Update on Vestibular Disorders

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University Hospital Zürich
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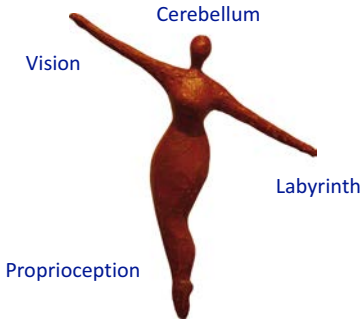
Stare Splavy, 12 May 2018

Disclosure

The author acts as an unpaid consultant and has received funding for travel from GN Otometrics.

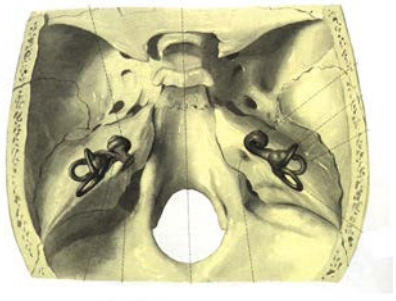


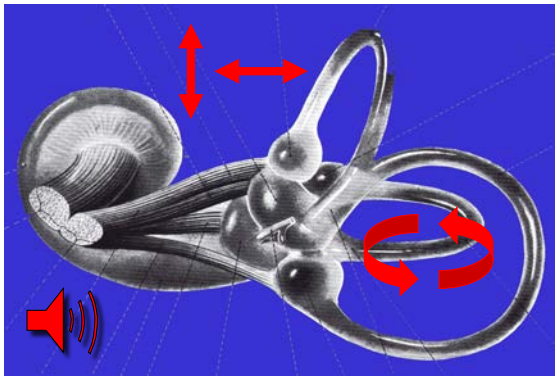
The 6th Sense

Bewegungsempfinden

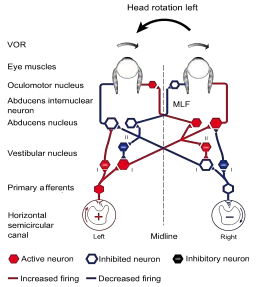

GRUNDLINIEN
LEHRE VON DEN
BEWEGUNGSEMPFINDUNGEN
Dr. E. MACH.
1875


Ernst Mach 1838 – 1916


Ferner & Staubesand 1982

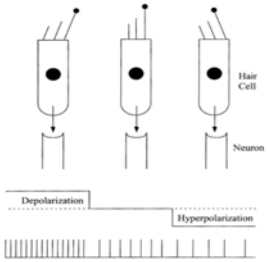


Push-Pull Cooperation of Horizontal Semicircular Canals



Dr Dolittle's
Pushmi-Pullyu

