Use of Suborbital Flight to Elucidate the Role of Tonic Otolith Stimulation Due to Gravity in Balance Testing and Orientation Tasks.

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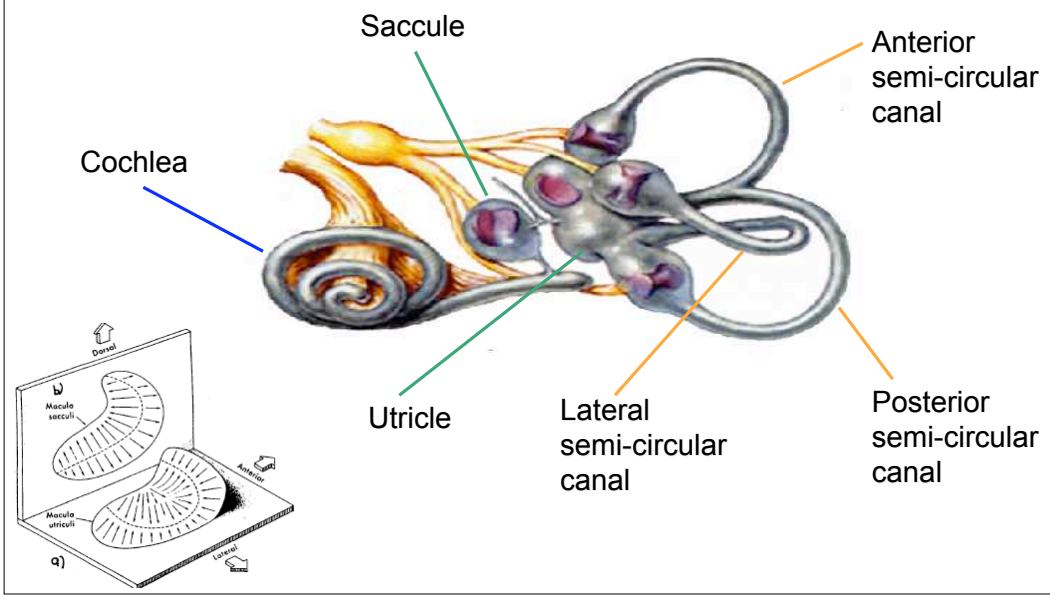
Introduction-

Suborbital fight provides an opportunity for further understanding --

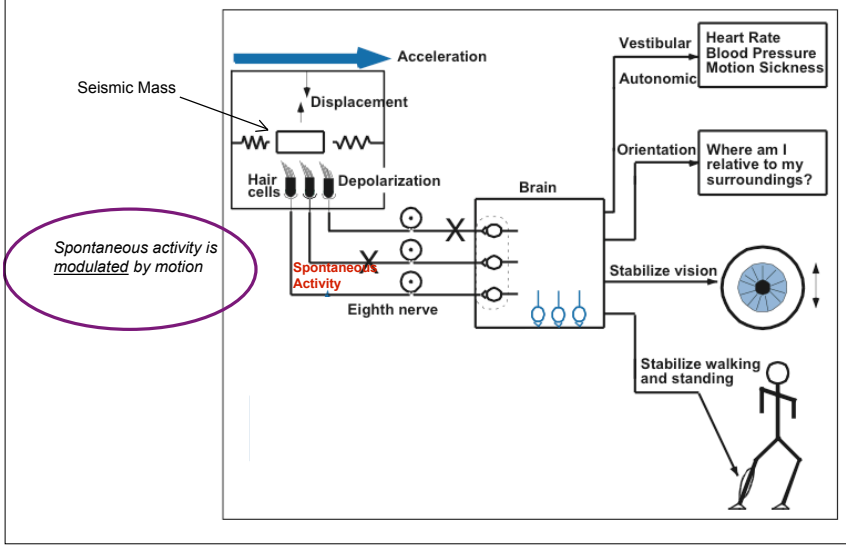
- An emerging test for the clinical evaluation of otolith function, called VEMP
- The tonic effect of gravity upon certain indicators of oculomotor function, called Memory Saccades
- The use of tactile cues for spatial orientation

