

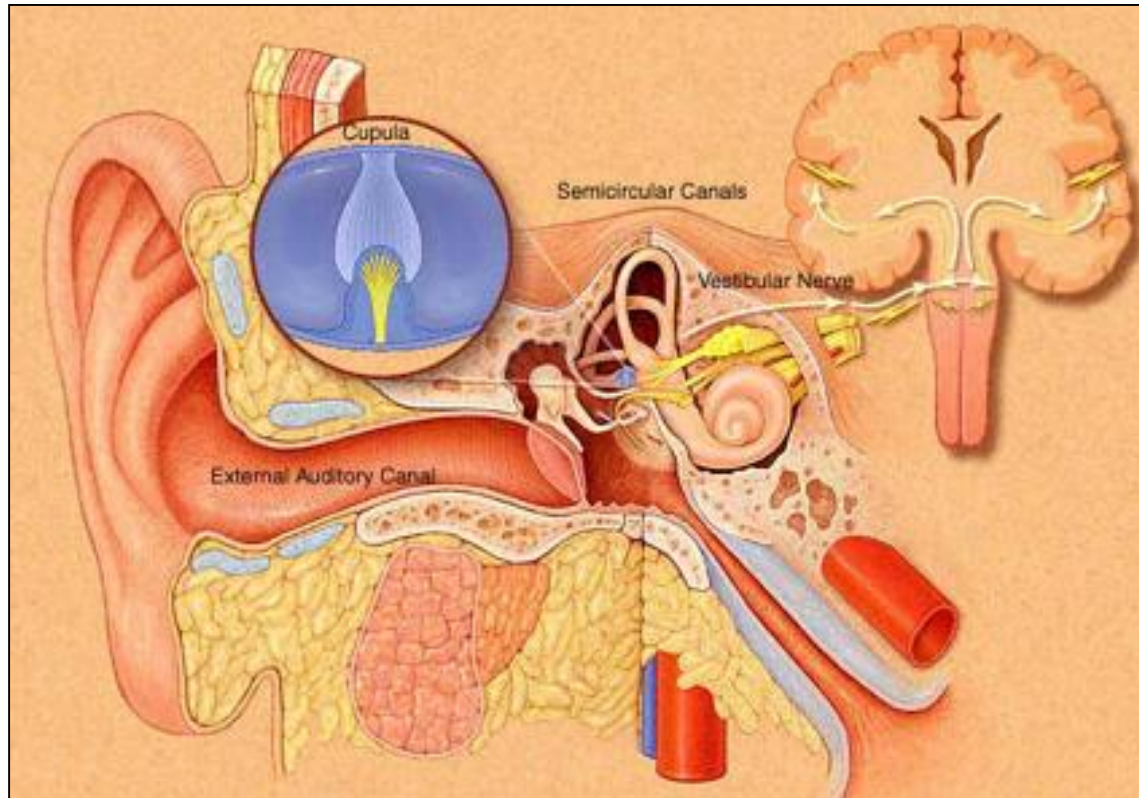
# Bringing Balance To The Brain

*Dr. David Wilkinson*



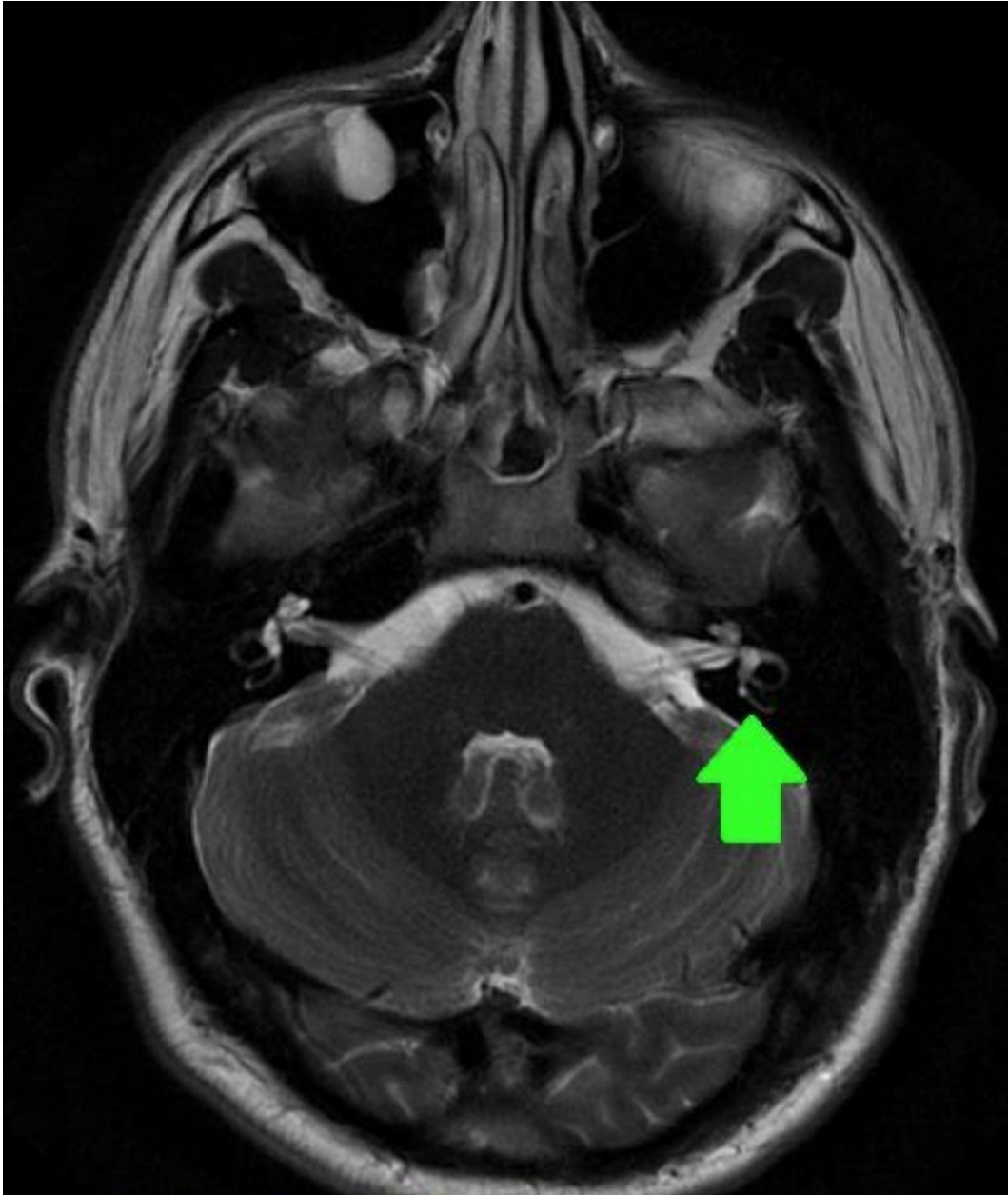
# The Balance Organs of the Inner Ear

➤ The inner ear contains the vestibular (aka balance) system which is made up of two receptor organs; the semi-circular canals and otoliths.



