

Ocular Tilt Reaction

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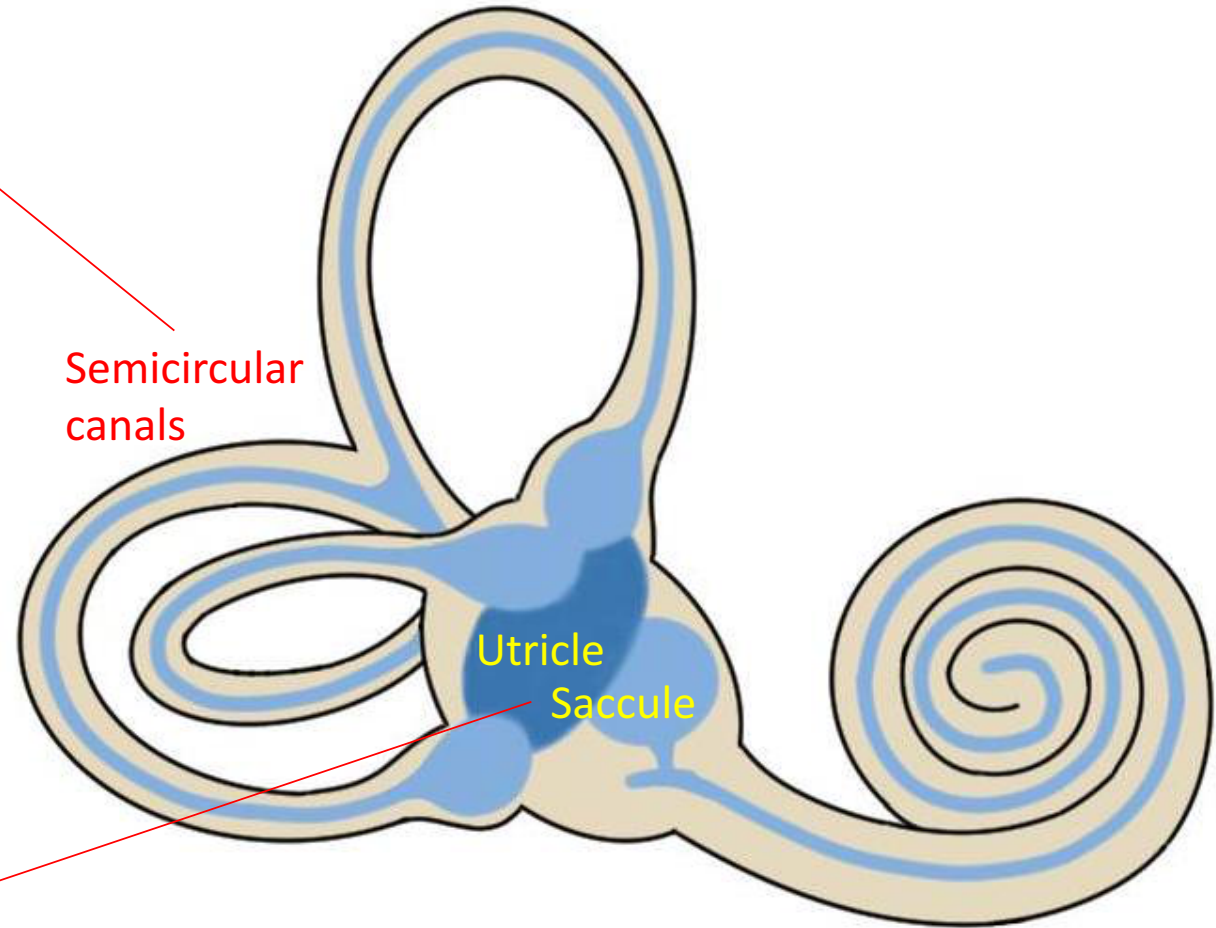
Department of Neurology, Taichung Tzu Chi Hospital

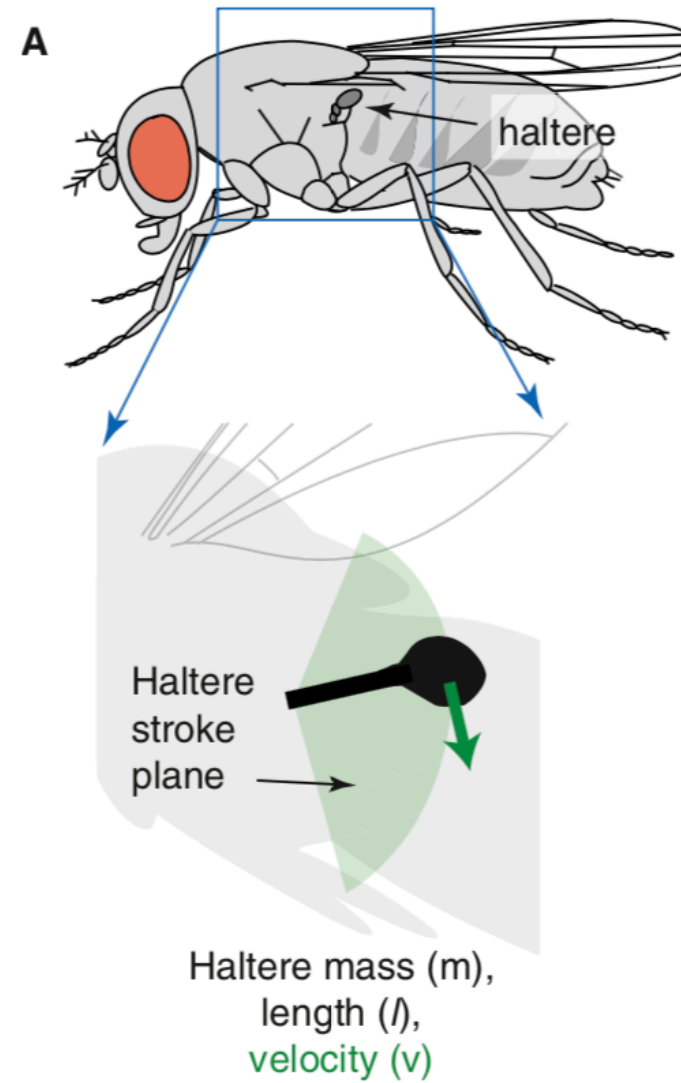
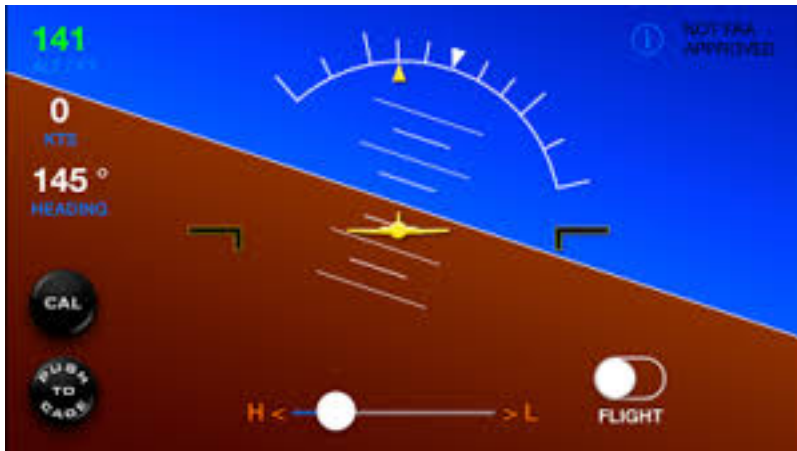
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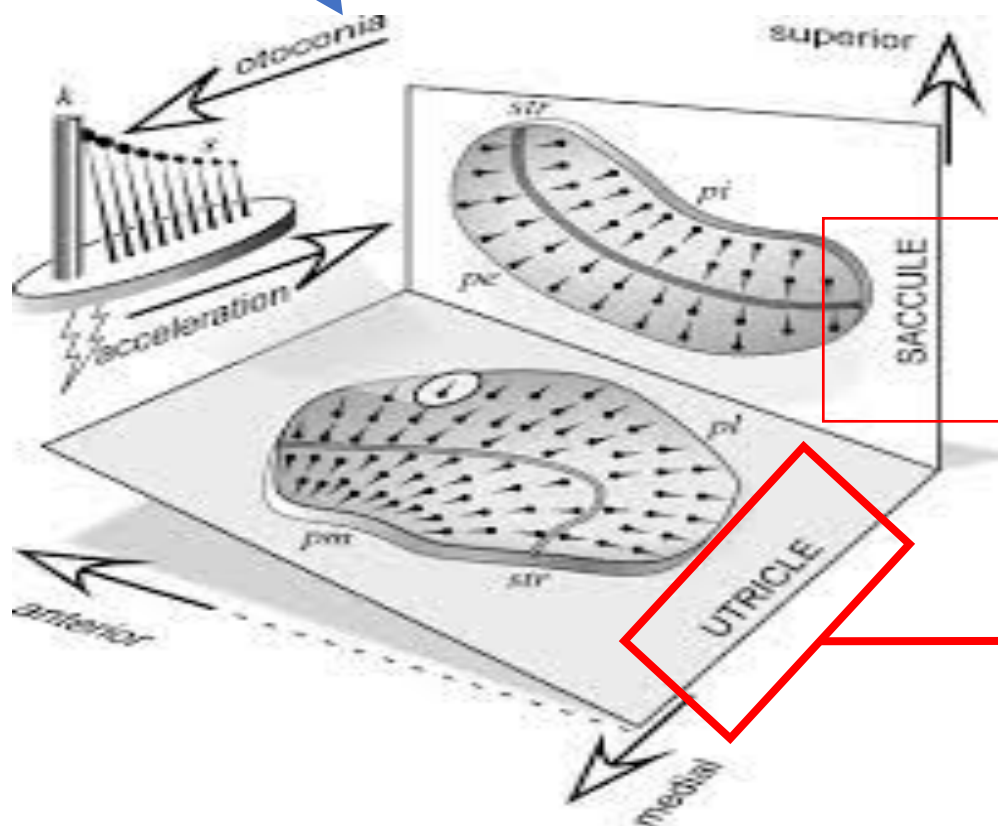
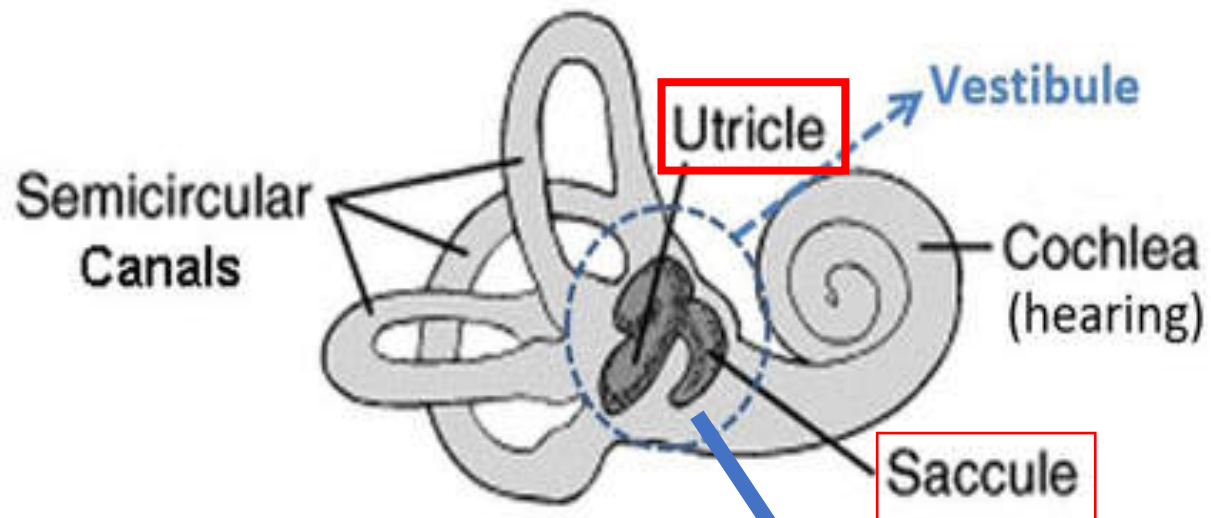
**Dynamic vestibular function :
angular acceleration**

