Introduction-

Suborbital flight 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”

Seismic Mass

Spontaneous activity is modulated by motion

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 sternocleidomastoid 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 a subtle effect on brain function.

Target 1

Target 2

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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°

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 aircraft’s navigation system.

*The Vibrotactile Device builds upon TSAS*
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.

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Thank you
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Target 1  

Target 2  

○  ○