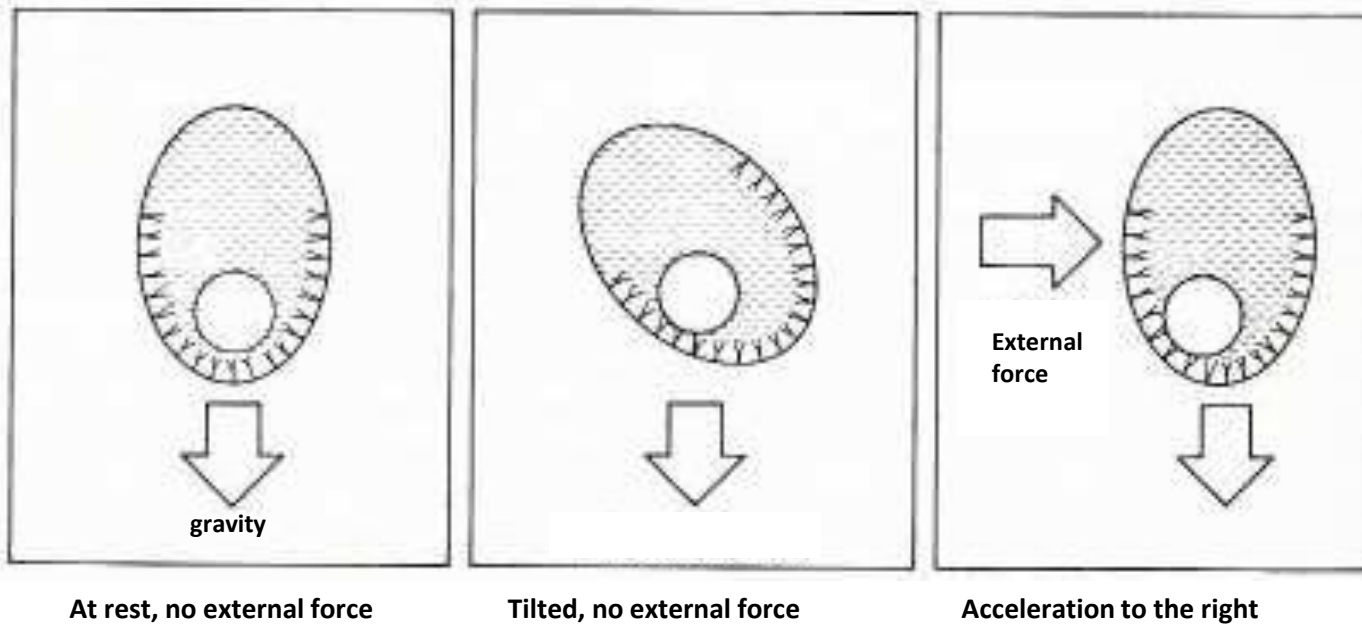
- These organs detect the position and movement of the head
- This information is needed to help keep us upright

# Gross Anatomy



- In land mammals, the development of a closed labyrinth located deep within the cranium still requires explanation.