**Dynamic vestibular function:
linear acceleration**

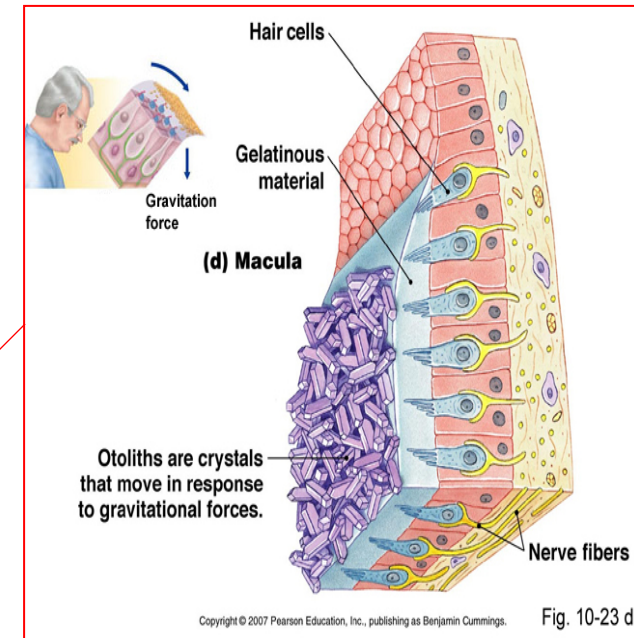
**Static vestibular function :
head tilt**



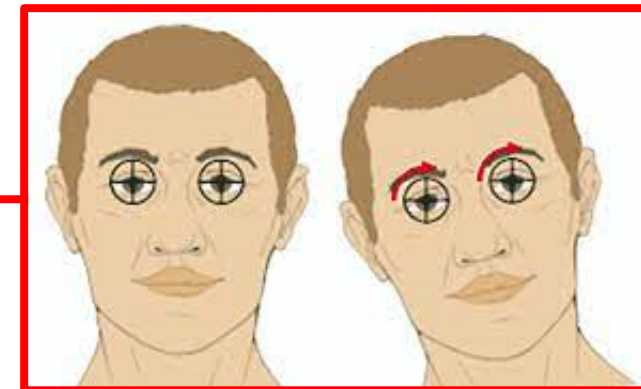




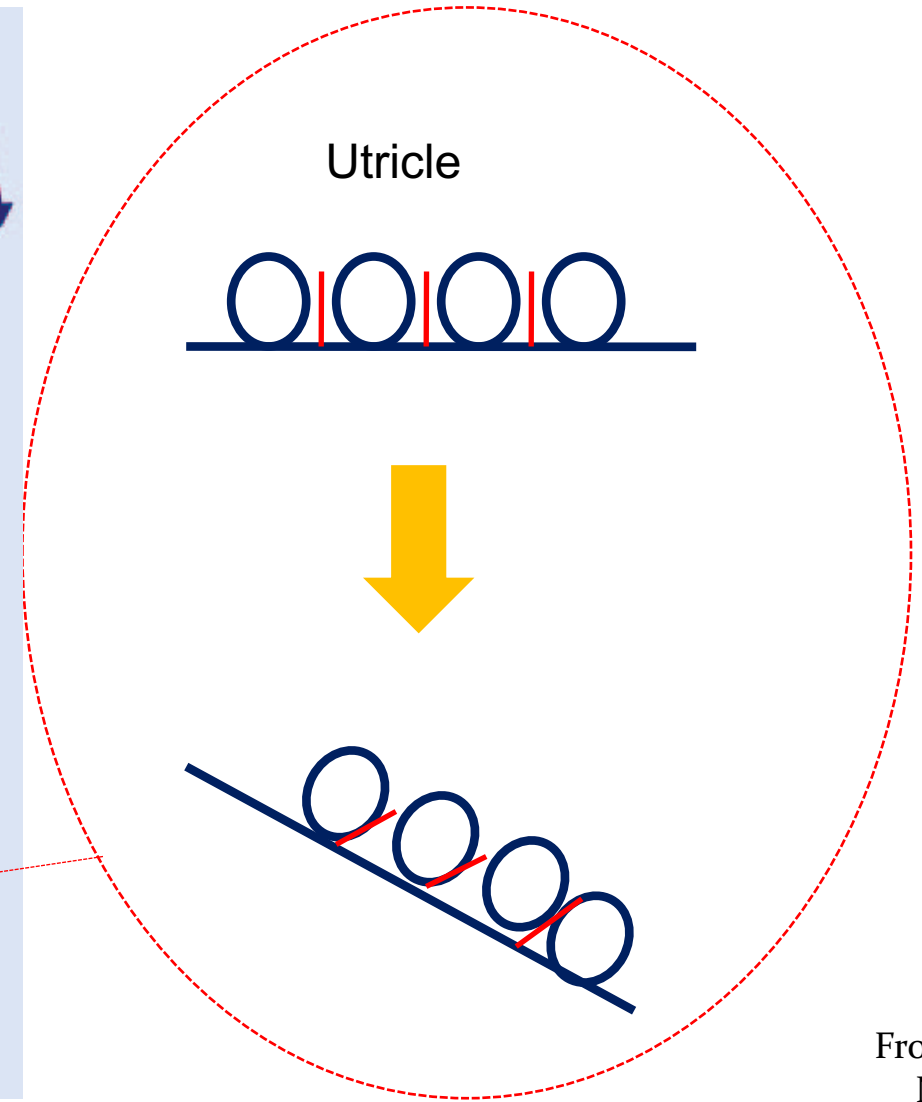
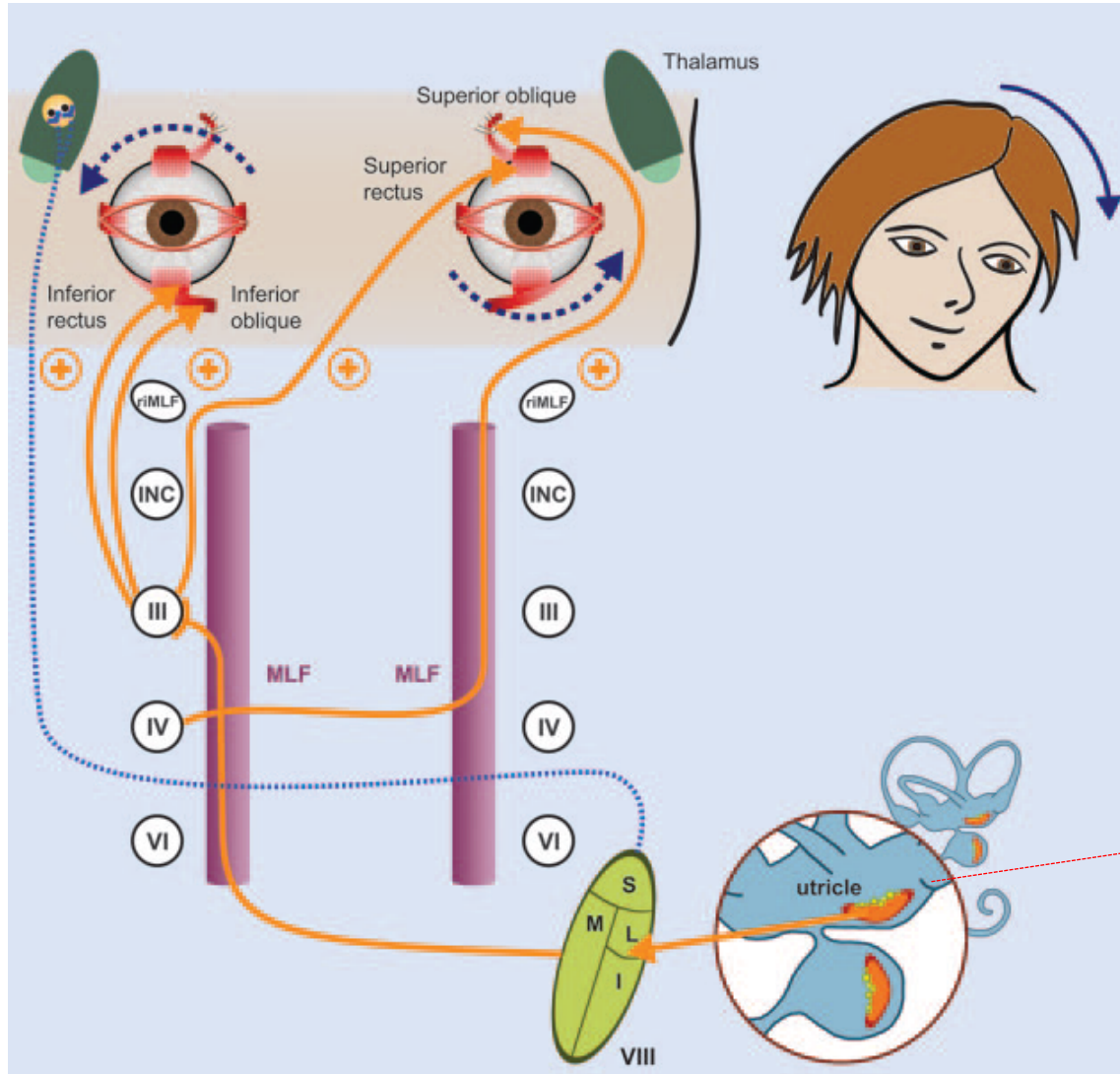
Pitch plane



