Potential Factors Associated with Uncompensated Unilateral Peripheral Vestibular Deficits – Intervention Technique or Ocular Alignment

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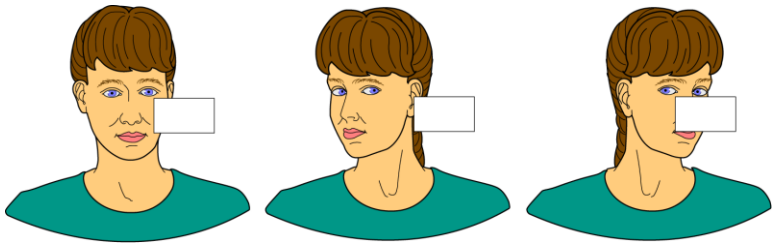

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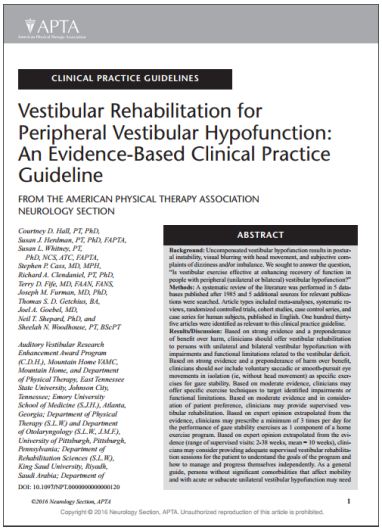
Vestibular Rehabilitation for Peripheral Vestibular Hypofunction (Hall et al., 2016)

- Strong evidence **supports** vestibular rehabilitation for persons with unilateral and bilateral vestibular hypofunction.
- Strong evidence **should not include** voluntary saccadic or smooth-pursuit eye movements in isolation as specific exercises for gaze stability.



APTA

CLINICAL PRACTICE GUIDELINES

Vestibular Rehabilitation for Peripheral Vestibular Hypofunction: An Evidence-Based Clinical Practice Guideline

FROM THE AMERICAN PHYSICAL THERAPY ASSOCIATION NEUROLOGY SECTION

ABSTRACT

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Objectives

Upon completion of this session, the participant will be able to:

- Describe the mechanisms of neuroplasticity following unilateral peripheral vestibular lesion.
- Describe the "ideal exercises" to facilitate central adaptation of the vestibulo-ocular reflex in individuals with peripheral vestibular hypofunction.

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Peripheral Acute Vestibular Syndrome:
Unilateral Peripheral Vestibular Hypofunction

- **Signs and Symptoms.**
  - Dynamic manifestations (Brandt et al., 2010)–
    - After 6 weeks most patients are nearly symptom free.
    - 40% of patients will have chronic impairments
      - Dizziness
      - Imbalance
      - Oscillopsia
      - Fear of Movement

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Dominant Clinical Sign of UPVH: Reduced VOR Function

- **VOR:**
  - Main vision stabilizing mechanism during rapid head movement.
  - VOR functions up to 15 Hz for all head rotation directions (Migliaccio et al., 2004).
  - VOR normally functions during normal activities like walking and running (Rinaudo et al, 2019).
    - Vertical head movements 5.8 Hz.
    - Horizontal head movements 2 Hz.
- **Clinical Manifestation of Reduced VOR Function**
  - **Oscillopsia.**
    - Blurred vision during movement of head – retinal slip.
    - Severest during high-frequency head motion.
  - **Reduced gain.**
    - Gain of VOR = eye velocity/head velocity
    - Eye lag with rapid motion of head.
    - Compensatory saccade in direction opposite to head movement to maintain fixation.