# The Early Vestibular Sense



The development of fluid filled sacs and canals from a single chamber coincides with the emergence of aquatic vertebrates such as the lamprey



## Otolith Organs

The otolith organs have two functions:

1. The otoliths sense the head's linear acceleration (motion in a straight line).

They sense how quickly you are accelerating forward or backward, left or right, or up or down.

linear accelerations



2. They are also able to sense the head's position relative to gravity. These are the organs that tell us whether we are upside down or right side up.



## Semicircular Canals

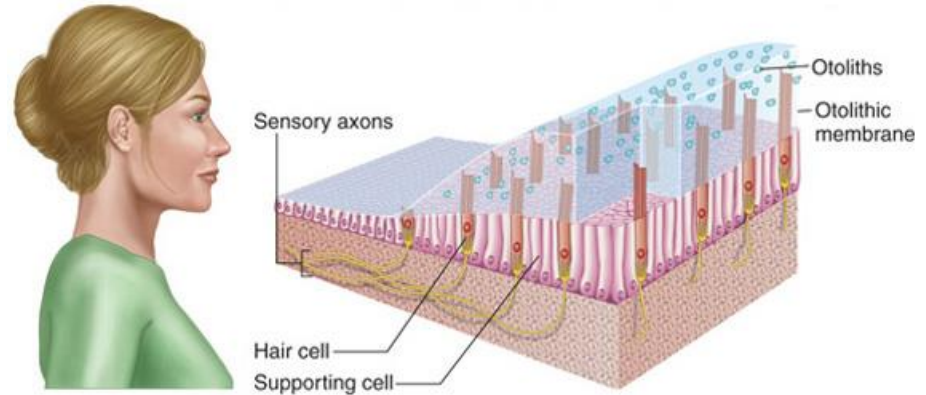
The canals detect the head's rotation (turning motion).

angular motion

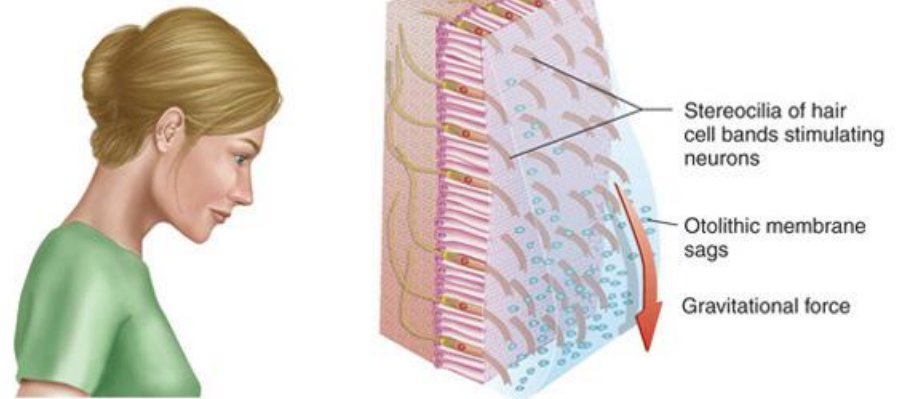


# Otolith Organs: Utricle and Sacculle

- Utricle sensitive to horizontal acceleration
  - Hairs pushed backward during forward acceleration
- Sacculle sensitive to vertical acceleration
  - Hairs pushed upward when person descends