Roll plane

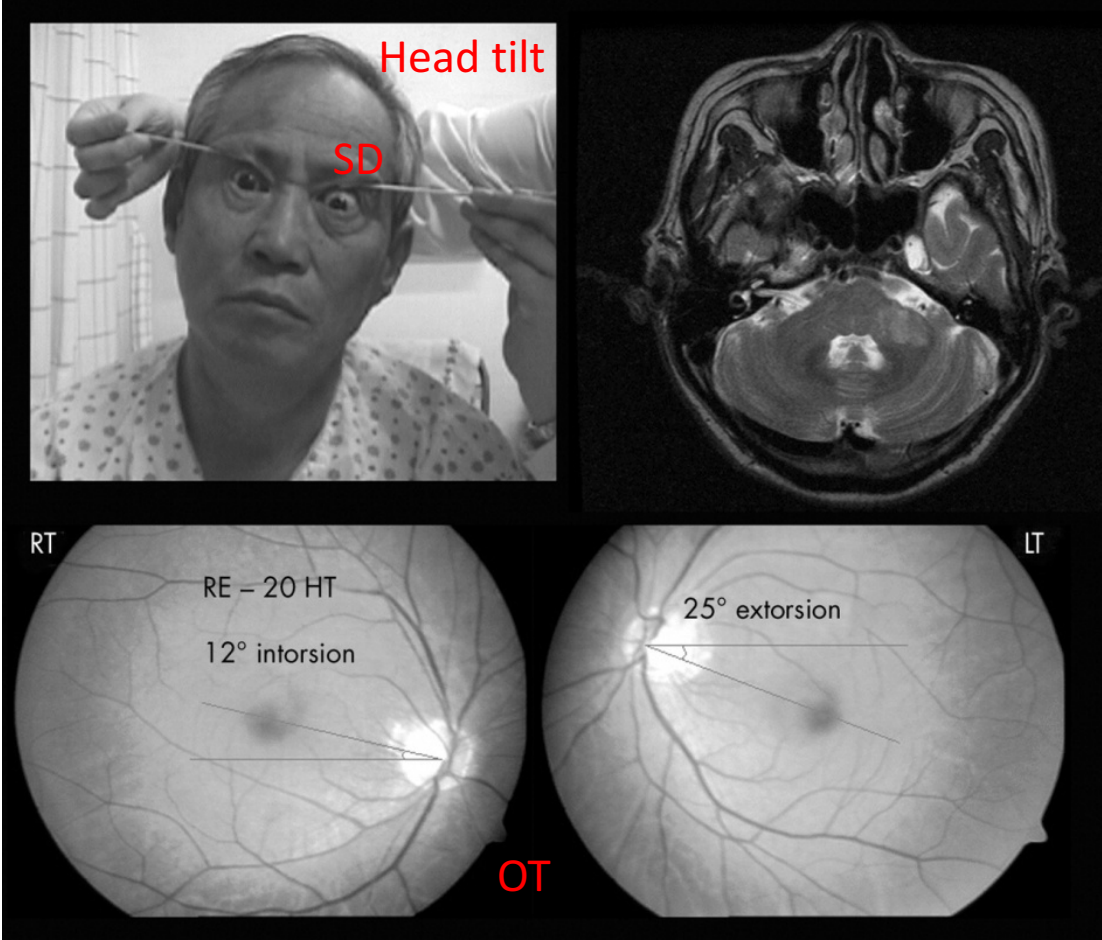


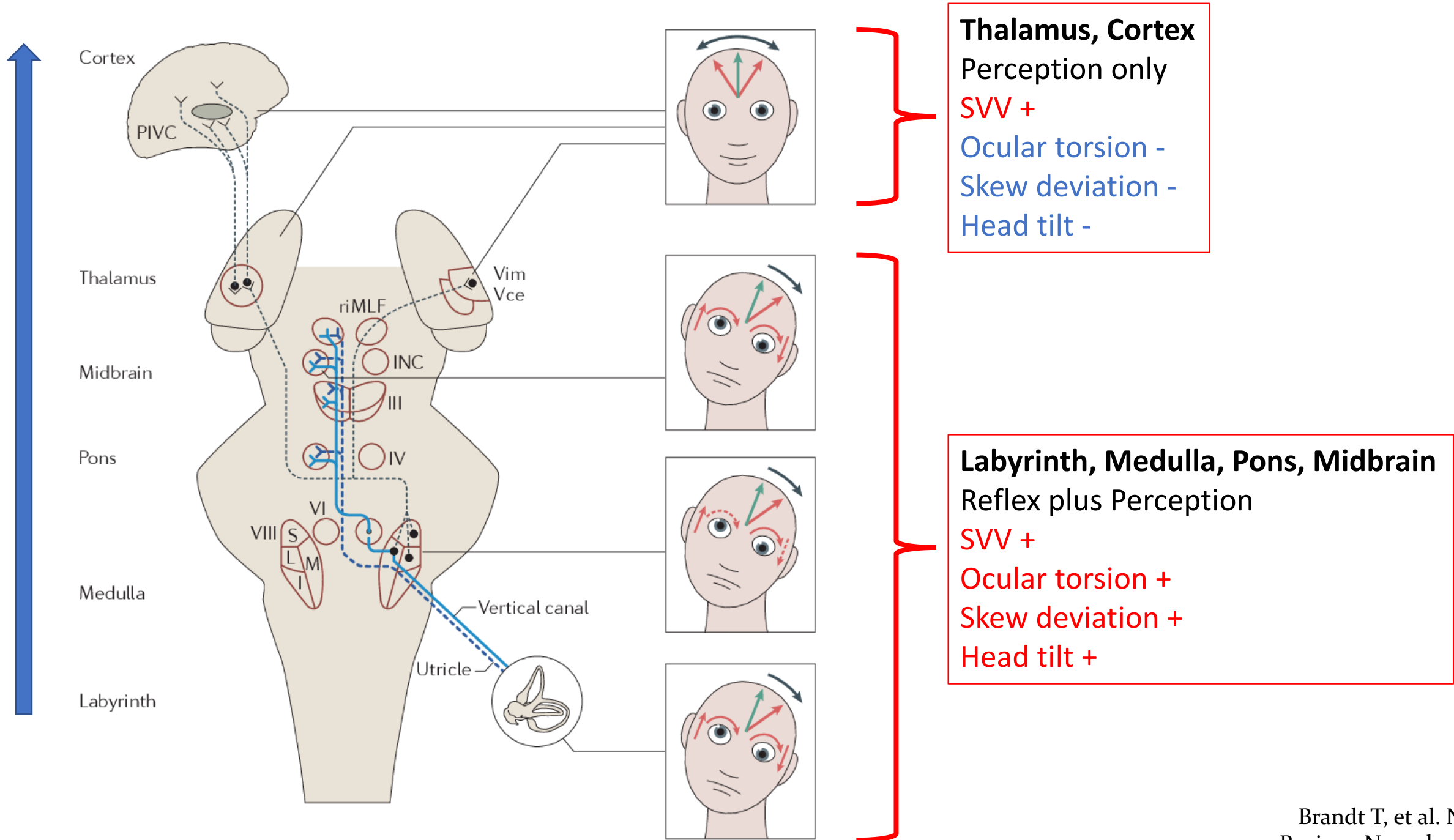
Utricular-Ocular Reflex and Vestibular Perception

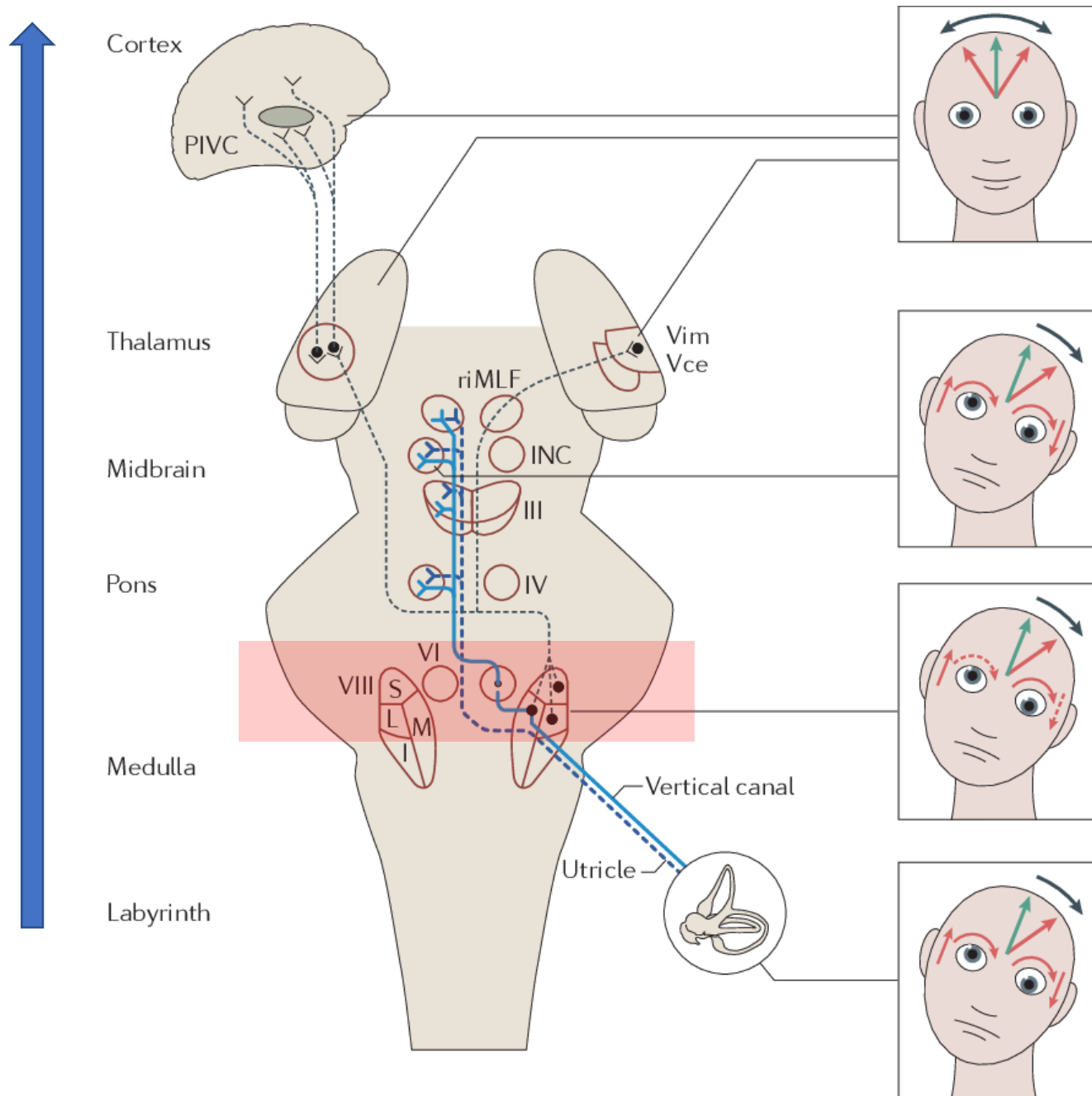


Ocular Tilt Reaction (OTR)

- Tilt of subjective visual vertical (SVV)
- Ocular torsion (OT)
- Skew deviation (SD)
- Head tilt

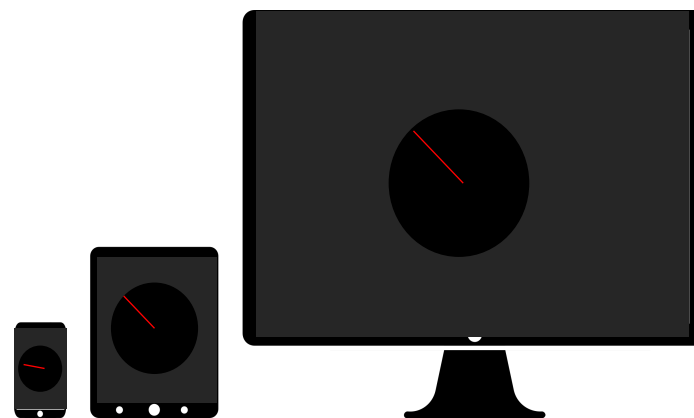




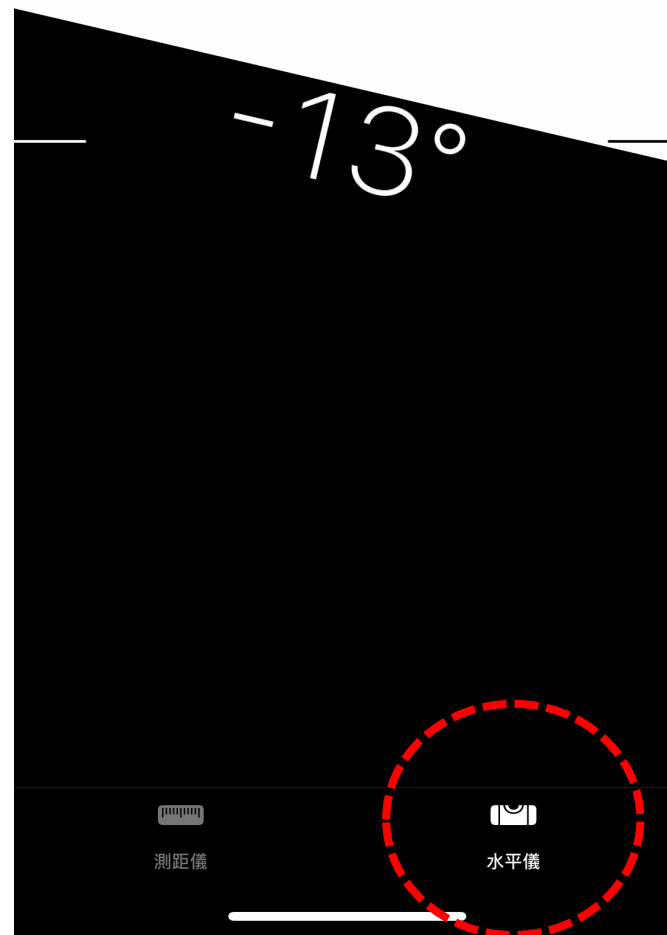


- **Decussation: mid- to-lower pons**
- **Lesion below decussation:** Tilt toward the lesion side (ipsiversive OTR)
- **Lesion above decussation:** Tilt away from the lesion side (contraversive OTR)
- **Thalamus or cortex lesion:** ipsi- or contra-versive SVV