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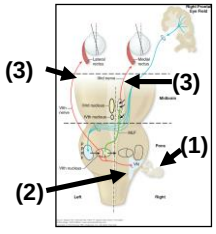
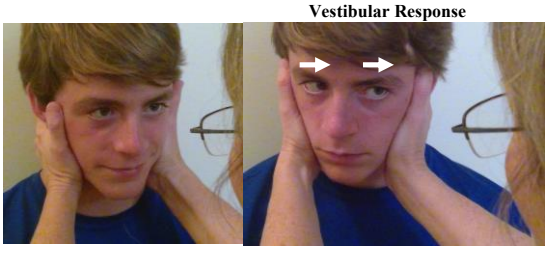
Clinical Head Impulse Test:

(Head Thrust or Rapid Doll's Eyes) (Halmagyi & Curthoys, 1988).

- **Purpose**: Test the high frequency function of the angular vestibular ocular reflex (aVOR).
- **Findings:** Gain of VOR.
  - **Normal –** eye movement equal and opposite to head movement.
  - **Abnormal –** Compensatory saccade in direction opposite to head movement to maintain fixation.



VOR – 3 neuron arc.



Head thrust right. Normal vestibular response - eyes move equal and opposite towards left. Intact VOR on right.

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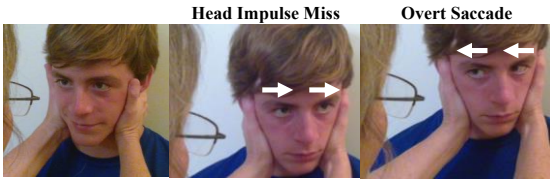
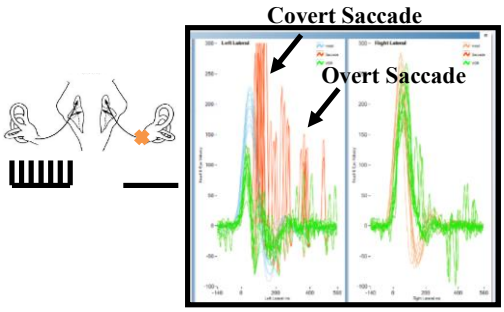
Video Head Impulse Test (vHIT):

Instrumented test of the a(VOR)
(Halmagyi & Curthoys, 1988; Schneider et al., 2009)

- **Findings of Reduced VOR Function.** Head impulse misses with rotation of the head towards the side of the lesion.
- **Two types of compensatory or corrective side** in direction opposite of head movement.
  - ***Overt or catch-up saccade*** observed when head movement stops.
    - Acute - observe first 5 days.
    - Observe in room light.
  - ***Covert or predictive saccades*** during head movement.
    - Chronic – observe > 5 days.
    - Observe with specialized equipment.



Head thrust left – Head impulse miss. Positive corrective overt saccade towards right. Left ear involved.



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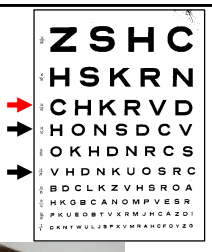
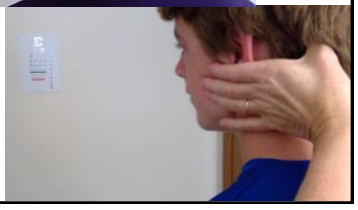
Dynamic Visual Acuity Test – Non Instrumented:

(DVAT-NI) (Longridge & Mallinson, 1987)



- **Purpose:** Behavioral measure of aVOR - ability to maintain fixation on a target during passive, rotation of the head (2Hz).
- **Test:**
  - Static visual acuity - Visual acuity with head still.
  - Dynamic visual acuity - Visual acuity with passive rotation of the head at a frequency of 60°/s (2 Hz or 120 bpm metronome).
- **Findings:**
  - **Positive test:** >2 line difference between static and dynamic visual acuity.



