing SNR differences
- Some type of ordering effect/list effect?

But now, seven years later, we have a replication article:



McCardle et al. Are two ears not better than one? *JAAA*, 2012, 3: 171-181.

In Part II, the background was restaurant noise, recorded from 8 speakers via the KEMAR—then played to the subjects through earphones.



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What We're Planning At Vandy

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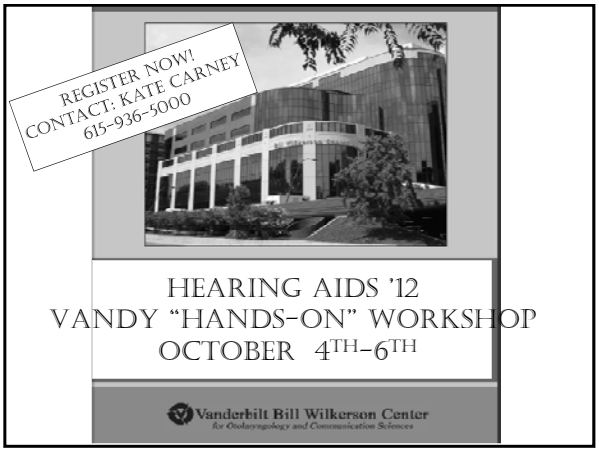

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The Current Status of the Video Head Impulse Test

Devin L. McCaslin, Ph.D.
Associate Professor
Vanderbilt Bill Wilkerson Center

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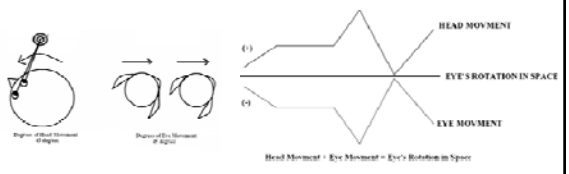
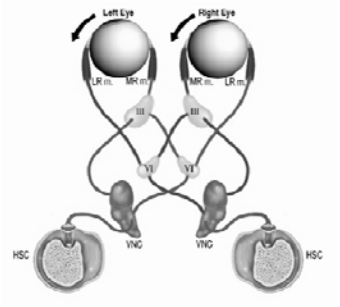
Vestibulo-ocular Reflex (VOR)

– Acts to maintain stable vision during head motion





Head Impulse Test

- The HIT test is a screening test that utilizes doll's eye reflex, to identify unilateral and bilateral peripheral vestibular system impairment.
- In 1988, Halmagyi and Curthoys reported that with unilateral and bilateral vestibular system impairments will demonstrate an abnormal catch-up saccade when the head is thrust in the direction of the impaired system.

Head Impulse Technique

- The test is comprised of the examiner gently grasping the patient's head and passively guiding it through a quick head turn.
- Before the head is turned, the patient is instructed to fixate on a target and maintain fixation on it throughout the head turn.

Head-Thrust Technique

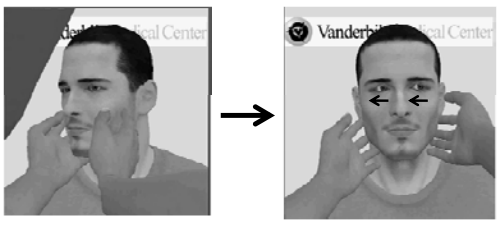
- The patient's head should be tilted forward down 30 degrees in order to position the lateral semicircular canals coplanar to the ground
- Gently grasp the patients head on both sides and rapidly and abruptly (>2000 deg/sec2) rotates the patient's head approximately 15 to 20 degrees to one side.

(Schubert, Tusa, Grine, & Herdman, 2004).

Interpretation of the HIT

- Looking for "catch-up" saccades suggesting that the VOR is not 180 deg. out of phase with head movement.
- Smooth pursuit function is not operable at these high frequencies so test is entirely VOR.

"Catch-up saccade"



Head-Thrust Test

- Normal Result
  - A translation toward patient's to either side should invoke a corresponding compensatory eye movement.

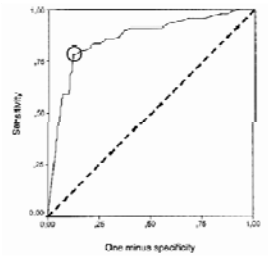
Head-Thrust Test

- Abnormal Result
  - Damage to the left peripheral vestibular system will result in a catch-up saccade movement to the right on left head turn.

Left side impaired

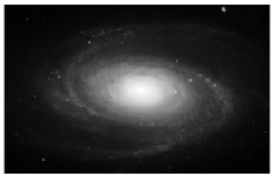
Performance

Best cut-off point is 42.5%



Perez and Rama-Lopez 2003

Then….