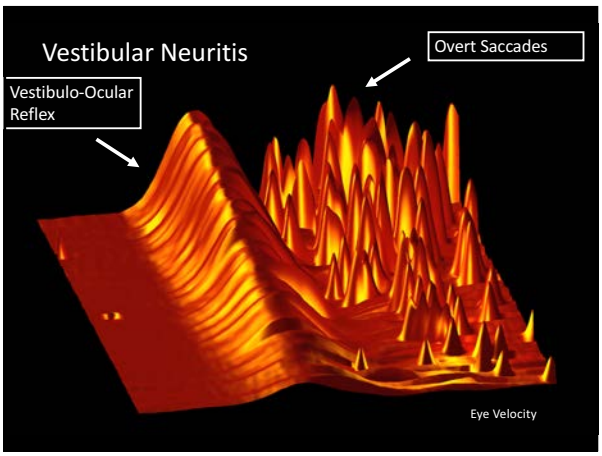
Vestibular Haircells

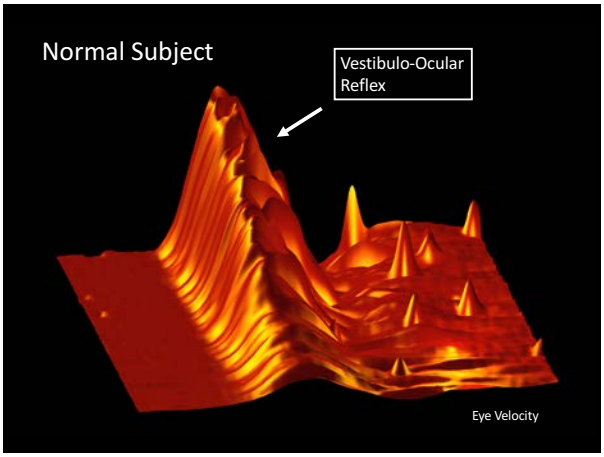


8. Cranial nerve

Left Vestibular Neuritis

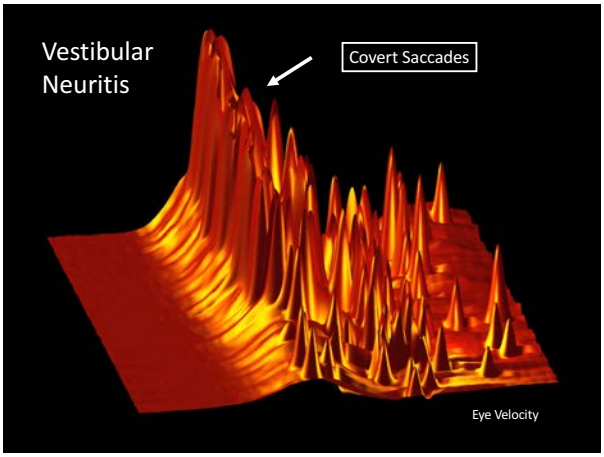
Weber et al. Neurology 2008

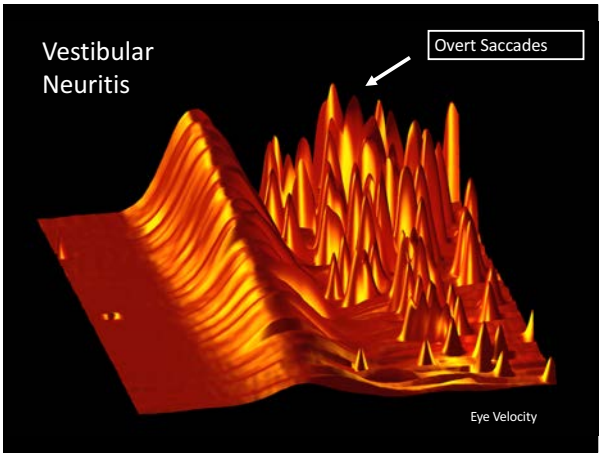




Left Vestibular Neuritis

Weber et al. Neurology 2008





What you see is not what you measure!

- **Bedside Head Impulse Test**
  Assessment of the catch-up saccade.

- **Video Head Impulse Test**
  Vestibulo-ocular reflex and catch-up saccades.

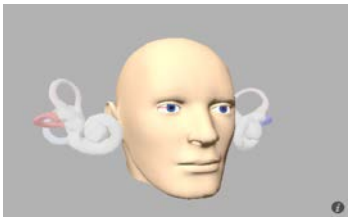
Modified Vertical Head Impulses

LARP: left anterior – right posterior
RALP: right anterior – left posterior

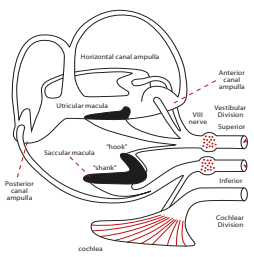
Video: free iphone app ‚aVOR'
MacDougall et al. PLoS ONE 2013.