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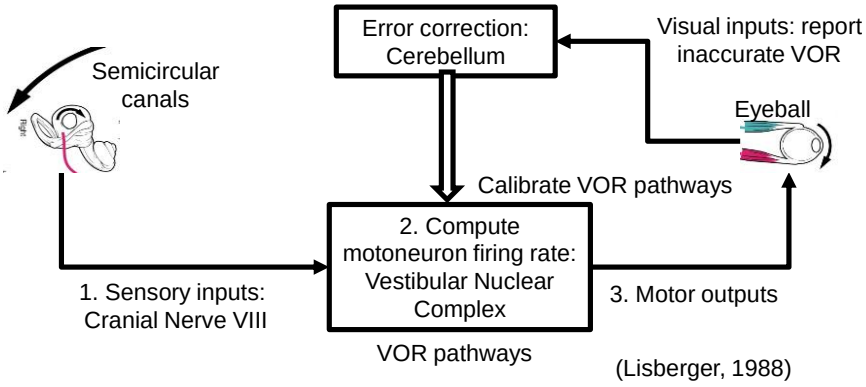
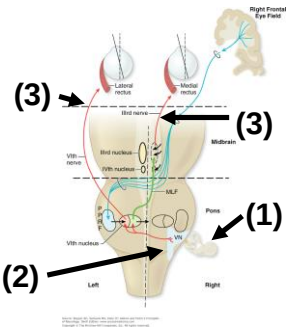
Vestibular Ocular Reflex (VOR)

- VOR is an open feedback loop system – Error signal retinal slip (blurred vision).
- Visual experiences is **necessary** to acquire and maintain the gain of the VOR (Fetter, Zee, & Proctor, 1988)
- Gain = output/input. Gain of the VOR = eye velocity/head velocity = .8 - 1





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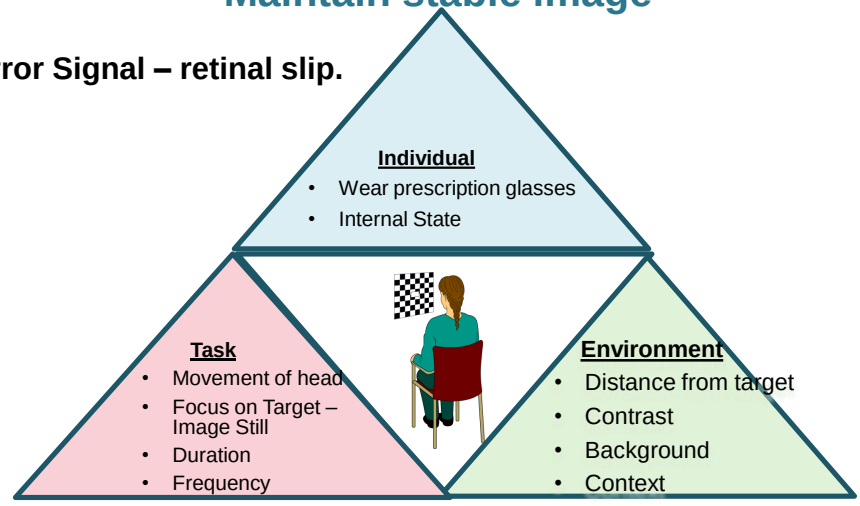
Principles of VOR Gaze Stability Exercises: Maintain stable image

- **Avoid Error Signal – retinal slip.**



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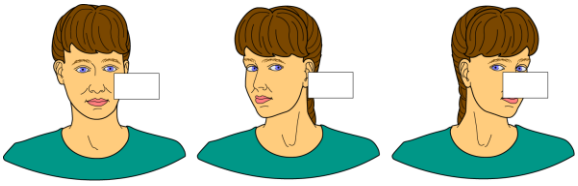
Principles of VOR Gaze Stability Exercises

Task

Aim - Maintain clear and stable image of object on retina with movement of the head.

Stimulus – movement of an image across the retina combined with movement of the head.