(a) Head upright

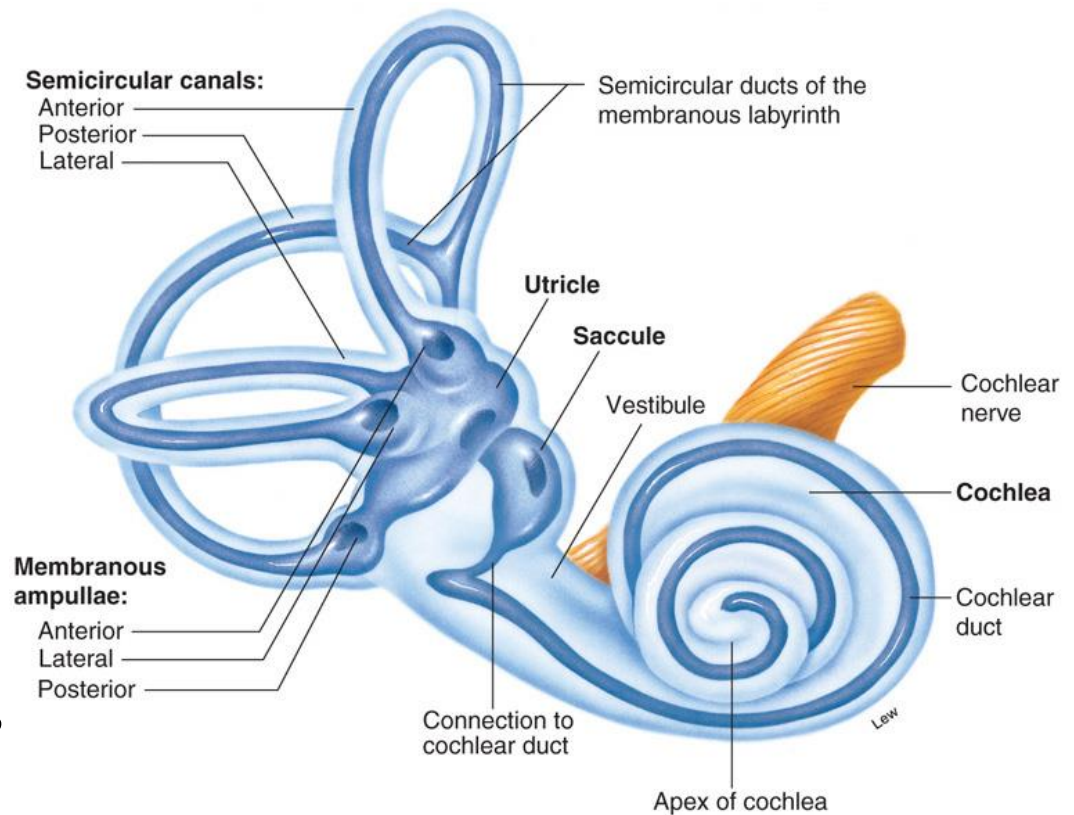


(b) Head bent forward

- In aquatic, semi-aquatic and terrestrial mammals, the size, shape and location of the vestibular organs differ, but in all species the presence of a gelatinous substance overlying a sensory epithelium is ubiquitous.

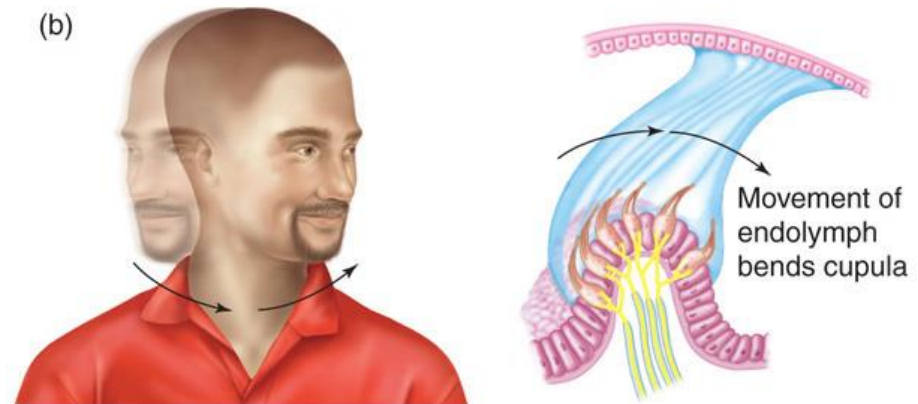
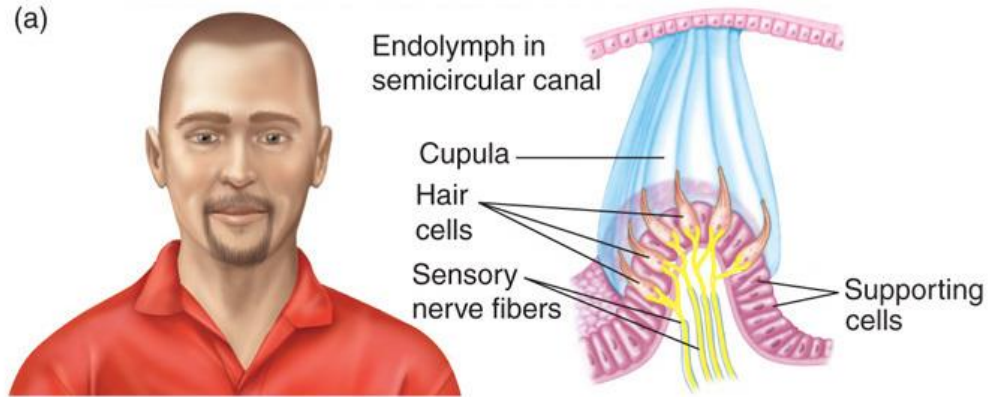
# Semicircular Canals

- Provide information about rotational acceleration
- Project in 3 different planes
- Each contains a semicircular duct
- Crista ampullaris – where sensory hair cells are located