Now…

Head Impulse Testing Using Video-oculography

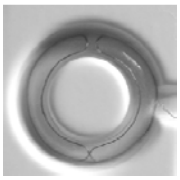
Klaus Bartl, Nadine Lehnen, Stefan Kohlbecher, and Eric Schneider

Annals of the New York Academy of Sciences, 2009 May;1164:331-3

What they described…

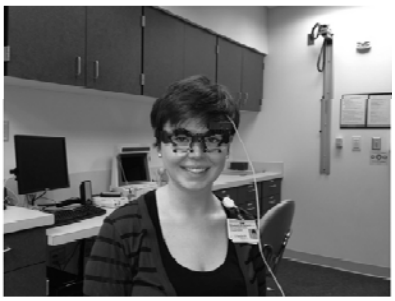
- A high-frame-rate video-oculography (VOG) system for determining the gain of the VOR at the bedside that was equivalent to scleral search coils.

Why it matters…

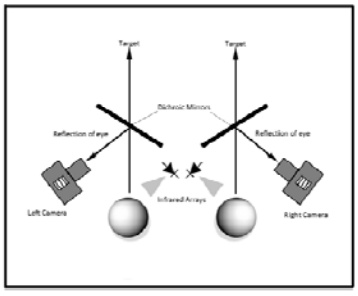


- Low noise of the coil method allows for high spatial (< 1 degree) and temporal (less than 1 msec) resolution.

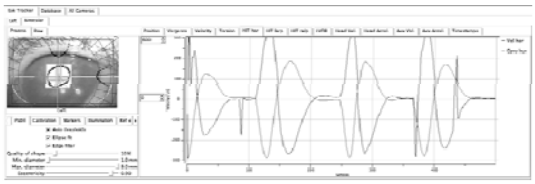
"EyeSeeCam"



Video-oculography



Collecting vHIT responses

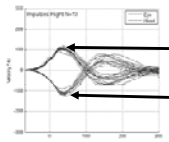


Parameters of Measurement
Gain

- The relation between head movements and eye movements during head thrusts is described in the velocity domain.
- Eye velocity (E) divided by the head (H) velocity.

$$g = \frac{\dot{E}}{-\dot{H}}$$

Calculation of VOR Gain

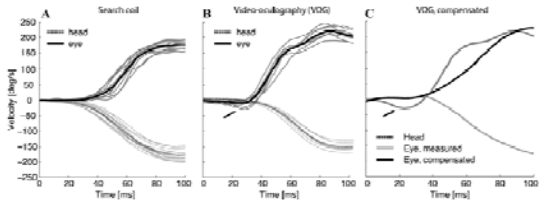


Eye Velocity

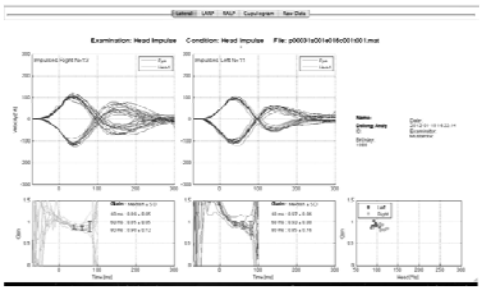
Head Velocity

Head velocity
Eye Velocity

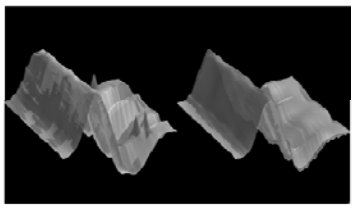
What they found…



Normal 2D



Normal 3D



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And now it's time for . . .

Vandy Vignettes

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Anyone know who "invented" Posturography?

Hint: He's an Adjunct Professor at Vandy!

The Video Head Impulse Test

H.G. MacDougall, K.P. Weber, L.A. McGarvie, G.M. Halmagyi, and L.S. Curthoys

Neurology, 2009 Oct 6;73(14):1134-41.

What they asked…

- To determine if the diagnostic accuracy of the video head impulse system was comparable to scleral search coils.
  - Used the parameters:
    - Gain
    - Overt Saccades
    - Covert Saccades

Why it matters…

- Up until recently the scleral search coil method (Robinson, 1963) was the standard of practice for high resolution eye movements.
- This consists of placing a silicon annulus in the eye that contains a coil of thin copper wire.
- When the patient is placed in a magnetic field the position of the eye can be determined from the amplitude of induction current in the coil.