- **Task** -
  - Focus on target with movement of head in yaw, pitch, and roll plane.
  - Target – Letter. Minimum 14 pt font or ⊗ (Thaler, Schutz, Goodale, & Gegenfurtner, 2013)



Horizontal plane - 40º right/40º left

Vertical plane - 30º up/30º down

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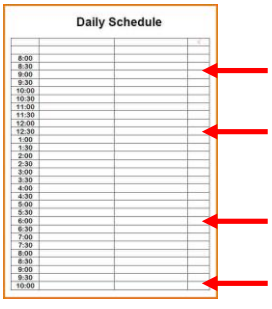
Principles of VOR Gaze Stability Exercises

Task

Task -

- **Duration**
  - Ideally 30 minutes of stimulation. (Collewijn, Martins, & Steinman, 1983)
    - Exercises: Gradually progress to 1-2- minutes 4 times per day.
    - Encourage functional activities such as sports and games (safety first).



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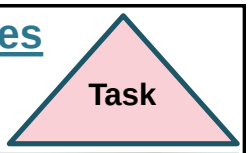
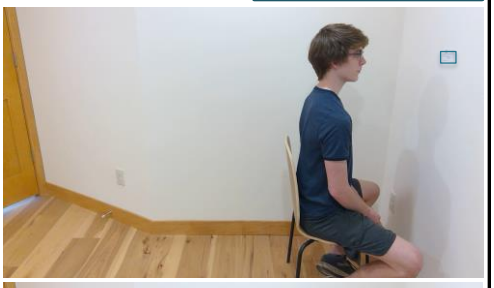
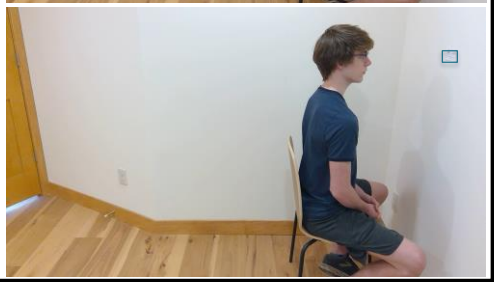
Principles of VOR Gaze Stability Exercises



Task.

- **Frequency**
  - Greater the velocity the greater the carry-over into functional activities.
    - Head rotation frequency typically 0.5 Hz (one complete head rotation cycle every 2 s) (Roller & Hall, 2018) – lower-end of functional range of the VOR. Predominantly invokes smooth pursuit vision stabilizing mechanism.
    - Head rotation > 2 Hz. VOR primary contributor to gaze stability.(Rinaudo, Schubert, Figtree, Todd, & Migliaccio, 2019)





  - Perform VOR adaptation exercises at frequency that does not cause error signal or retinal slip.

- **Signs and symptoms of retinal slip.**
  - Image jumps, disappears, or gets wavy.
  - Patient detects and clinician observes jump in vision. When head is moving towards the side of lesion, consistent point in range of head movement see jump.

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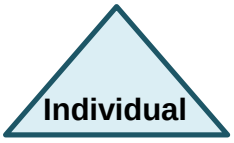
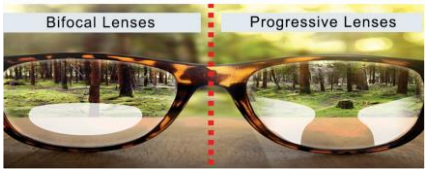
Principles of Gaze Stability Exercises



– **Individual** –

- Wear prescription glasses if needed for distant vision. If bifocals, move head within available range of viewing.

- Internal State. Attention, Mentation, Emotion, and Concentration - Greater increase in gain with active than passive movement (Collewijn, Martins, & Steinman, 1983).