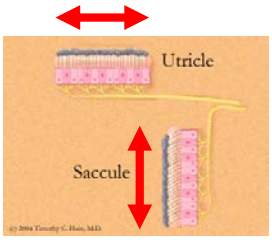
Free iPhone App: aVOR

THE UNIVERSITY OF SYDNEY



Otolith Organs



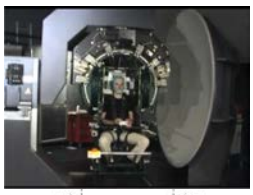


Linear Acceleration

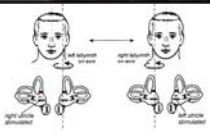
Why VEMPs?

Hexapod

Eccentric Rotation



Measuring the linear vestibulo-ocular reflex is notoriously difficult!



Why are the otoliths selectively activated? **Evolution**

Amphibians

Reptiles

No cochlea
Use otoliths for ‚hearing'
Sensitive to mid-frequencies

Crocodylids
Birds
Mammals

In humans, vestibule and otolith hair cells still have properties allowing activation by sound

Non-physiological stimuli?

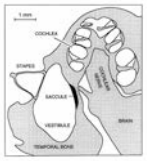
(Carey & Amin, 2006)

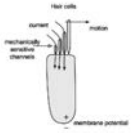
Sound and Vibration are effective and easy stimuli for the otoliths

Air-conducted sound

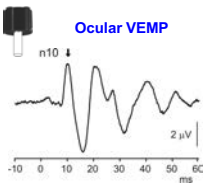
Bone-conducted vibration

Curthoys 2010





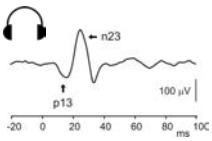
Ocular VEMP



Inferior oblique

Mainly *utricle*

Cervical VEMP



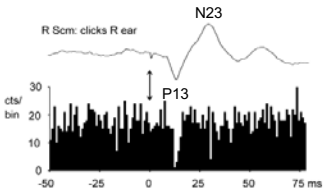
SCM

Mainly *saccule*

Standard cVEMP

Ipsilateral Projection

Inhibitory Reflex



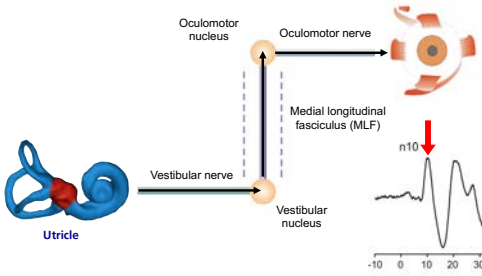
- Evoked by air-conducted sound
- Recorded in the ipsilateral SCM

Simultaneous surface and single motor unit recordings from the SCM

Colebatch and Rothwell, *J Physiol*, 1993; 2004

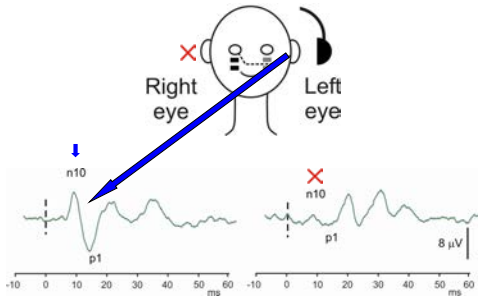
oVEMP

ocular Vestibular Evoked Myogenic Potentials



Weber KP, Rosengren, SM, Clinical utility of oVEMPs. *Curr Neurol Neurosci Rep*, 2015.

Standard oVEMP
Contralateral projection



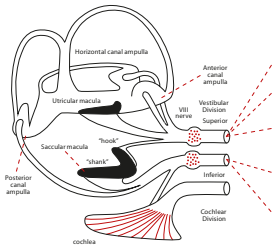
Iwasaki S et al. *Neurology* 2007

Summary

Cervical VEMPs	Ocular VEMPs
Vestibulo-*collic* reflex	Vestibulo-*ocular* reflex
*Ipsi*lateral projection	*Contra*lateral projection
Elicited with *sound*	Elicited with *vibration*
Otolith test	Otolith test
Mainly *saccule*	Mainly *utricle*

Rosengren SM, Welgampola MS, Colebatch JG. Vestibular evoked myogenic potentials: past, present and future. Clinical Neurophysiology 2010, 121:636-651.