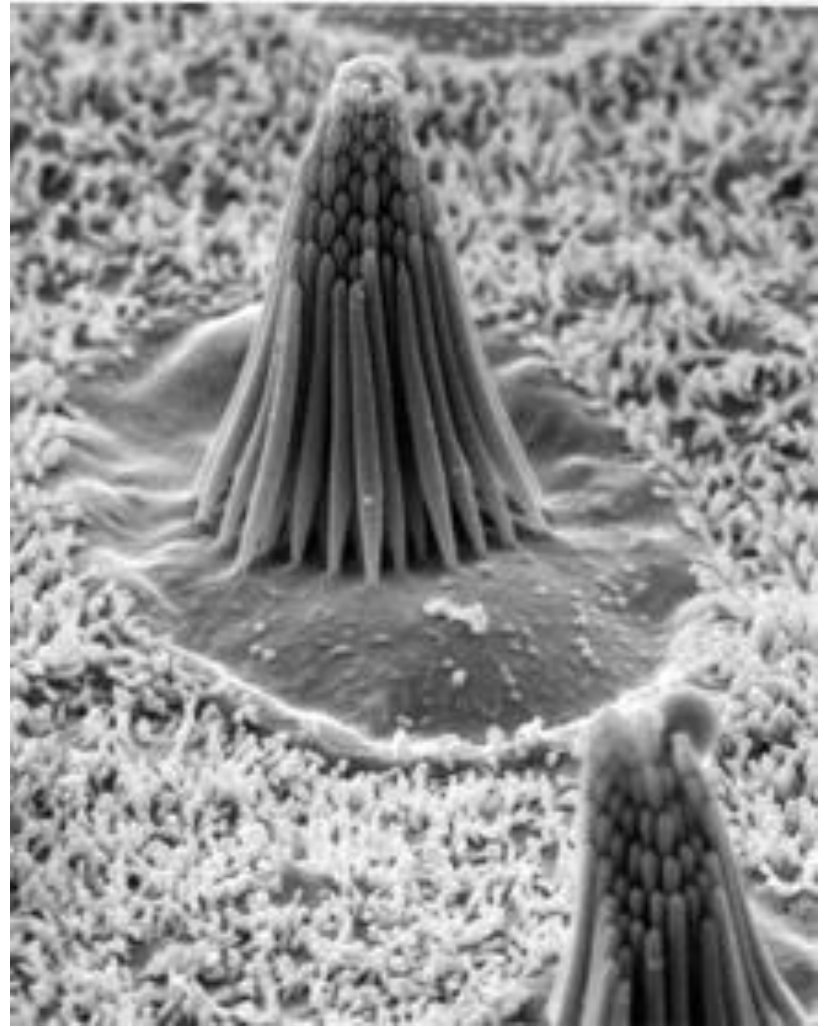
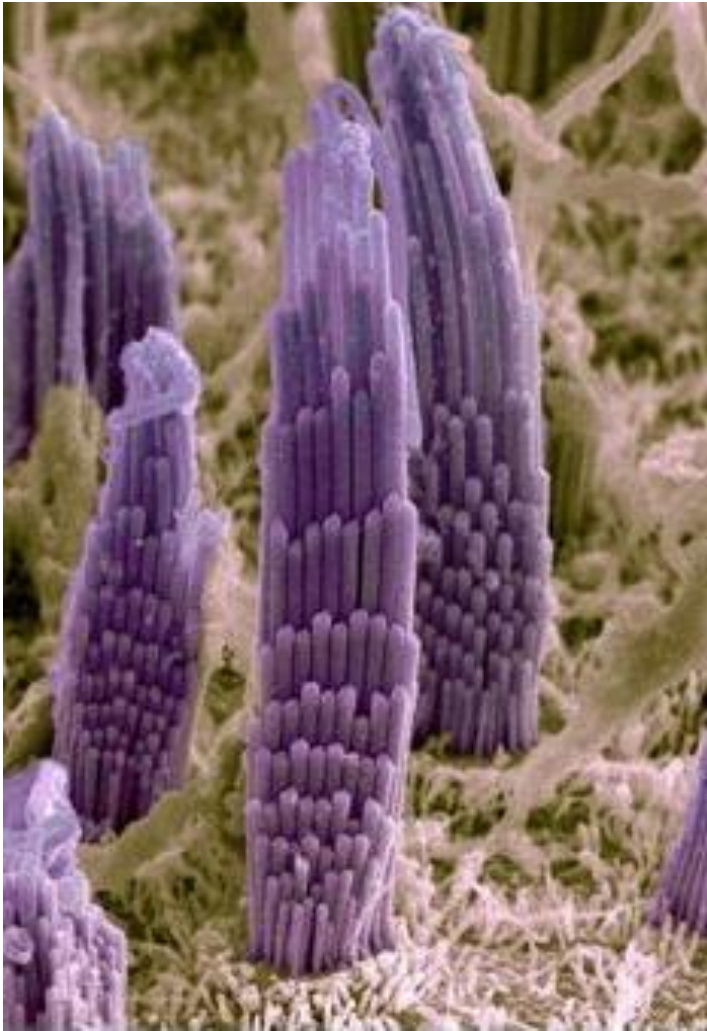
# Semicircular Canals

- Hair cell processes embedded in **cupula** of crista ampullaris
- When endolymph moves, cupula moves
  - Sensory processes bend in opposite direction of angular acceleration





# Mammalian Vestibular Hair Cells



# Our Vestibular Systems Do More Than Just Balance

Diseases of the vestibular organs not only affect our balance, but also decision-making, remembering and mood.