Subjective Visual Vertical (SVV)



工具程式

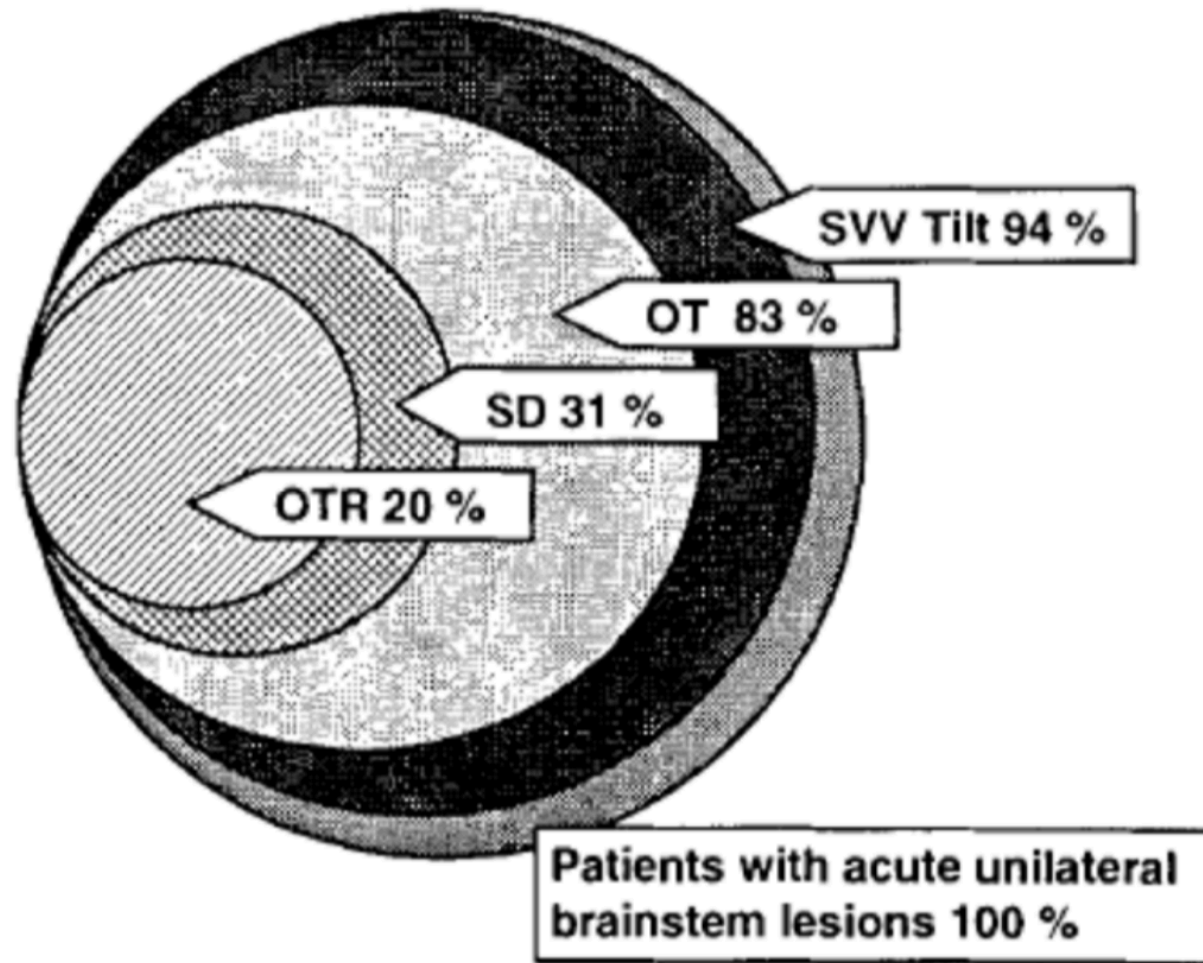


Subjective Visual Vertical (SVV)

- The most sensitive sign in OTR
- May be abnormal in both peripheral and central (brainstem, cerebellum and cortex) lesions
- Good for differentiating structural vestibular lesion from functional dizziness (e.g. PPPD) or non-vestibular dizziness (e.g. drug-related dizziness)
- **SVV only** cannot differentiate central from peripheral lesion.
- **SVV plus other clinical tests** (e.g. head impulse test) can help identify central lesion.
- SVV is an exclusive clinical test for vestibular perception.

Sensitivity for brainstem lesions:

SVV > ocular torsion > skew deviation > all OTR signs



OTR in cerebellar lesions

- In 31 patients with acute unilateral cerebellar infarction:
 - 100% had SVV tilt
 - 74% contraversive tilt VS 26% ipsiversive tilt
 - 55% had ocular torsion (OT)
 - 42% contraversive OT VS 13% ipsiversive OT
 - 26% had skew deviation (SD)
 - 19% contraversive SD VS 6% ipsiversive SD

Table 2 Number and percentage (in brackets) of the cerebellar lesions in patients with ipsiversive or contraversive tilts of the SVV

| Tilts of the SVV [N (%)] | Middle cerebellar peduncle | Dentate nucleus | Pyramid of vermis | Uvula | Tonsil | Flocculus | Nodulus | Biventer lobule | Inferior semilunar lobule |
|---------------------------|----------------------------|-----------------|-------------------|--------|---------|-----------|---------|-----------------|---------------------------|
| Ipsiversive 8 patients | 6 (75) | 3 (38) | 3 (38) | 3 (38) | 5 (63) | 3 (38) | 0 | 5 (63) | 4 (50) |
| Contraversive 23 patients | 12 (52) | 21 (91) | 9 (35) | 9 (35) | 16 (70) | 1 (4) | 2 (9) | 7 (30) | 3 (13) |

Abnormal in acute, unilateral, and structural lesions (peripheral or central)

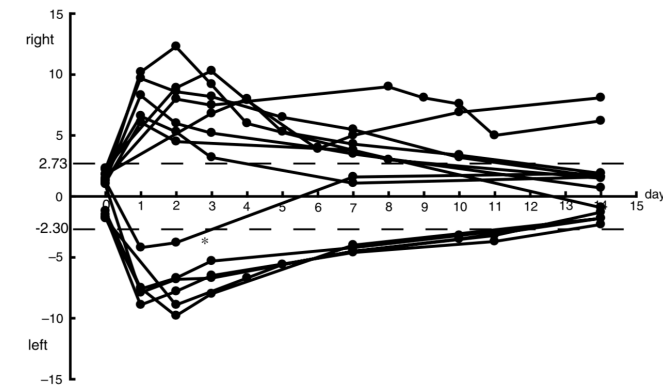
Table 2 Applications of SVV measurements in clinical practice

| Applications for SVV measurement | Pathologic SVV deviation |
|--|--------------------------|
| Detection of unilateral graviceptive (mainly otolithic) pathway damage | |
| Vestibular neuritis ⁴ | >90% |
| Vestibular pseudoneuritis ⁷ | >90% |
| Wallenberg syndrome ⁸ | >90% |
| Internuclear ophthalmoplegia ² | >90% |
| Midbrain damage ¹ | >90% |

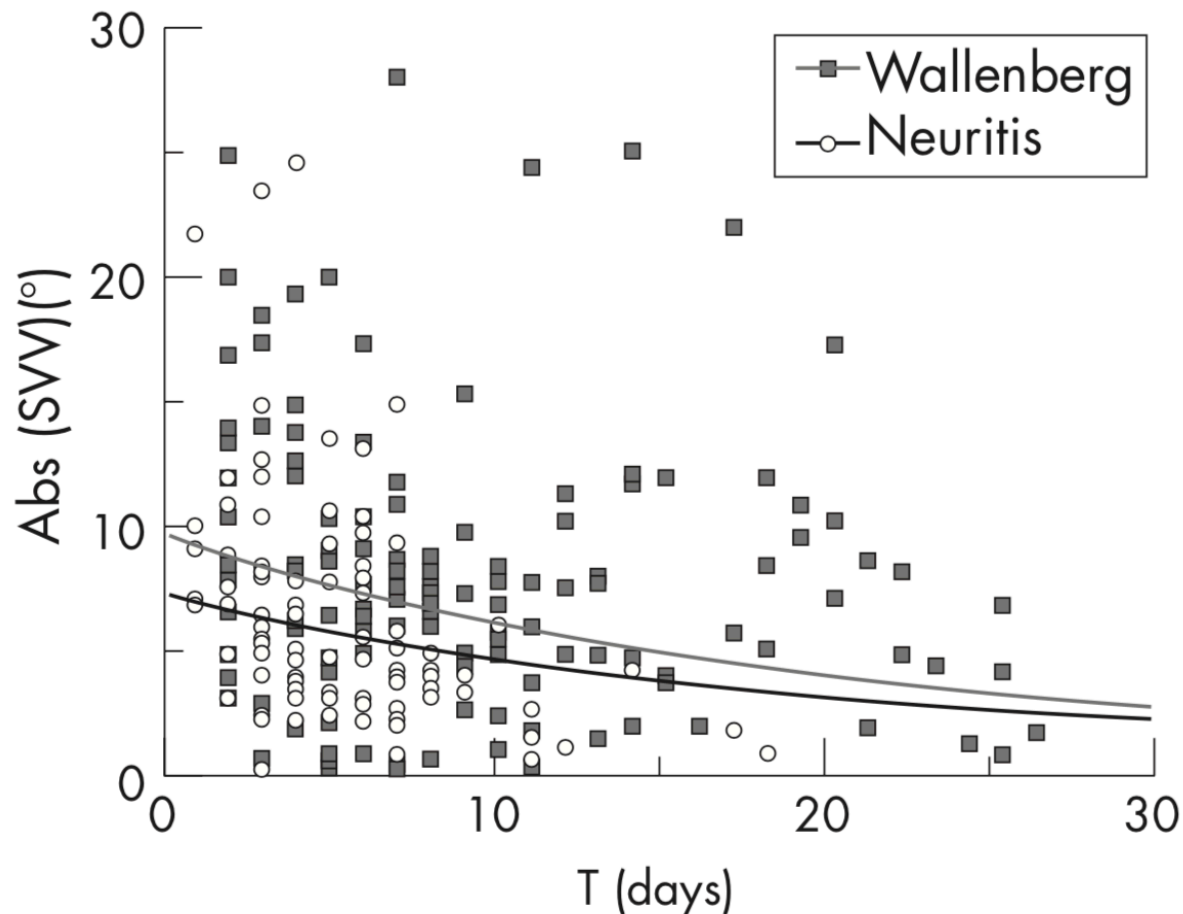
| | SVu (°) | | | n |
|--------------|---------|-----|-----------|----|
| | Mean | SD | Range | |
| Normals | -0.1 | 0.6 | -1.8-1.0 | 25 |
| Neurectomies | | | | |
| Preop. | 0.0 | 1.9 | -5.2-3.0 | 15 |
| Acute | 12.4* | 5.1 | 4.8-21.4 | 15 |
| Vest.NE | 13.0* | 5.8 | 4.8-21.4 | 10 |
| Coch-vest.NE | 11.0* | 3.2 | 7.4-15.0 | 5 |
| Chron. | 1.3* | 2.0 | -2.0-6.4 | 26 |
| Vest.NE | 0.4 | 1.2 | -1.4-2.0 | 8 |
| Coch-vest.NE | 1.8* | 2.1 | -2.0-6.4 | 18 |
| Neuronitis | 6.8* | 7.1 | -0.2-33.0 | 20 |
| Zoster | 10.4* | 5.8 | 3.2-17.2 | 4 |
| BPPV | 0.2 | 0.8 | -1.2-2.4 | 19 |