Complete Testing of the Peripheral Vestibular System

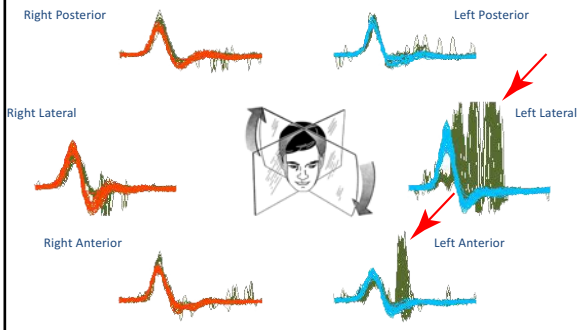


Clinical Test	Healthy Subjects	Superior Vestibular Neuritis	Inferior Vestibular Neuritis	Unilateral Vestibular Loss
Horizontal HIT	✔	✘	✔	✘
Anterior HIT	✔	✘	✔	✘
oVEMP	✔	✘	✔	✘
cVEMP	✔	✔	✘	✘
Posterior HIT	✔	✔	✘	✘

✔ = Normal Response ✘ = Abnormal Response

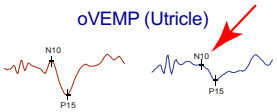
Courtesy I. Curthoys

Vestibular Neuritis

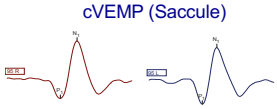


Vestibular Test Battery

oVEMP (Utricle)



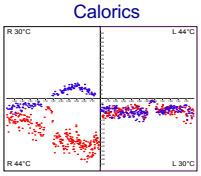
cVEMP (Saccule)



Fundus

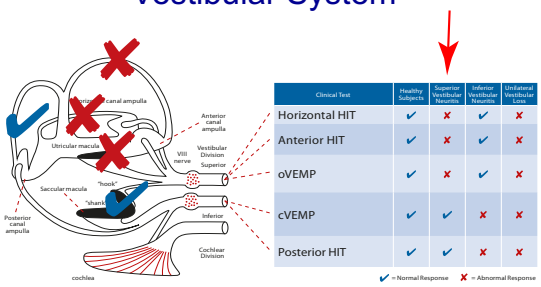
Subjektive visual vertical: 19° left

Calorics



Canal paresis factor: 94% left

Complete Testing of the Peripheral Vestibular System



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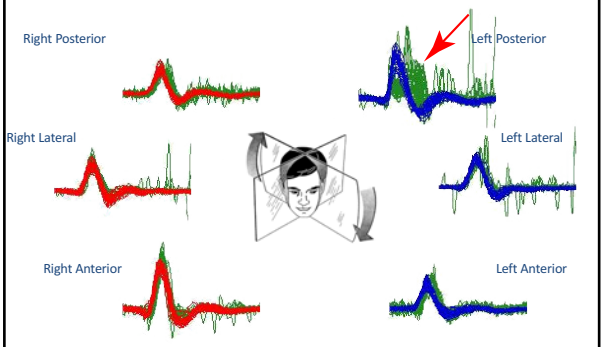
Superior Vestibular Neuritis