*•Over 80% of patients with vestibular disease report spatial memory loss in the absence of more general intellectual deterioration*

*Other common complaints involve:*

- Depression and fatigue*
- Depersonalisation*
- Difficulty concentrating*
- Difficulty with mental arithmetic*

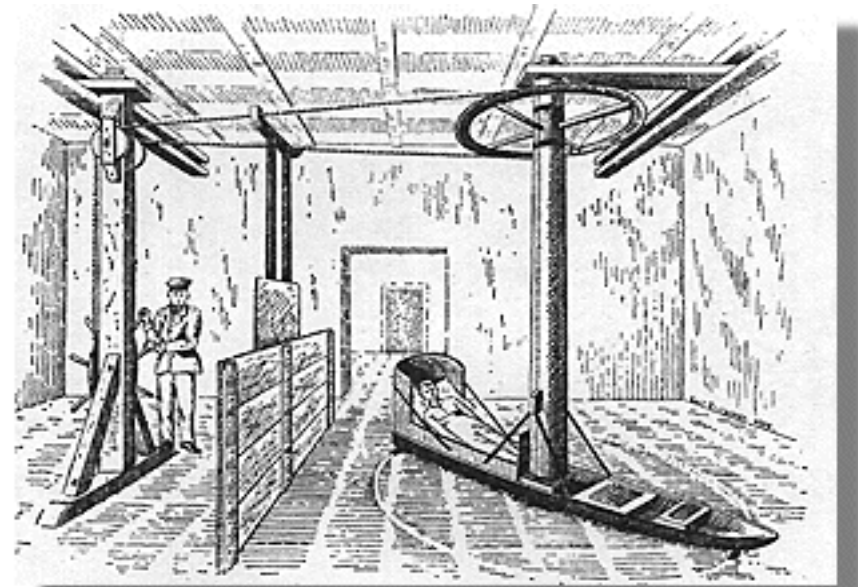
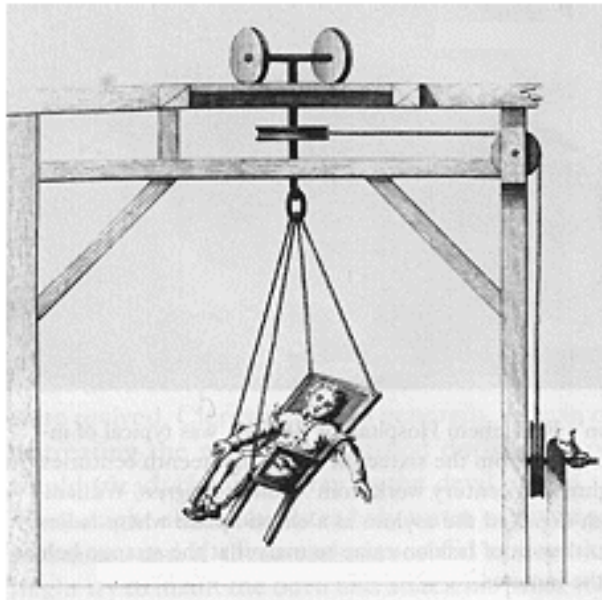
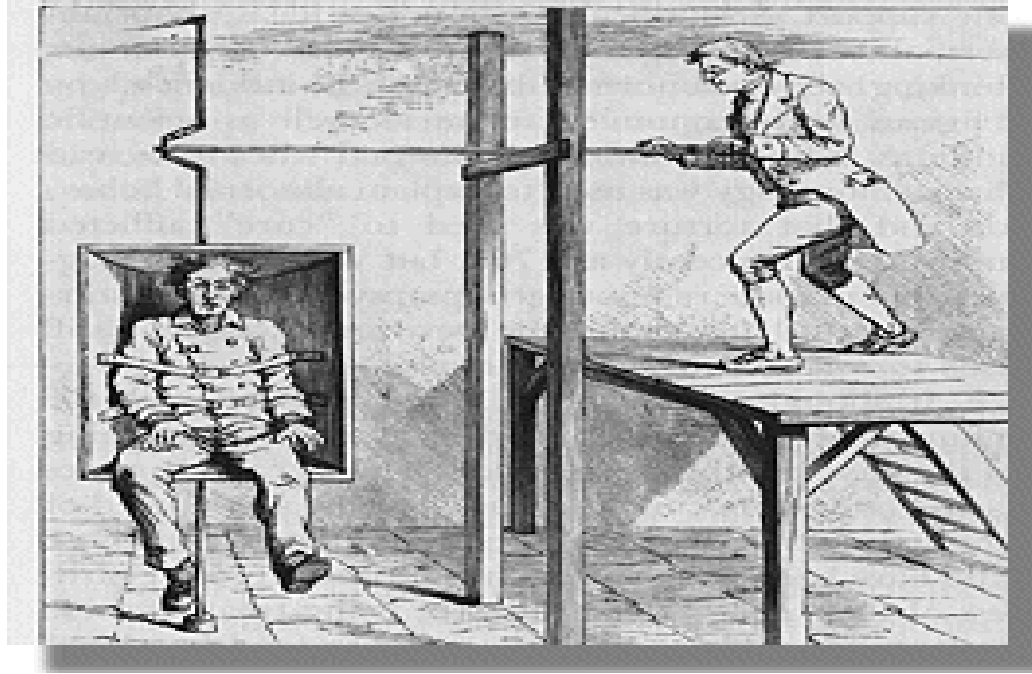
*•Astronauts report memory problems in zero-gravity*