Me´nie`re's disease:

- Acute stage: 64% SVV tilt
- Interictal stage: 9% SVV tilt



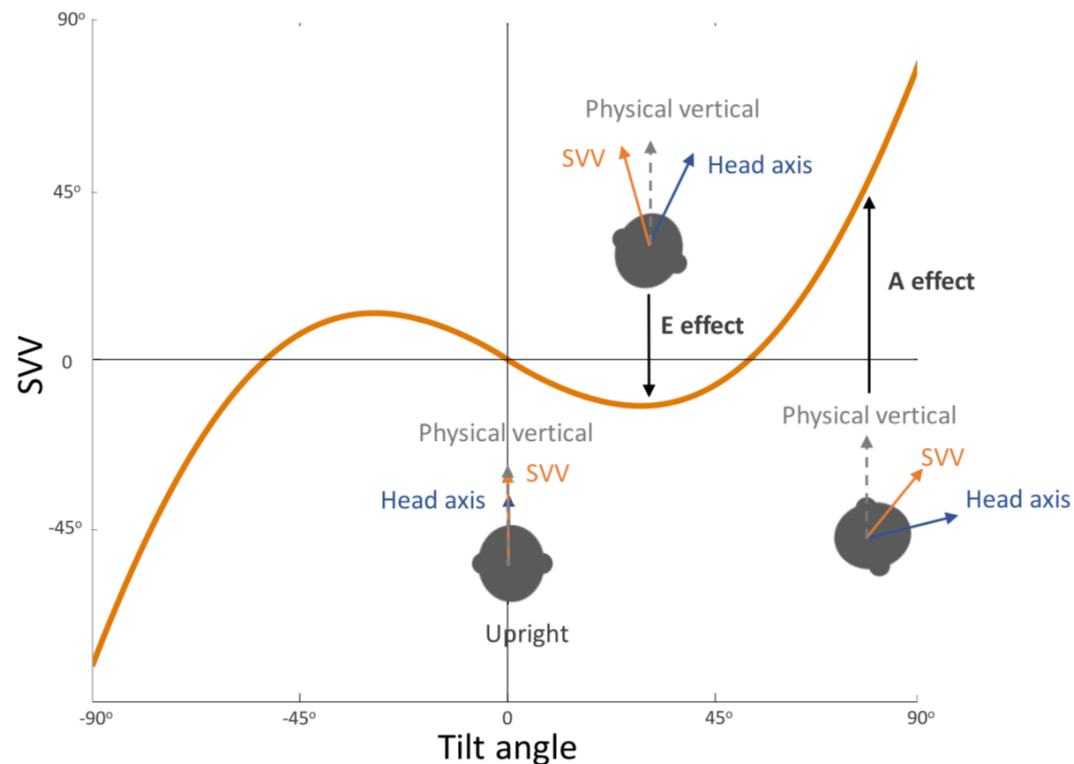
SVV tilt gradually returns to normal level after acute stage



- SVV is one of the parameters of **vestibular compensation**
- In chronic stage, SVV is not sensitive to detect vestibular lesions
- **ANY WAY** to enhance SVV sensitivity for chronic vestibulopathy?

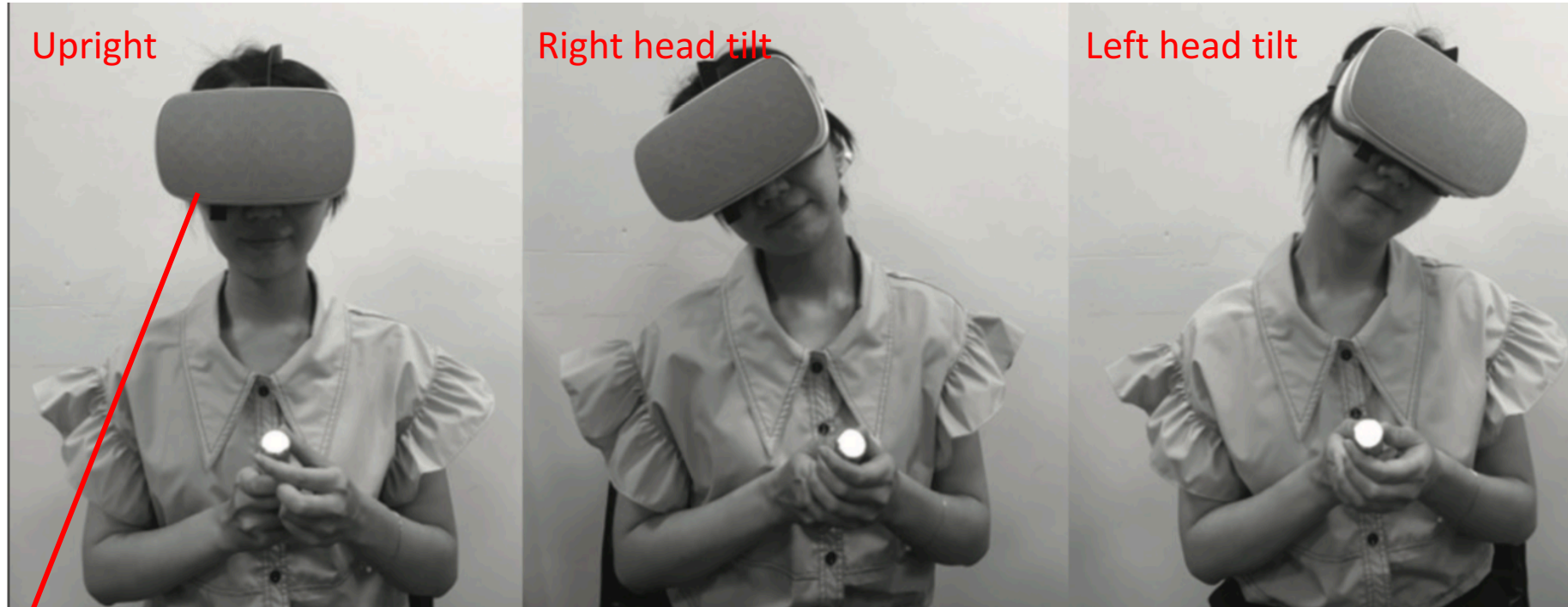
SVV with lateral head tilts

- A (Aubert) effect: SVV lies on the same side as head position
- E (Müller) effect: SVV lies on the opposite side of head position



In Healthy people,
0° - 60°: E effect
60° - 90°: A effect

Clinical Application for SVV with lateral head tilts



VertiSVV, Zehnit, Shanghai

Gyroscope inside the SVV VR goggles



SVV with lateral head tilts in chronic vestibulopathy

- 2E: E-effect at bilateral head tilts;
- 2A: A-effect at bilateral head tilts;
- 1A1E: A-effect at one-side head tilt and E-effect at the other side

| Head tilt 30° | Number of cases | 2A | 1A1E | 2E |
|---------------------------|-----------------|----------|-----------|------------|
| Healthy controls | 30 | 0 (0) | 2 (6.7%) | 28 (93.3%) |
| Bilateral vestibulopathy | 6 | 3 (50%) | 1 (16.7%) | 2 (33.3%) |
| Unilateral vestibulopathy | 14 | 1 (7.1%) | 5 (35.7%) | 8 (57.1%) |

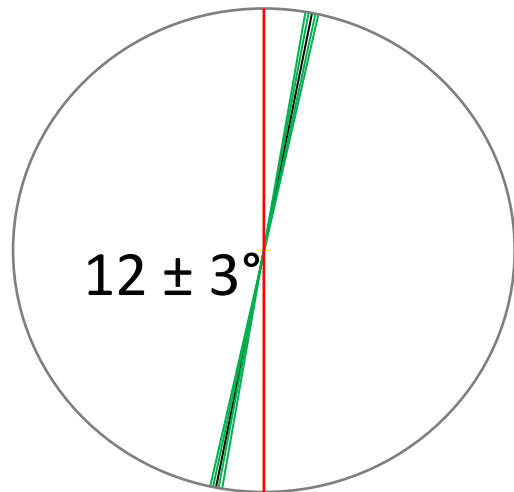
- In head tilt for 30°, most healthy people (>90%) have bilateral E-effects.
- About **50%** of patients with bilateral vestibulopathy had bilateral A-effects, implicating loss of bilateral utricular functions.
- Around **35%** of patients with unilateral vestibulopathy had one-side A-effect, but **the side of of A-effect is not always compatible with the lesion side** (ipsilesional in 3 and contralesional in 2)



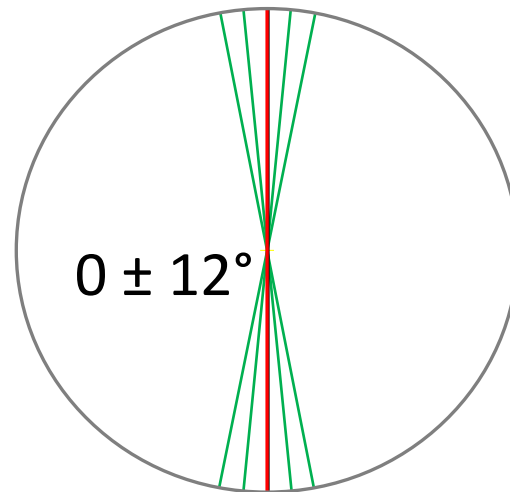
SVV imprecision (variability) and dizziness

SVV imprecision (variability):