Aw ST et al. *Neurology* 2001
Taylor RL et al. *Neurology* 2016

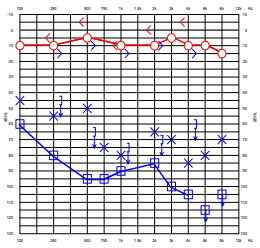
Courtesy of Curthoys

Patient with Vertigo & Hearing Loss

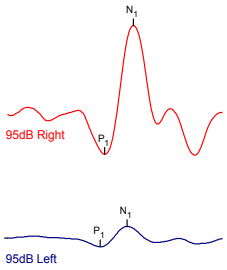


Vestibular Test Battery

Audiogram

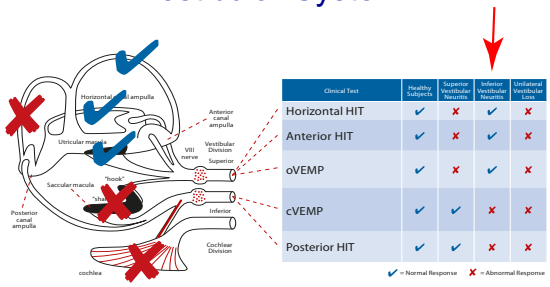


cVEMP



○ Right □ Left

Complete Testing of the Peripheral Vestibular System



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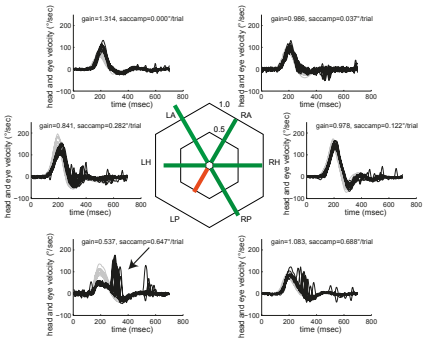
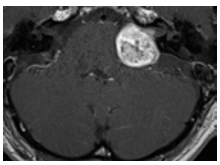
Vestibulo-Cochlear Loss
aka ‚Inferior Vestibular Neuritis'

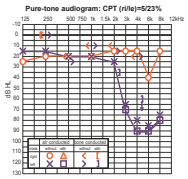
Courtesy of Curthoys

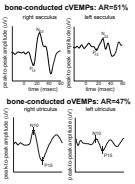
'Isolated' Posterior Canal Dysfunction

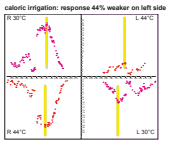


Vestibular Schwannoma









'Isolated' Loss of Posterior Canal Function

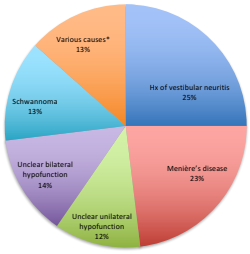
2904 patients with 3D vHIT

52 patients with

- 40 unilateral posterior (77%)
- 12 bilateral posterior (23%)

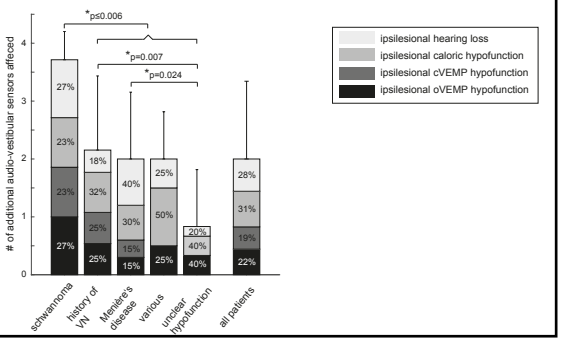
- >80% associated deficits in unilateral posterior loss
- <20% associated deficits in bilateral posterior loss
  - Calorics
  - oVEMP
  - cVEMP
  - Audiogram

Distribution of diagnoses (n=52)



Tarnutzer AA et al. 2017

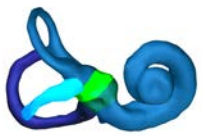
Associated Deficits in 'Isolated' Loss of Posterior Canal Function