**The vestibular system may play an important role in cognition & emotion because it senses sudden positional changes that require a 'flight or fight' response**



**If under-activation of the vestibular system impairs mental function, then could over-activation improve it?**

# Early Methods of Stimulation



# Galvanic Vestibular Stimulation: Early Attempts



**Alessandro Volta  
(1745-1827)**

“In 1790, in between putting the electrodes of his newly invented battery in his ears and his subsequent collapse, Volta briefly experienced the sensations of an explosion inside his head, spinning, and the sound of boiling tenacious matter. The spinning was likely the manifestation of vestibular stimulation and the boiling either auditory stimulation or the sound of flesh boiling. The explosion needs no further explanation: a pile of 30–40 Zn/Ag elements generates 30V”,

(Fitzpatrick and Day, 2004, p.2301)

# Modern Methods of Stimulation

## Galvanic Vestibular Stimulation (GVS)



- Small amplitude current delivered to mastoids via skin electrodes.
- Positive currents inhibit activity, negative currents excite activity.
- Minimal side-effects at low current (<2mA).
- Cheap and easy to administer

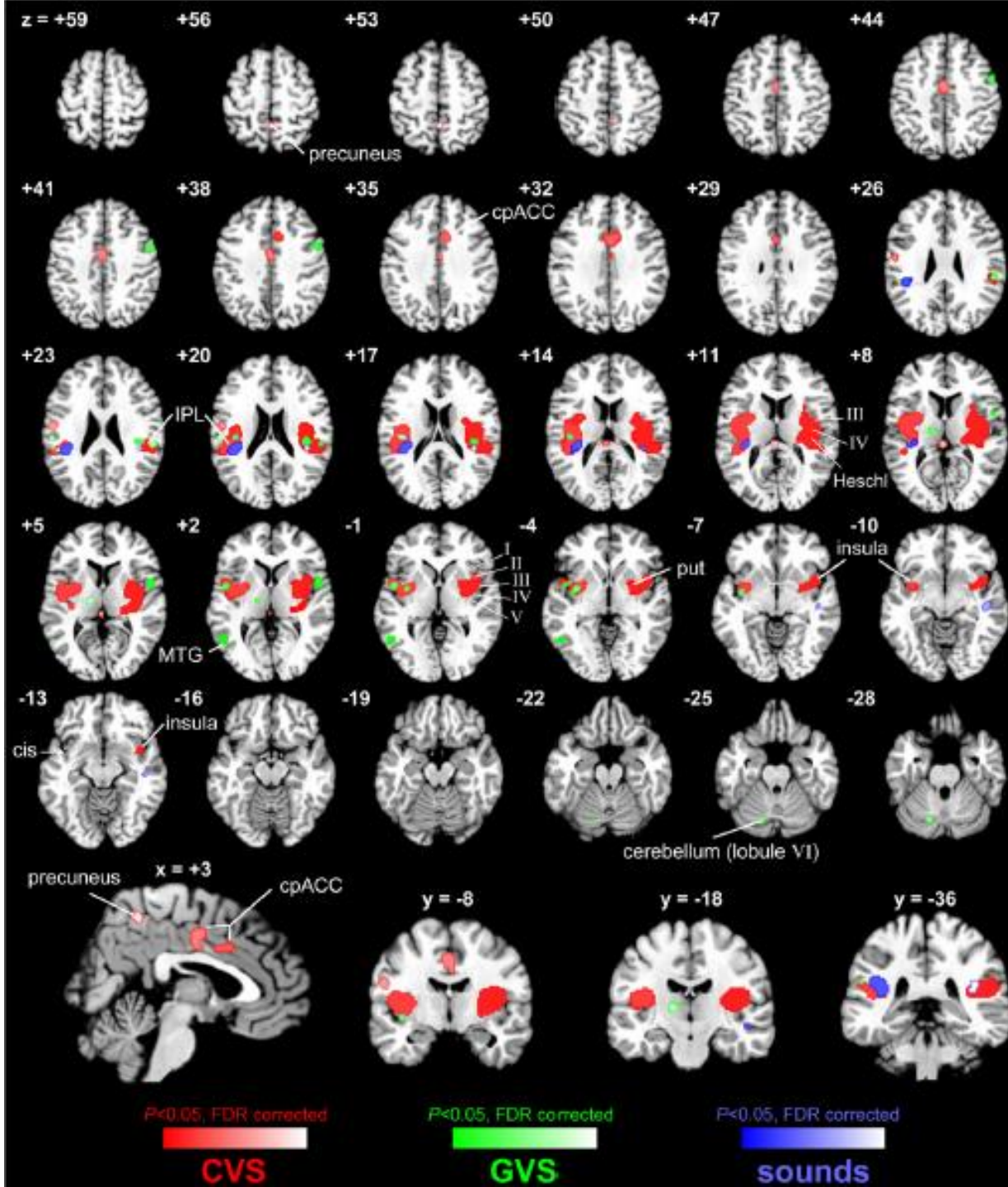
# Modern Methods of Stimulation

## Caloric Vestibular Stimulation (CVS)



- Mild thermal current delivered to the external ear canal
- Temperatures +/- 37°C change the density of fluid within the inner ear which in turn modulates the firing rates of the vestibular hair cells
- Cold temperatures excite neuronal activity, warm temperatures inhibit it.
- Minimal side effects >15°C
- Cheap and easy to administer

# Artificial vestibular stimulation increases blood flow within the brain





# Current Research Focus



Parkinson's  
Disease



Moderate-  
severe  
traumatic  
brain injury



Stroke



Migraine



Mental health of  
people with inner  
ear problems



Balance function in  
military veterans  
with mild brain  
injury



Measuring the  
brain's electrical  
response to  
vestibular  
stimulation

# Media Coverage

Meridian Regional News  
**itv Meridian Tonight**

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## New Stroke Technique

6.20PM Mon May 9 2011

Electric currents could improve recovery rates

A new medical technique being used on stroke patients could lead to improved recovery rates. It will help people who are unable to move to the left, which means they are often impaired.