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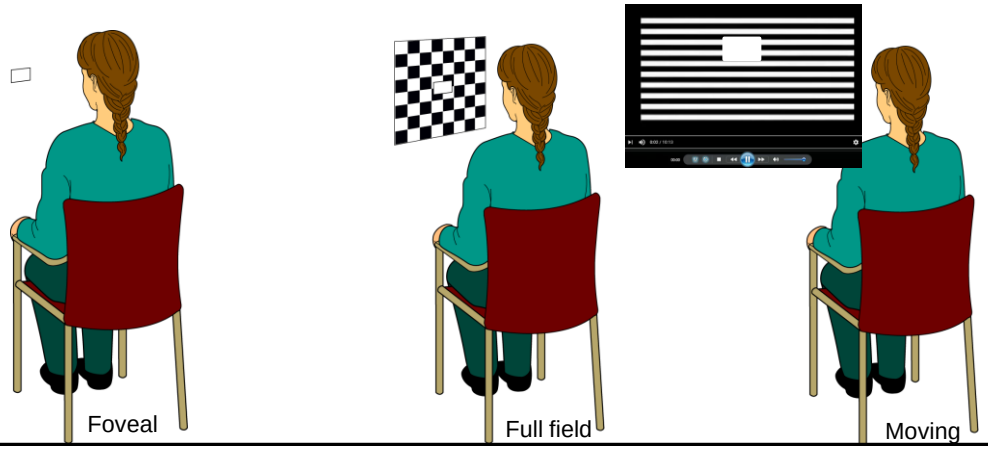
Principles of Gaze Stability Exercises

Environment

- **Environment -**
  - Distance from target range from 3' to 10'(difficult to easy). Recommend 3'. Does not require vergence.
  - High visual contrast (bright target and moderate ambient lighting ie curtains closed and lights turned off (Muntaseer Mahfuz et al., 2018)). Usual performed low-contrast target.
  - Background progression from foveal to full field to moving background (easy to difficult).



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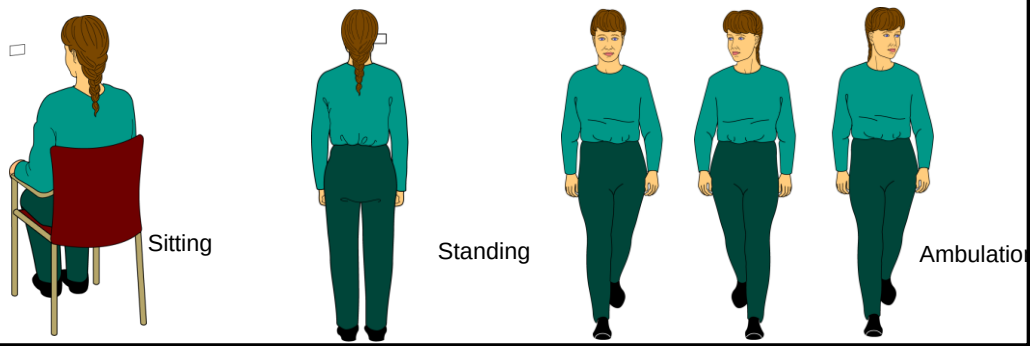
Principles of Gaze Stability Exercises

Environment

- **Environment -**
  - Context Specific
    - Adaptation is position specific (Baker, Wickland, & Peterson, 1987). Progression sitting to standing to ambulation.
    - Exercises should incorporate interaction of vestibular, visual and proprioceptive cues.



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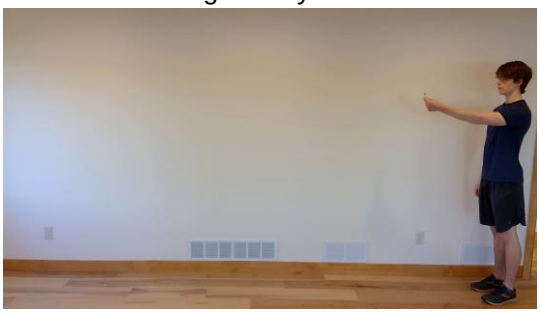
Principles of Gaze Stability Exercises

- **Environment -**
  - Context Specific
    - Walk while reading (hold a page of 12 font words at arm length).
    - Walk while making rapid horizontal and rapid vertical head oscillation (moving in synchronization to a metronome set at 2 Hz).
    - Dual task walking (serial subtractions by sevens).
    - Walking with eyes closed.