Correlation vHIT – calorics / VEMPs

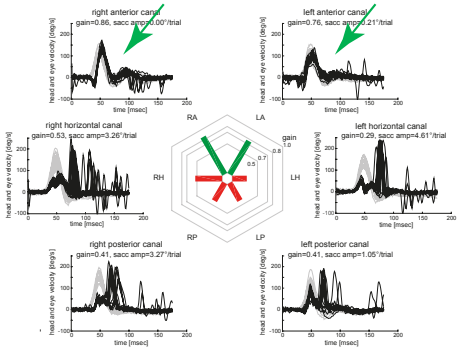
Expected patterns (based on innervation & vascularization):
Posterior SCC +

- **sacculus (cVEMP): 40%**
- **cochlea (PTA): 60%**
- **sacculus + cochlea: 35%**
- **lateral SCC (calorics): 65%**
- **utriculus (oVEMPs): 50%**
- **lateral SCC + utriculus: 38%**
- **Involvement of any of the three (calorics, oVEMP, cVEMP): 83%**

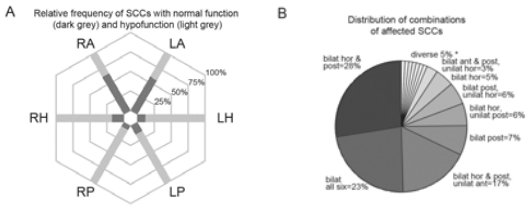


Modified after Bradshaw et al. 2009 JARO

Anterior Canal Sparing after Gentamicin Vestibulotoxicity

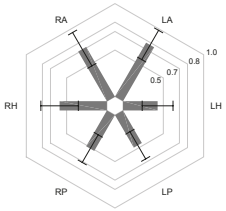


109 Patients (out of 2123) with Bilateral Vestibular Loss

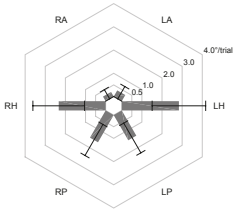


Tarnutzer AA et al. Clin Neurophysiol. 2016

VOR Gain

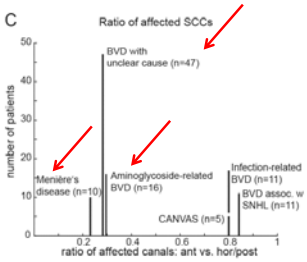


Saccade Amplitude



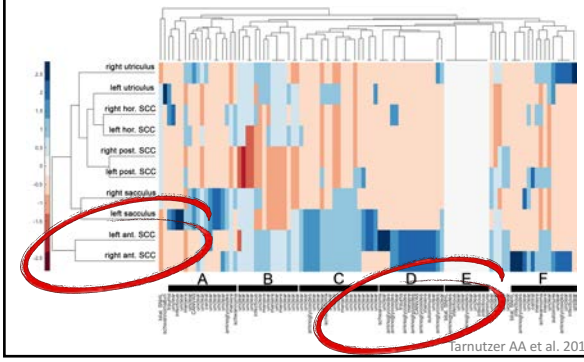
Disease-Specific Anterior Canal Sparing

Relative sparing of the anterior SCCs



Hierarchical Cluster Analysis

101 patients with bilateral vestibular loss

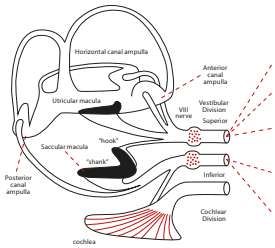


Tarnutzer AA et al. 2018

Anterior Canal Sparing

- Anterior canals less prone to damage or better recovery?
- Accumulation of gentamicin at more caudally located canals (posterior and lateral)?
- Common in
  - Gentamicin vestibulotoxicity
  - Menière's disease
  - Unknown etiology

Complete Testing of the Peripheral Vestibular System



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Anterior HIT	✔	✘	✔	✘
oVEMP	✔	✘	✔	✘
cVEMP	✔	✔	✘	✘
Posterior HIT	✔	✔	✘	✘

✔ = Normal Response ✘ = Abnormal Response

Courtesy I. Curthoys

Thank you for your attention!