The idea…

- Do video head impulse testing and scleral search coil testing in the same groups
  - A normal healthy group
  - A group of patient with various vestibular impairments.

What they did…

- Subjects
  - 16 subjects were recorded using both methods (vHIT and search coils) simultaneously.
    - 8 neurologically intact subjects
    - 6 patients had vestibular neuritis
    - One patient with Meniere's disease
    - Patient with bilateral vestibular system impairment. (systemic gentamicin vestibulotoxicity.

What they did…

- Experiment design:
  - Subjects fixated on a laser dot on the wall
  - 50 horizontal head impulse to each side were completed in an unpredictable manner.
  - The same eye that was recorded during vHIT was recorded with the scleral search coil
  - All recordings were performed by the same team of investigators (i.e. to control for training).
  - A HIT gain of less than 0.68 was considered abnormal.

What they found…

- Statistical Approach:
  - Paired-sample t test
    - A statistical test that is used to compare the means between the same sample or subjects.
    - Difference in gain between vHIT and scleral search coil
  - Pearson product-moment correlation
    - A statistical test is a measure of the correlation (linear dependence) between two variables
    - How well are the gain of the vHIT and search coil related.

What they found…

- Results:
  - Head movement acceleration between the vHIT and the search coils were highly correlated (0.999).
  - Eye movement acceleration between the vHIT and the search coils were highly correlated (0.93).
  - Gain of the vHIT and search coils was not significantly different.

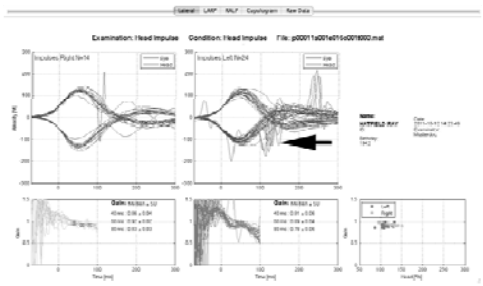
Why is this important…

- Detection of vestibular deficit (gain of less than .68)
  - The scleral search coil correctly identified the VOR deficit in all patients. The vHIT also correctly identified the VOR deficit in all patients.
  - This would suggest a sensitivity and specificity of 1.0.

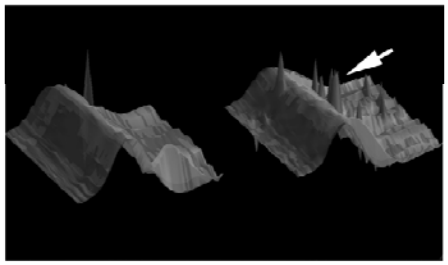
Does it matter clinically…

- YES
- The findings would suggest that the head impulse test is equivalent to search coils in identifying peripheral vestibular end-organ impairments
- Results need to be examined in various pathologies and severities of impairment.

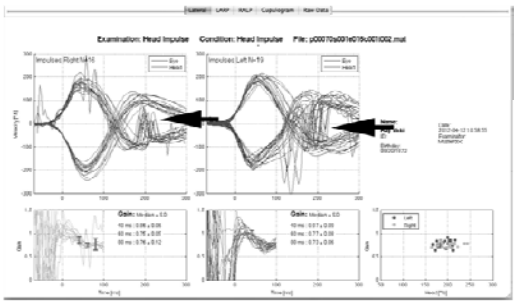
Overt 2D Left UW (54%)



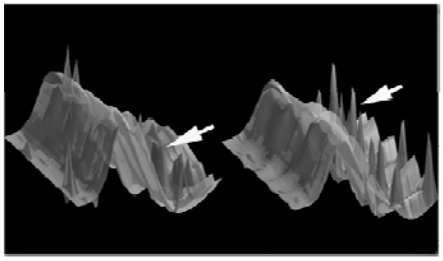
Left UW Overt



Bilateral Caloric Weakness



Bilateral Overt 3D



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Commodore Award

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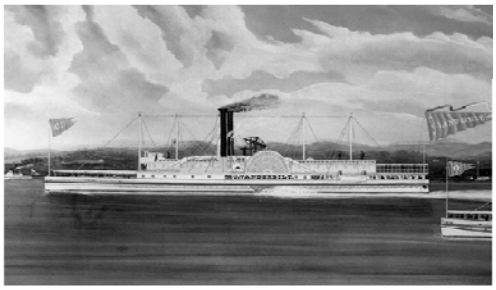
Commodore Vanderbilt Steamship (circa 1860)



Plasticity During Vestibular Compensation: the role of saccades.