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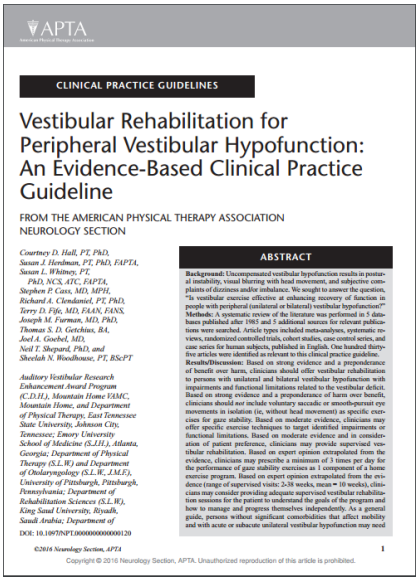
Vestibular Rehabilitation for Peripheral Vestibular Hypofunction: An Evidence-Based Clinical Practice Guideline. (Hall et al., 2016)

Expert opinion extrapolated from the evidence

- Perform gaze stability exercises a minimum of 3x's per day.
- Provide adequate supervised vestibular rehabilitation.
  - acute or subacute unilateral vestibular hypofunction supervised for 2-3 weeks
  - chronic unilateral vestibular hypofunction once a week for 4-6 weeks
  - bilateral vestibular hypofunction once a week for 8-12 weeks.
- Provide daily home exercise program



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ABSTRACT

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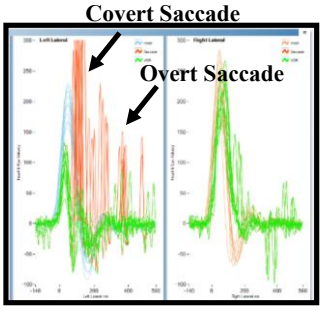
Does Adaptation Occur Following Gaze Stability Training?

Conventional gaze stability training results in compensatory strategy not adaptation (Chang, Schubert, 2020).

- Reduced latency of compensatory saccade.
- Reduced VOR gain. Opposite of objective of gaze stabilization training.

If VOR gain improves, need for compensatory saccade should be reduced.



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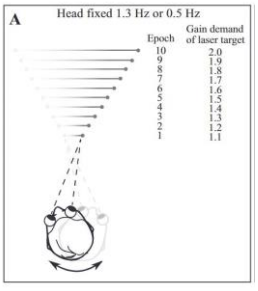
Modify Environment to Optimzie VOR Motor Learning – Enhance VOR gain

- Target high contrast (Mahfuz et al, 2018).
  - Complete darkness with red LED as target.
- Visual target motion closely synchronized to head motion (x2 viewing) (Fadee and Migliaccio, 2016)
- Use a metronome and verbal feedback to ensure subjects rotate their head at the correct frequency (Rinaudo et al. 2019).
  - Frequency twice rate of sinusoidal frequency.
  - Frequency incremental .5-2 Hz. (Rinaudo et al, 2019). Begin .5 Hz. Increase frequency each epoch .17 Hz. Final epoch 2 Hz.
    - .5 Hz smooth pursuit and optokinetic reflexes which are prone to fatigue
    - 2 Hz – VOR gain increased suggesting adaptation.
- Practice Duration – Exposure to the Training Target Critical (Mahfuz, et al 2018).
  - Stimulus duration – 15 minutes of stimulation – 20 minutes duration
    - 10 epochs lasting 90s: 30 s between each epoch.

Sitting



Rinaudo et al. 2019

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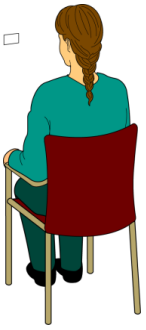
Principles of Adaptation – Error Signal

- **Error Signal -**
  - Incremental error signal (computer controlled) is more effective at driving neural plasticity and learning.
  - If error signal too large, adaptive processes may assign the stimulus as invalid.
  - Increase variability, decrease VOR adaptation (Rinaudo et al, 2021).