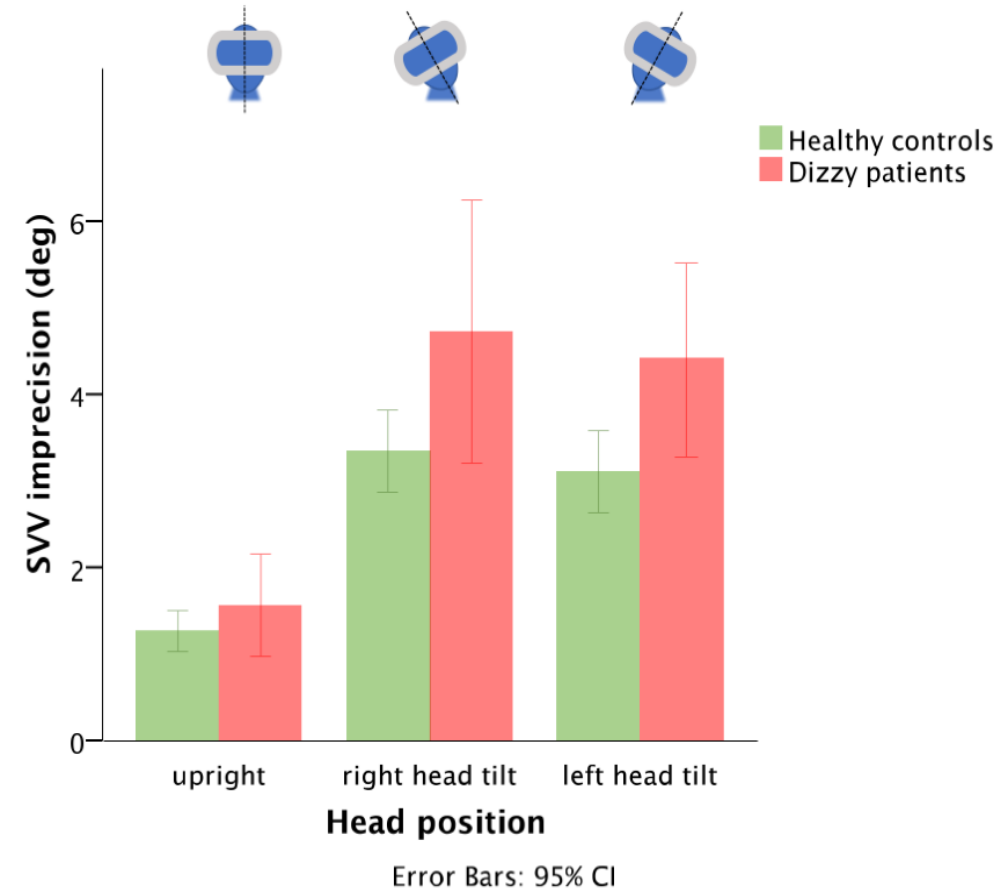
- The **standard deviation** of SVV values in repeated trials
 - Noise of vestibular or somatosensory signals
 - Disturbance of multisensory integration



inaccuracy

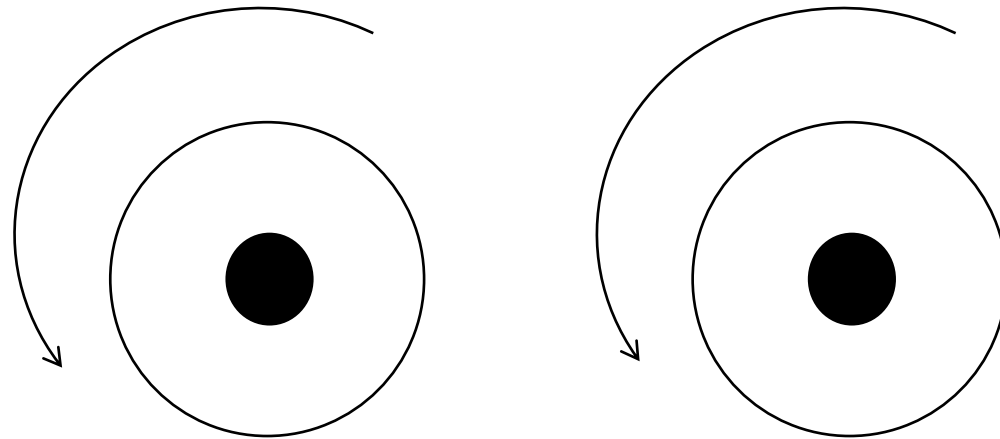


imprecision



Ocular Torsion

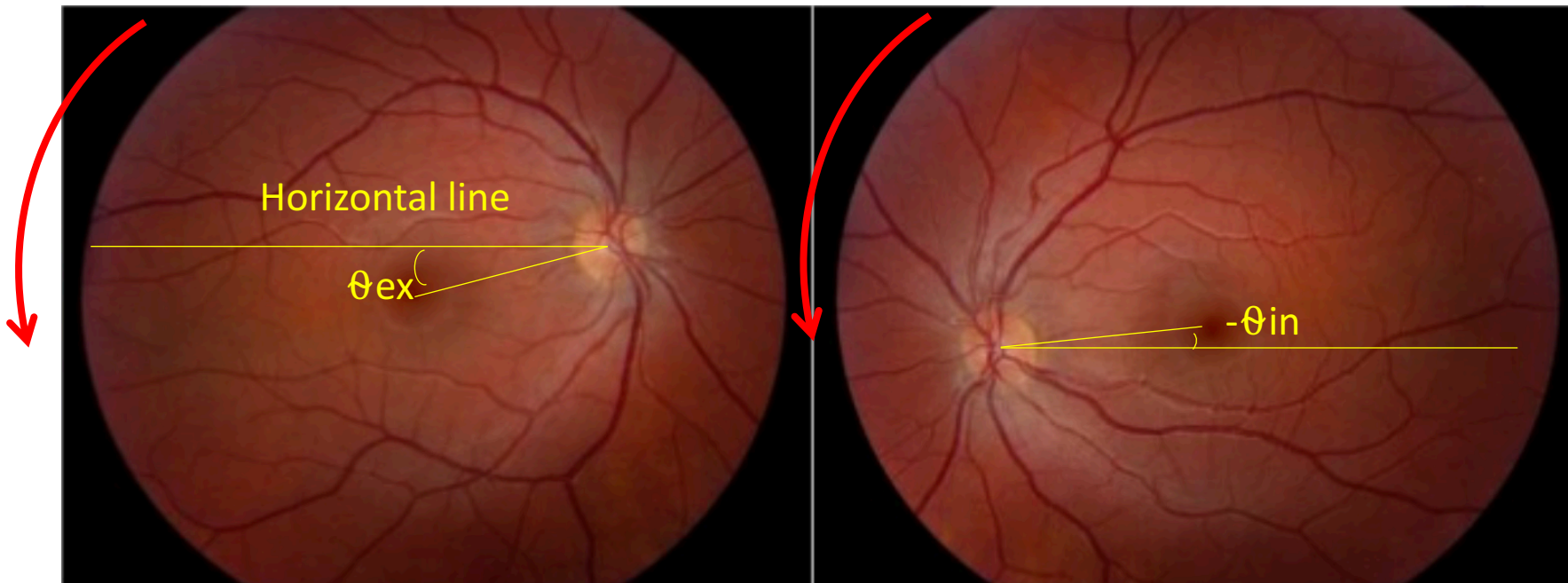
- Less sensitive than SVV
- Abnormal in **Acute Peripheral** or **Central** vestibulopathy
- Normal in thalamus, subcortical or cortical lesions.
- **Objective** sign, but cannot be observed by naked eyes



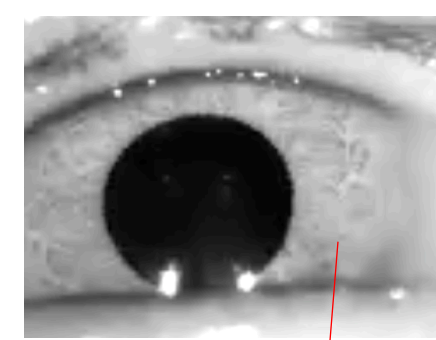
Absolute ocular torsion using fundus photography

Definition of Ocular torsion

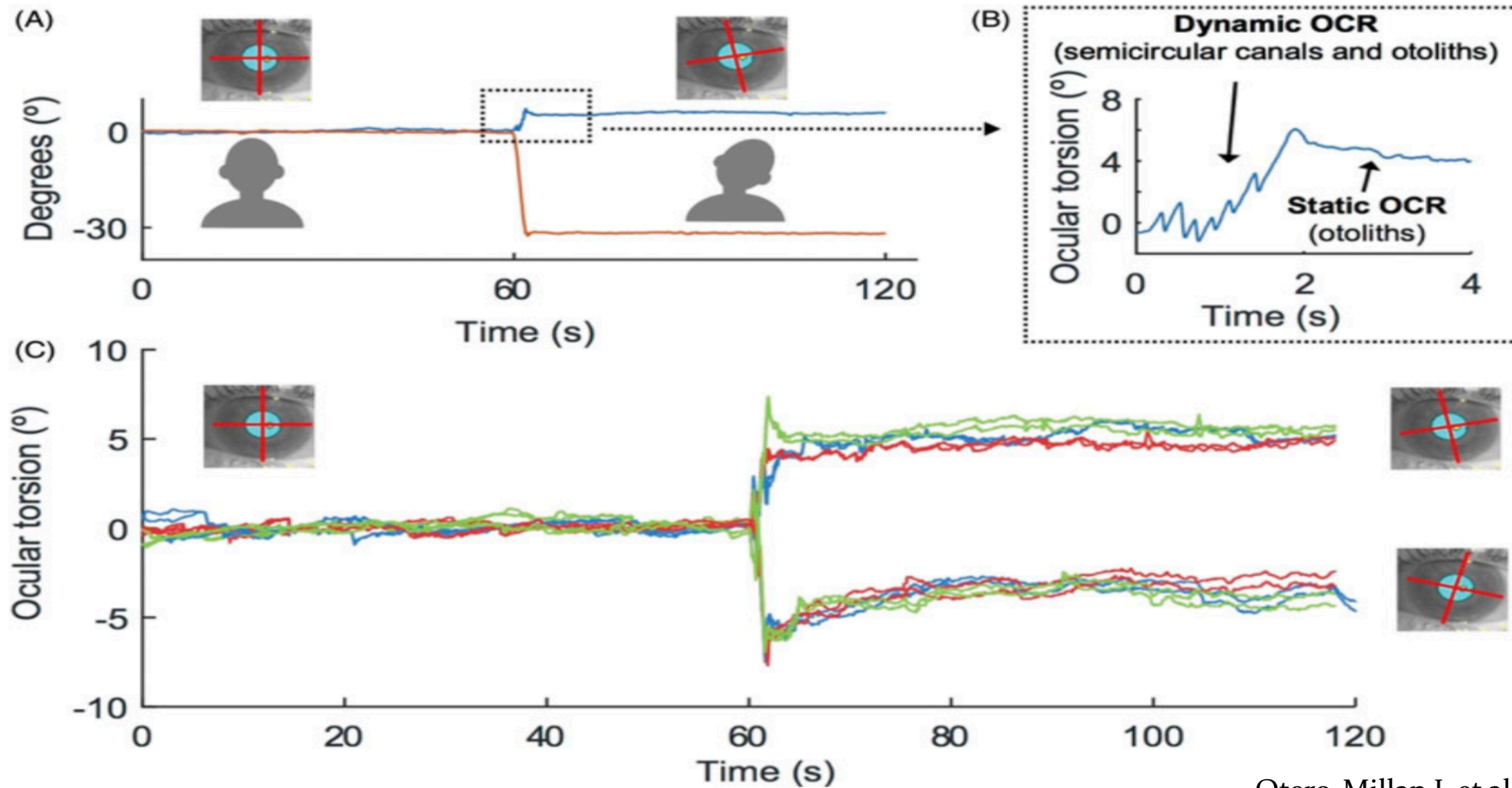
- $\theta_{ex} > 12.6^\circ$, or $\theta_{in} < 0^\circ$, or $\theta_{ex} - \theta_{in} > 8.8^\circ$