H.G. MacDougall and L.S. Curthoys. Frontiers in Neuro-otology 2012;3:21. Epub 2012 Feb 28.

What they reviewed…

- Following a vestibular impairment, the vestibular system "compensates" to reduce static and dynamic symptoms of dizziness and the role that saccades play in this process.
  - Static Compensation
  - Dynamic Compensation

Why it matters…

- There are 20-30% of patients with unilateral vestibular loss that are described as "poorly compensated".
- How is it that children with no vestibular function are not handicapped more by a complete loss of vestibular function?
- There now appears to be different mechanisms that facilitate vestibular compensation.

The idea…

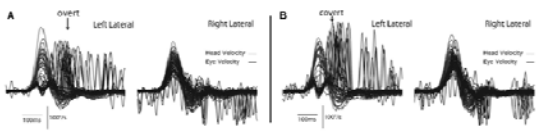
- Very early studies of compensation suggested that there was considerable recovery of the dynamic VOR.
- It is now known that with higher frequency head movements (natural) there is very little recovery of the dynamic VOR.

What they suggest…

- There are different systems allocated for compensating for low and high frequency impairments:
  - Since the majority of patients with high frequency impairments recover fairly well from a UVD the authors suggest two concepts:
    - The small recovery in low frequency function (i.e. gain) is enough to make them feel better.
    - They are using other strategies to overcome the loss of high frequency impairment.

What they suggest…

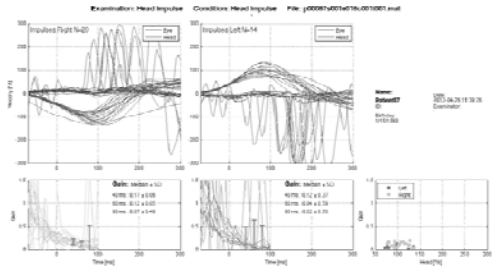
- The role of saccades in compensation:
  - If a patient with a unilateral impairment is asked to keep their gaze fixed on a target while the head is moved, they can learn to do so.
  - These new techniques have shown us that these patients generate a small saccade during the head movement that replaces or substitutes the slow phase of the vestibular response.
  - The saccades that occur during the head movement are known as “Covert” saccades.

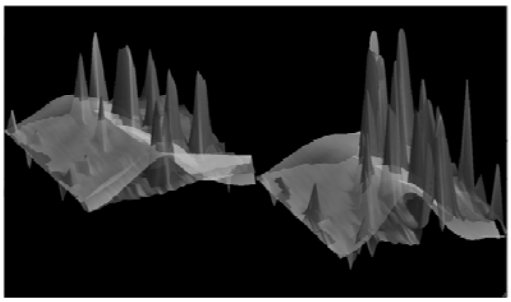


Initial head impulse test Impulse test hours later

H.G. MacDougall and L.S. Curthoys. Frontiers in Neuro-otology 2012;3:21. Epub 2012 Feb 28.

Complete Bilateral Caloric Weakness (rotational gain is absent at higher frequencies).





What they suggest…

- What generates the “covert saccade”.
  - Interestingly, many patients with totally absent bilateral vestibular function are capable of generating saccades (covert and overt).
  - What could be generating these eye movements? - cervico-ocular reflex (COR) pathway from the neck to the vestibular nuclei?

Why is this important…

– It has implications that would change the way that we look at vestibular compensation and how vestibular rehabilitation is directed.

Does it matter clinically…

- YES
- When evaluating patients in the balance clinic, the use of stimuli that produce unnaturally low values of head acceleration (e.g. caloric) may not be adequate to fully understand the centrally mediated compensatory mechanisms.

Does it matter clinically…

- Initial studies examining compensatory mechanisms using vHIT suggest that current methods of vestibular rehabilitation may need to be revisited.
- In instances where patients demonstrate permanent deficits of the dynamic VOR in the higher frequency ranges (i.e. natural accelerations) rehabilitation may need to be focused on developing saccadic behavior.

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Classroom Acoustic Measures...There's an App for That
Presented by Joseph Smaldino & Daniel Ostergren

Tuesday, June 19

How to Connect to Electronic Media: Resources for Educational Audiology
Presented by Tina Childress

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Wednesday, June 20
Counseling Strategies for Tweens/Teens with Hearing Loss
Presented by Kris English

Thursday, June 21
Perceptions of Children, Parents & Teachers on the Effects of Minimal/Mild Hearing Loss
Presented by Dawna Lewis

Friday, June 22
Essentials of Practice Management for Educational Audiologists
Presented by Cheryl DeConde Johnson