Each of these three ideas will be briefly explored

The Inner Ear - Hearing & Balance



Vestibular System & "Outputs"



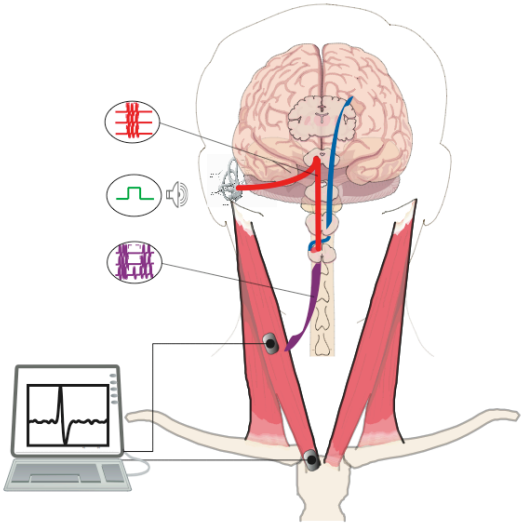
Vestibuloocular Reflex to stabilize vision during head motion

1. Clinical evaluation of otolith function

A VEMP (Vestibular Evoked Myogenic Potential) is an inhibitory modulation of the sternocleidomastiod muscle motor unit action potentials.

A sound, like a click, is used to stimulate the saccule. Its response, in turn inhibits the action of a nerve that activates the SCM.

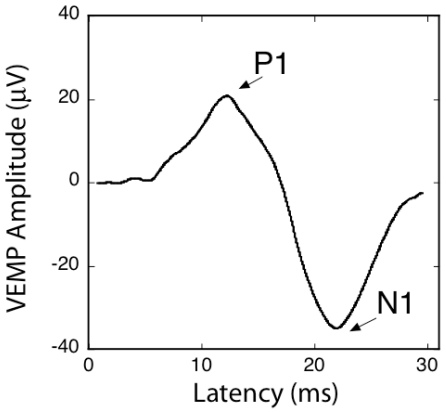
Proper loading of the muscle is crucial to getting a good response.



Clinical evaluation of otolith function

- VEMP appears to be sensitive to pre-symptomatic saccular hydrops and may thus be a good predictor for bilateral Meniere's disease
- Saccular hydrops appears to precede symptoms but does not necessarily cause them
- VEMP appears to scale w/ severity of disease –

Drop attacks > classic MD > normal



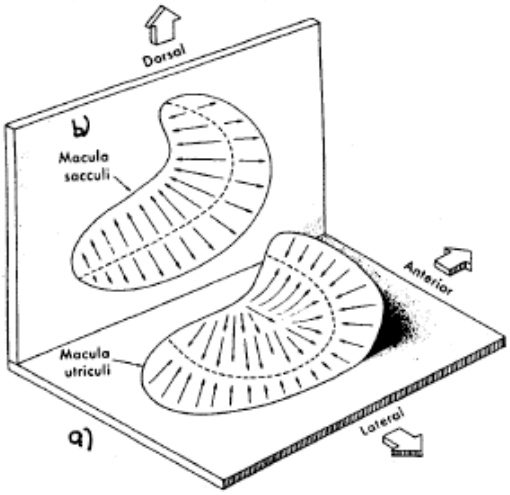
Courtesy of Steve Rauch, M.D.

Clinical evaluation of otolith function

The saccule is normally "loaded" by the 1g environment.

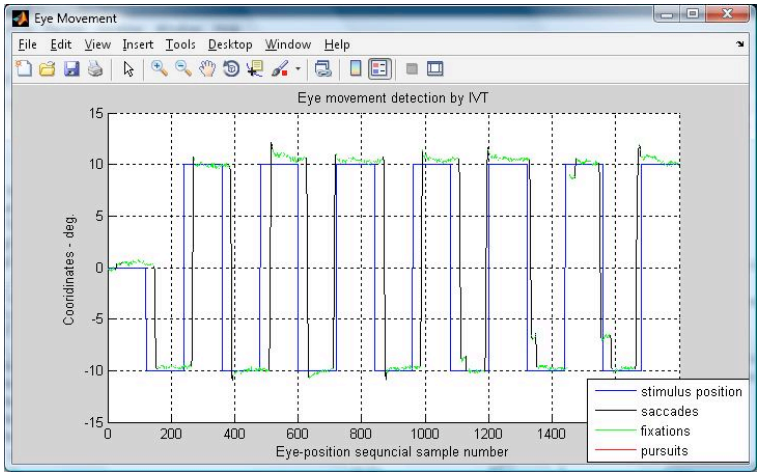
Microgravity will likely change the normal (1g) neural activity of the saccule.