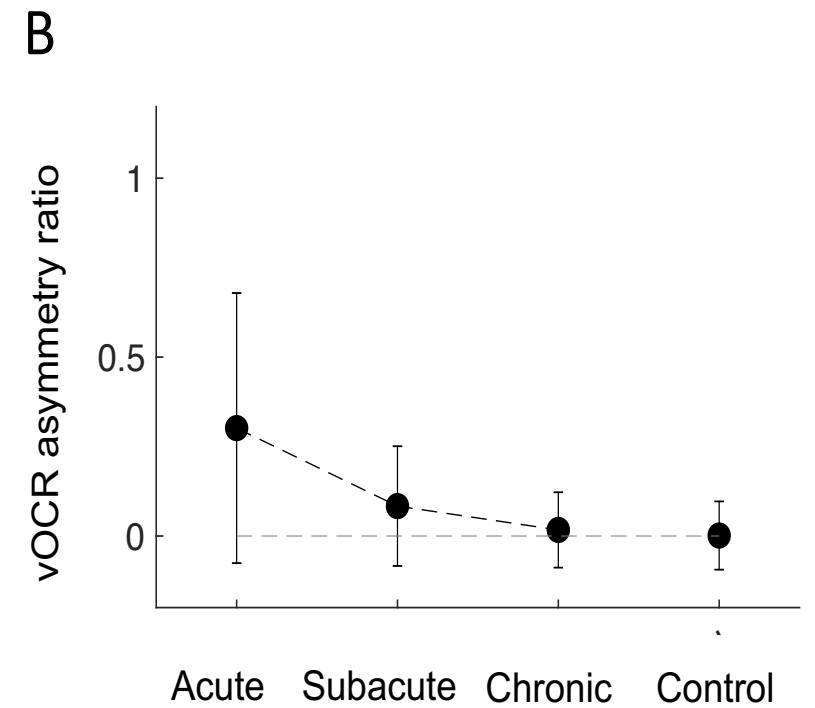
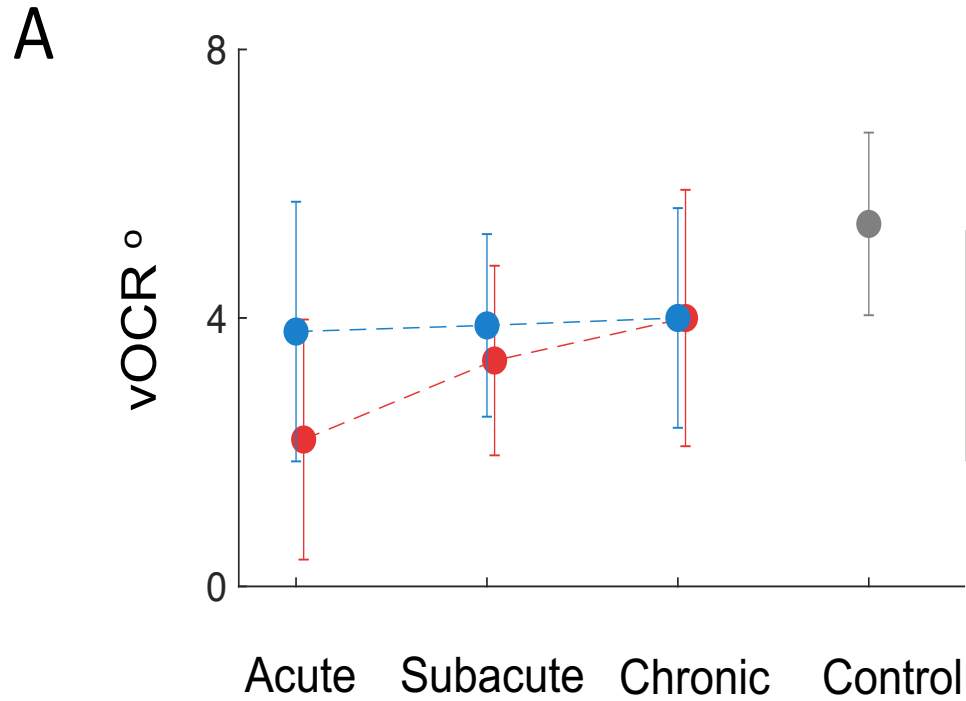
Relative ocular torsion during head tilt: Video Ocular counter-roll (vOCR)



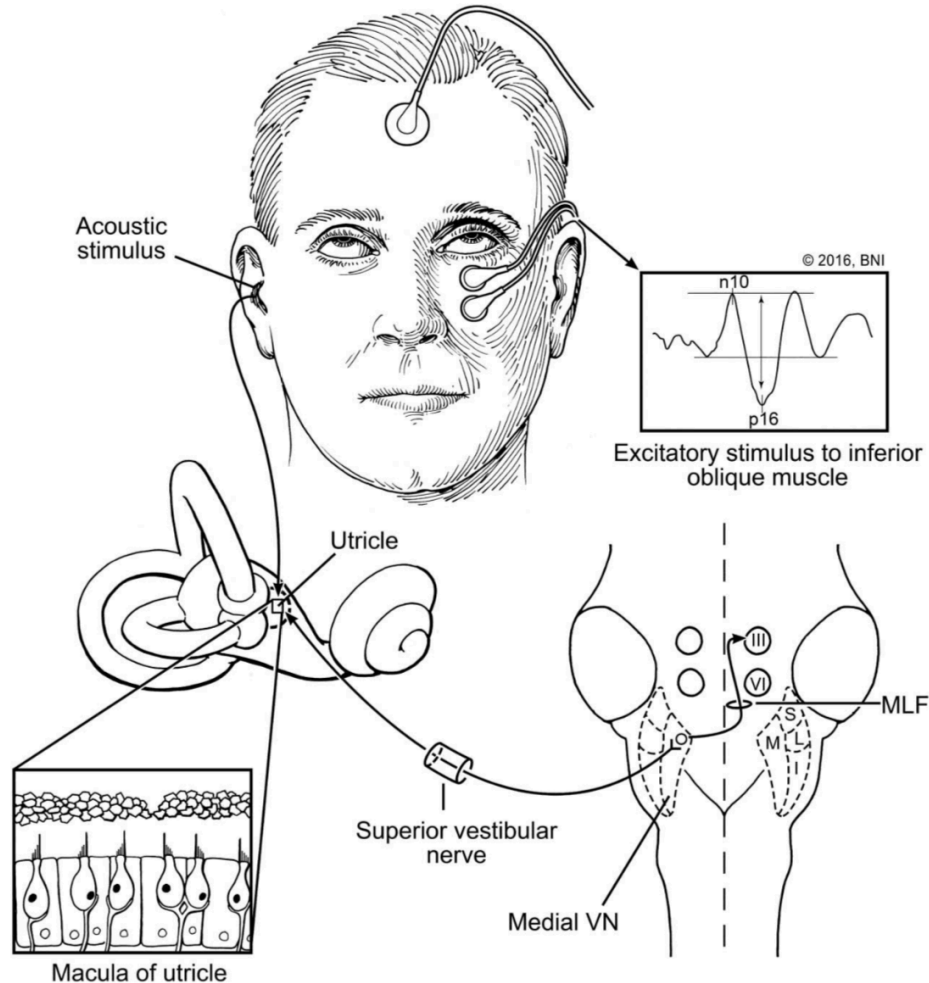
Iris pattern



vOCR in peripheral vestibulopathy



Ocular Vestibular-evoked Myogenic Potential (oVEMP)



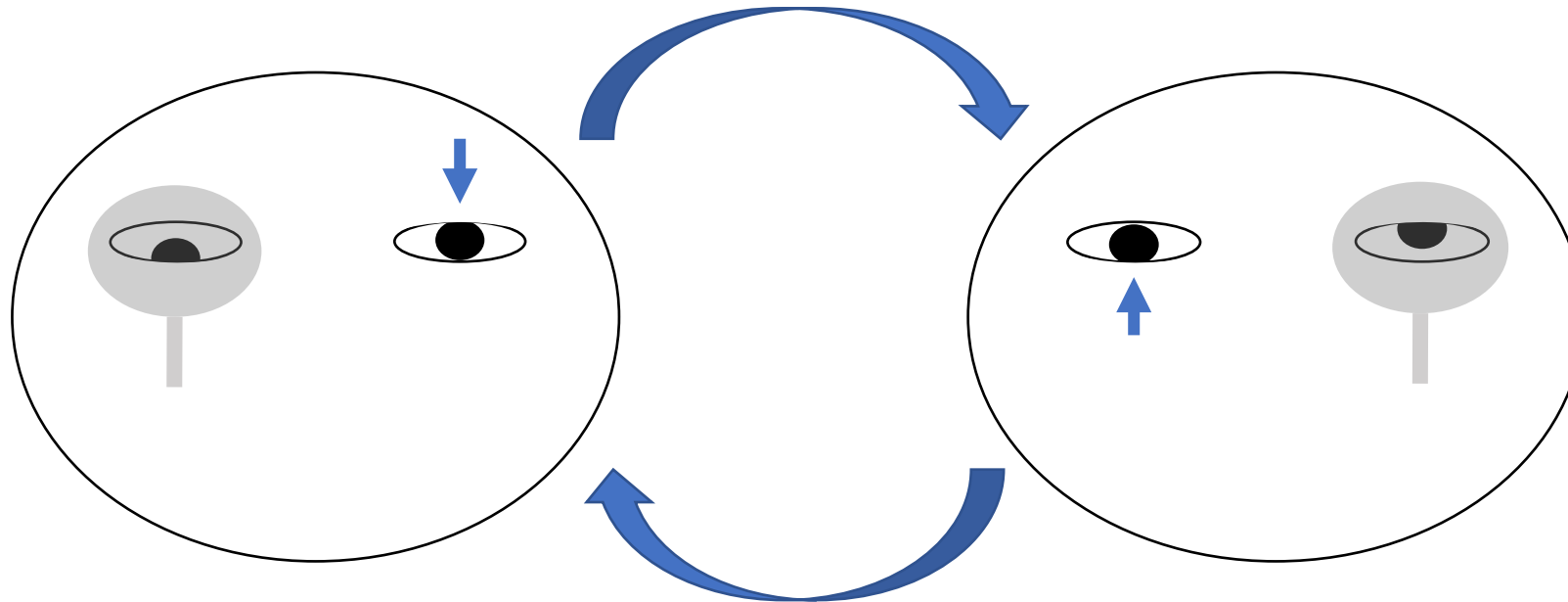
- **oVEMP can detect some chronic vestibulopathies**

- In chronic stage of vestibular neuritis, **60% abnormal**
- In vestibular schwannoma, **69% abnormal**

Skew Deviation

- Less sensitive than SVV or ocular torsion.....BUT
- It can be an adjunctive sign for differentiating central or peripheral disorders.
- HINTS = Head Impulse test, Nystagmus and Test of Skew