Sitting

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Vergence-Mediated VOR Gain Enhancement
(Chang & Schubert, 2020)

- For far-target viewing, retinal slip should equal zero. Rotation of eyes in orbit = Rotation of eyes in head.
  - For far-target viewing distance of 150 cm, ideal VOR gain is 1.07.
- For near-target viewing, an additional rotation of the eye is required. The eyes are positioned 10 mm in front of the axis of head rotation, requiring a translational eye rotation with the angular rotation(Migliaccio, Minor, & Carey, 2004).
  - For near-target viewing distance of 15 cm, ideal VOR gain is 1.67.
- Vergence-enhanced VOR gaze stability exercise.

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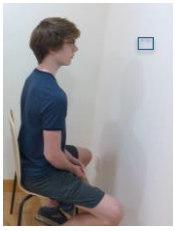
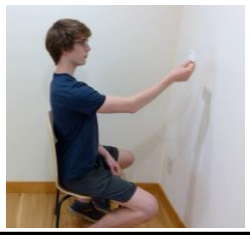
Vergence-Mediated VOR Gain Enhancement

Vergence-enhanced VOR gaze stability exercise. Moving the head in horizontal plane and maintaining focus on letter (Chang & Schubert, 2020).

- Near target viewing – letter 15 cm in front of eyes.
- Far target viewing – Letter arm's length in front of the eyes.
- Vergence VOR – Subject moves the target from arm's length to the bridge of their nose and back while attempting to keep focus on the target.

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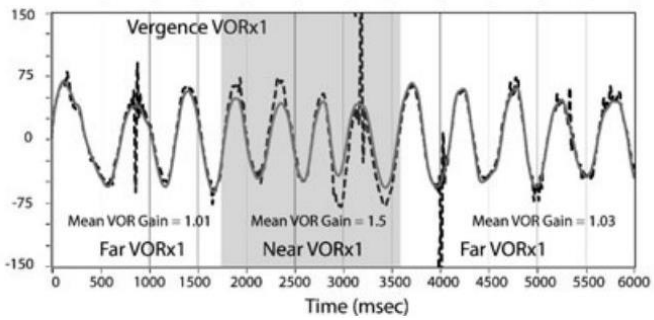
Vergence-Mediated VOR Gain Enhancement

Vergence-enhanced VOR gaze stability exercise(Chang & Schubert, 2020).

- Magnitude of recovery of vergence VOR gain was not statistically significant.
- VOR gain improved approximately 10%.
- The amount of change in VOR gain that has been shown to be clinically relevant as related to fall risk is >0.06(Chang & Schubert, 2018).



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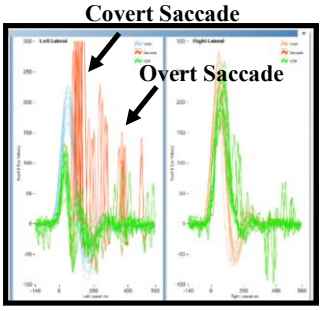
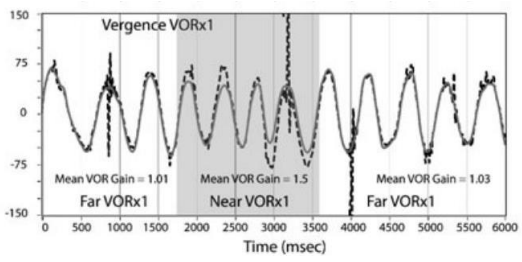
Summary Gaze Stabilization
(Chang & Schubert, 2020)

Conventional VOR gaze stabilization exercises causes compensation - modifies the latency of the compensatory saccade.



Vergence-enhanced VOR gaze stabilization exercises causes adaptation - increases the gain of the VOR.