There are no known studies on the effect of changing the g level on the VEMP response.



2. Effect of gravity upon saccades

A saccade is a fast movement of an eye, head, or other body part. Below are reflexive eye saccades



Memory Saccades

Making a movement to a target that is no longer visible –a so-called “memory” saccade is less well studied in microgravity, and may very well be influenced by g level, since g level effects the sense of orientation.

For this test, the subject must look back to the site of a previously shown target using memory of where that target had been. A sound cue then prompts the subject to shift gaze back to the site of the memorized target.

Target 1

Target 2

Memory Saccades

Memory saccades are thought to be sensitive to mild brain disorders, including mild traumatic brain injury (TBI) that could have an effect on cognitive function.

Could be influenced by g level, since g level affects orientation.

Thus, it may be possible to see whether the exposure to microgravity on suborbital flight has an subtle effect on brain function.

Target 1

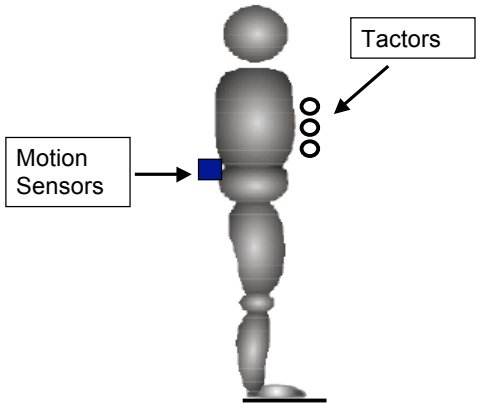
Target 2

3. Vibrotactile cues for spatial orientation

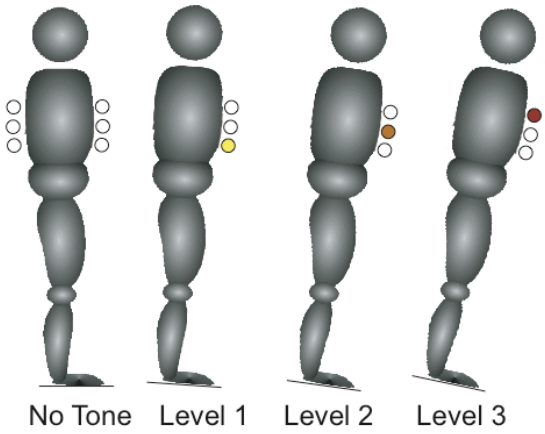
Vibrotactile Tilt Feedback (VTTF)

Sense body motion with gyroscopes and accelerometers.

Feed back body tilt to the patient using an array of noninvasive, vibrating elements (Tactors) that circle the trunk.

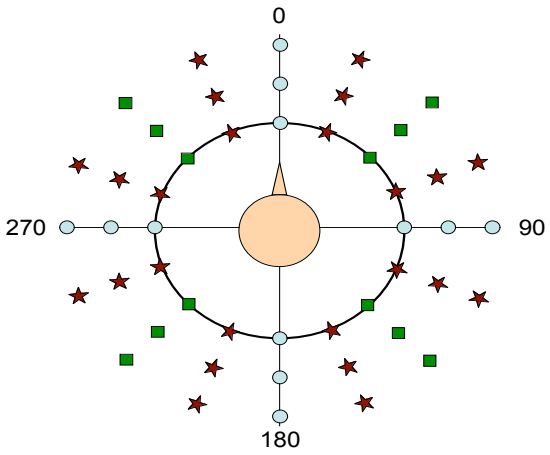


Magnitude is Coded by Signal Position
Signal Quality Remains Unchanged



Direction is coded by which column is activated

- No tactors
- 4 columns
  - Every 90°
    - Standard firing scheme
    - Independent scheme
- 8 columns
  - Every 45°
- 16 columns
  - Every 22.5°