Test of skew deviation: alternate cover test

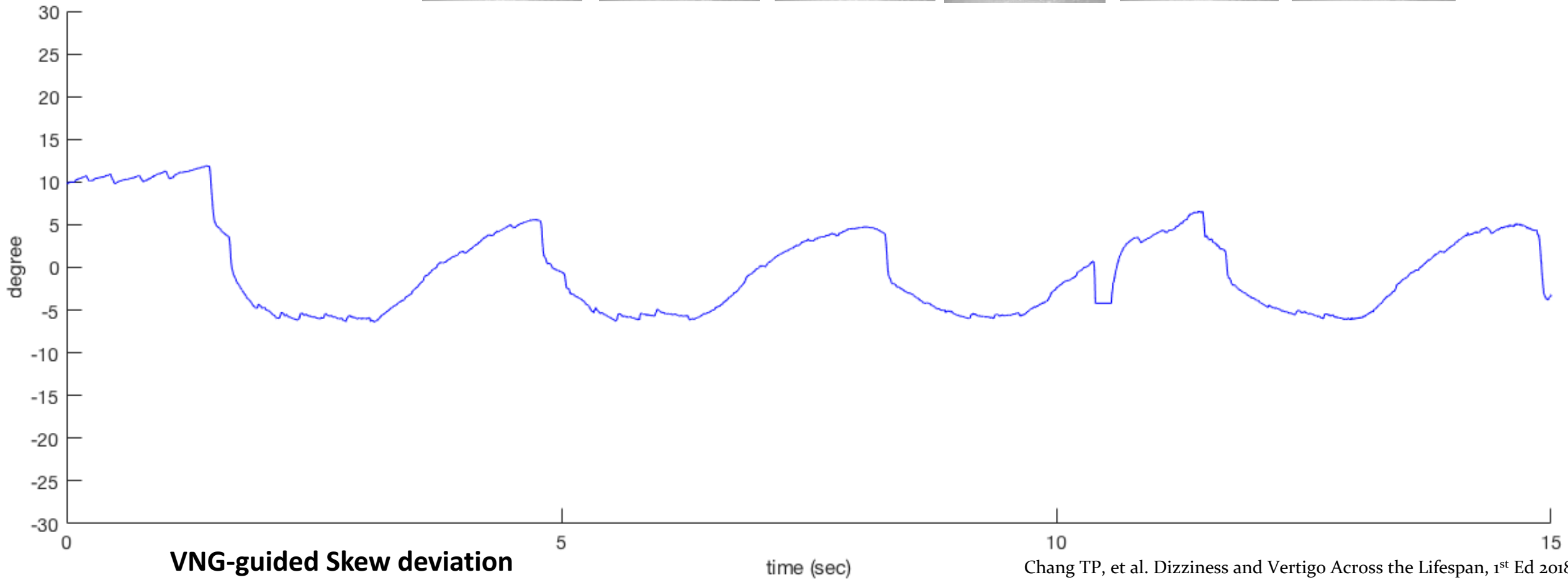
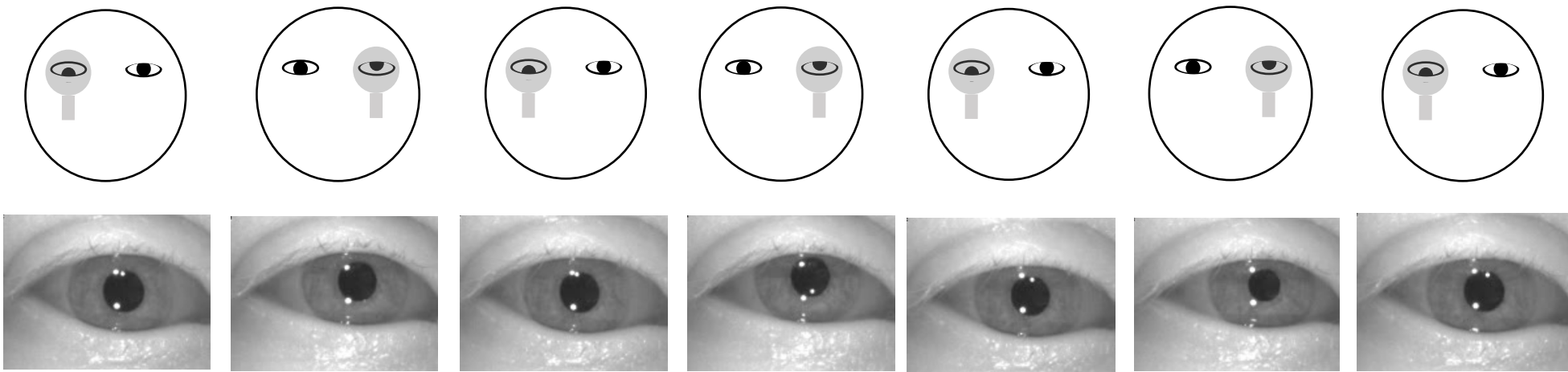


Note the vertical re-fixation of the uncovered eye

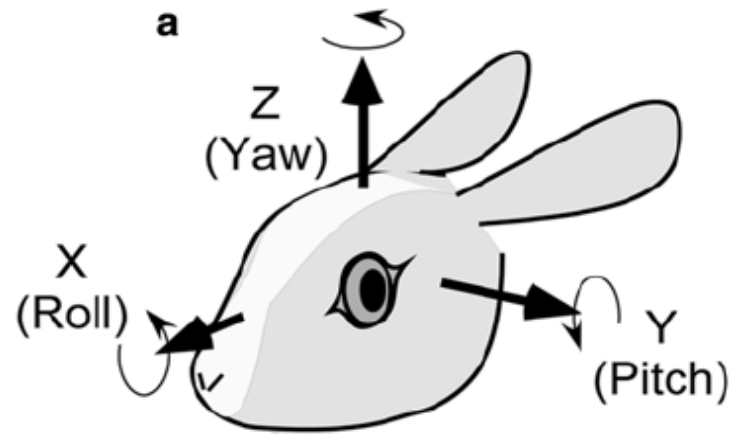
- Skew deviation occasionally appears in peripheral vestibulopathy, but the peripheral skews are **small and transient**.
- Central skews are **large and enduring**.
- **In clinical practice, skew deviation is a central sign.**

Table 4: Pooled analysis of key bedside diagnostic predictors of stroke in patients with acute vestibular syndrome*

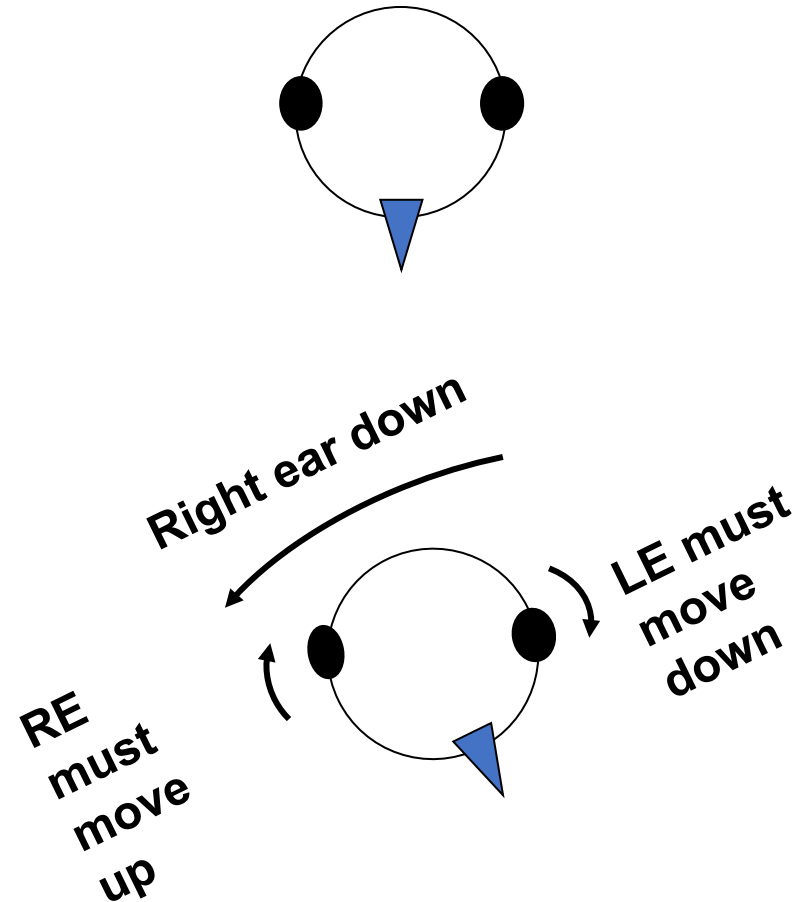
| Bedside diagnostic predictor* | No. of studies reporting data on total/peripheral/central causes | No. of patients, with peripheral/central causes | Sensitivity (95% CI†) | Specificity (95% CI†) | Negative likelihood ratio (95% CI†) | Positive likelihood ratio (95% CI†) |
|---|--|---|-----------------------|-----------------------|-------------------------------------|-------------------------------------|
| Normal result of horizontal head impulse test | | | | | | |
| All central causes ^{6,10,11,33} | 4/2/4 | 65/152§ | 0.85 (0.79–0.91) | 0.95 (0.90–1.00) | 0.16 (0.11–0.23) | 18.39 (6.08–55.64) |
| PICA or SCA stroke ^{6,10,33} | 3/1/3 | 25/72 (68 PICA) | 0.99 (0.96–1.00) | –** | 0.01 (0.00–0.10) | –** |
| AICA stroke ^{6,10} | 2/1/2 | 25/13 | 0.62 (0.35–0.88) | –** | 0.40 (0.20–0.80) | –** |
| Direction-changing nystagmus‡ ^{6,9–11,27,28} | 6/3/6 | 83/239§ | 0.38 (0.32–0.44) | 0.92 (0.86–0.98) | 0.68 (0.60–0.76) | 4.51 (2.18–9.34) |
| Skew deviation ^{6,11} | 2/2/2 | 65/119§ | 0.30 (0.22–0.39) | 0.98 (0.95–1.00) | 0.71 (0.63–0.80) | 19.66 (2.76–140.15) |



Hypothesis: “Rabbit in the Brain”

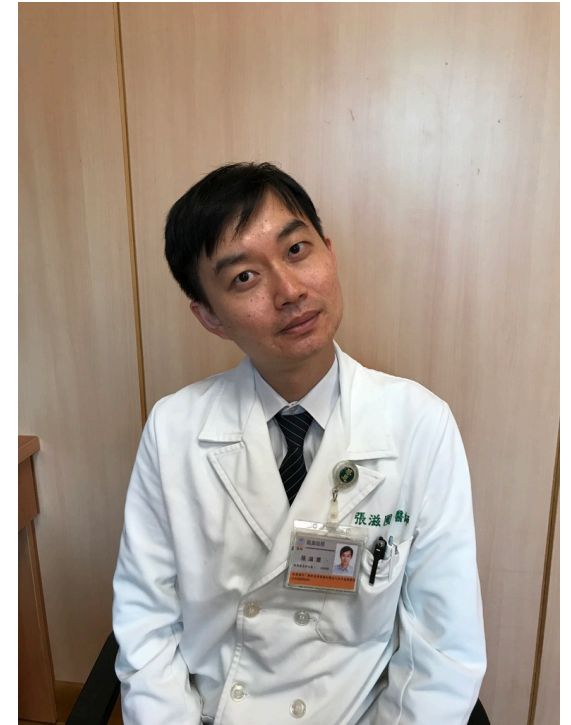


In the **lateral-eyed** rabbit, a lateral tilt (one ear up and the other down) leads to the eyes rotating around the *roll axis* with one eye rotating down and the other eye rotating up (a physiological **skew** as part of the OTR (Ocular Tilt Reaction))



Head Tilt

- The easiest to observe
- Few study about it
- **Mechanism:**
 - Vestibulospinal tract
 - Spinocerebellar tract
 - Compensation for ocular torsion or skew deviation
 - Compensation for illusive body/head tilt
- Medulla lesions usually cause the most apparent head tilt



Take Home Message

In OTR family, all the four members have different clinical values.

| | |
|----------------|--|
| SVV | SVV is one of the most sensitive sign for acute central or peripheral vestibular lesion. |
| | SVV with lateral head tilts may help diagnose chronic vestibulopathy. |
| | SVV with lateral head tilts can assess vestibular perception and sensory integration. |
| Ocular torsion | Ocular VEMP can detect the function of utricular-ocular reflex. |
| | vOCR can evaluate the vestibular compensation of utricular-ocular reflex. |
| Skew deviation | Skew deviation is less sensitive, but is usually a central sign. |
| Head tilt | Head tilt is the easiest to observe. |