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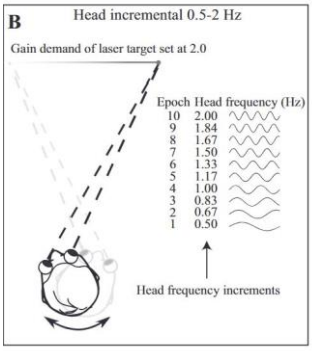
Visual-Vestibular Interaction (x2 Viewing)
(Rinaudo, Schubert, 2021)

- Stimulus. Interaction of pursuit and VOR.
  - Sinusoidal, small amplitude head rotation 10° right and 10° left. Synchronize movement of target in opposite direction of head with similar angular magnitude.
  - Moderate velocity. Testing at 1.3 Hz. Needs to be >150°/s.
    - Frequency twice rate of sinusoidal frequency.
    - Frequency incremental .5-2 Hz. (Rinaudo et al, 2019). Begin .5 Hz. Increase frequency each epoch .17 Hz. Final epoch 2 Hz.
  - Duration – 15 minutes of stimulation – 20 minutes duration
    - 10 epochs lasting 90s: 30 s between each epoch.
- Healthy controls resulted in significant, but 2/3's less, adaptation than computer-controlled x2 (non-variable demand) training.
- One session - patients with UPVD no change possibly because of significantly greater variability in training gain demand.



Rinaudo et al. 2019

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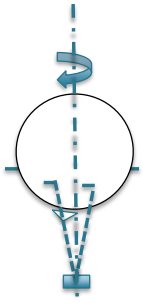
Impulse VOR

- Passive or Active Impulse VOR. Transient horizontal head rotations.
  - Active impulse – predictive. Passive impulse – non-predictive.
  - Moderate velocity. Testing at 1.3 Hz. Needs to be >150°/s.
    - Frequency twice rate of sinusoidal frequency.
    - Frequency incremental .5-2 Hz. (Rinaudo et al, 2019). Begin .5 Hz. Increase frequency each epoch .17 Hz. Final epoch 2 Hz.
  - Small amplitude (10°), transient, horizontal head rotation towards involved side.
  - Stimulus duration – 15 minutes of stimulation – 20 minutes duration
    - 10 epochs lasting 90s: 30 s between each epoch.



10° horizontal head rotation towards right.

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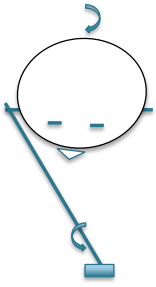
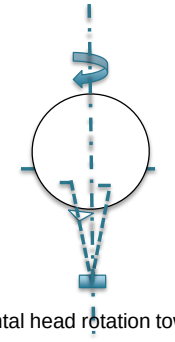
Summary: Gaze Stabilization – VOR Gain Enhancement

Visual-vestiular interaction (x2 viewing) causes adaptation.



Passive and active head impulse causes adaptation - increases the gain of the VOR.



10° horizontal head rotation towards right.

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Peripheral Vestibular Hypofunction:
Individual Factors that may Limit Performance.

Individual Factor Limit Performance	Modifications to Address each Individual Factors
Vertebral Artery	Positive VAT – Red flag. Do not perform exercises
Cervical Spine • Limited ROM • Pain	Caution. Cervical spine intervention prior to or in conjunction with gaze stabilization exercises
Visual Acuity – Blurred vision head at rest • Glasses – wear prescription glasses • Acquired or pre-existing ocular misalignment • Gaze evoked nystagmus	• Reduce range of head movements - accommodate lenses • Reduce range of head movements or vary distance of target. Address ocular misalignment prior to or in conjunction with gaze stabilization exercises. • Perform ex within ocular range that does not evoke GEN
Cognition. • Difficulty attending to task • Anxiety or fear of moving	• Constant cuing. Targets “like’s” and “dislike’s” • Education
Medication – vestibular suppressants	• After 1st 5 days, stop vestibular suppressant medication with physician approval.

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