The Vibrotactile Device builds upon TSAS

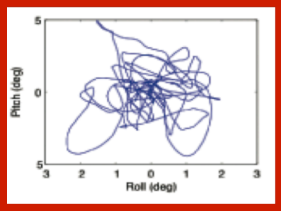
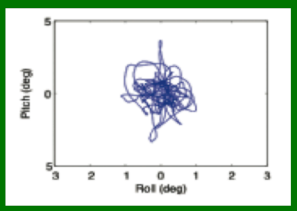
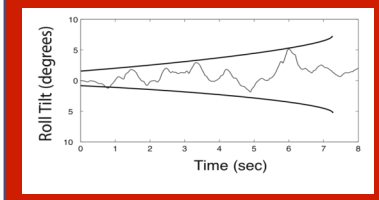
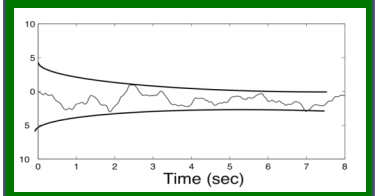
Angus Rupert @ the Naval Aerospace Medical Research Laboratory (NAMRL) developed a vibrotactile vest called TSAS to improve Tactical Situational Awareness for Navy pilots. It was an array of tactile vibrators (tactors) that surrounded the upper body, and indicated the direction of "down" by activating the tactor whose direction most closely corresponded to "down" as measured the the aircraft's navigation system.

Some Clinical Results -

Reduced wavering when standing

Reduced tilting when walking

Risk of falling

VTTF Off	*VTTF On*
	
	
80%	*20%*

Vibrotactile cues for spatial orientation

Possible Suborbital Experiments:

- Can VTTF provide an artificial horizon?
- Can VTTF be used as a navigation aid?
- Can VTTF be used to counter illusions like the inversion illusion?

Conclusions.

- Three clinically-oriented approaches that might benefit from suborbital flight investigations have been presented.
- All of them have been well studied in 1 g. but not in altered g.
- All of them can be investigated in the time frame of suborbital flights.
- All of them need only compact experimental set-ups.

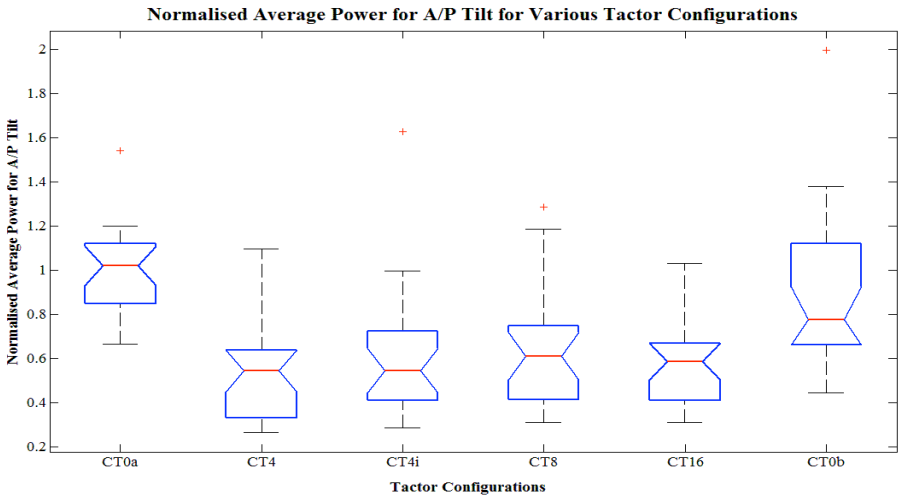
Acknowledgements.

Mark Shelhamer for helpful discussions & guidance

Steve Rauch for slide material and discussion on VEMPs

NIH NINCDS for research support on vibrotactile feedback

Thank you


Normalised Average Power for A/P Tilt for Various Tactor Configurations
Normalised Average Power for A/P Tilt
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
CT0a
CT4
CT4i
CT8
CT16
CT0b
Tactor Configurations

Memory Saccades

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