hospital news



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Tom Savvides reports

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**HEALTH ADVANCES**

# Pioneering work leads to trial of new treatment

by Sian Napier

from an debilitating condition can shave just one side of their face or eat the food on only one side of their plate, whereas others with less pronounced symptoms may simply regularly "lose" things that they have put down on their left-hand side.

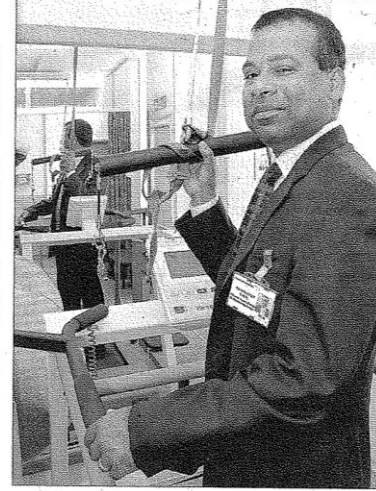
Dr Mohamed Sakel, director of neuro-rehabilitation and research at the hospitals trust, said: "This condition can be enormously debilitating. It is a very strange thing. Sufferers do not have a problem with their vision - it is simply that their brain will not perceive that there is anything on the left-hand side. Many people find it impossible to live a normal life. Just walking across a room is difficult as they will walk into furniture or people."

However, a treatment may be on the horizon as Dr Sakel, his colleague Dr David Wilkinson and other members of the trust have discovered a new technique.

The team will carry out a randomised controlled trial, which will last for 12 months.

recovery from the condition. The Medical Research Council grant - the first of its kind for the East Kent Hospitals Trust - will allow the team to carry out a randomised controlled trial, which will last for 12 months.

Medical experts have been trying to find an answer to



PIONEERING TREATMENT: Dr Mohamed Sakel with the equipment used to treat hemi-spatial neglect. Picture: Barry...

# MailOnline

## Help at last for stroke victims who are left with only half a life

By Rachel Ellis  
Last updated at 3:52 AM on 23rd August 2011

Like 31

Doctors discovered an innovative new treatment that could transform the lives of thousands of stroke patients who 'forget' their left side.

The condition, known as hemi-spatial neglect, affects a quarter of the 150,000 patients who suffer a stroke in Britain every year.

It can also occur in people with a brain tumour or injury to the right side of their brain - as it is this side that controls the left side of the body.

University of Kent Research  
Research collaboration aims to help stroke sufferers

How team worked to find new solution

Dr Sakel said many more people are surviving stroke catastrophic head injuries, but about 100,000 people in the UK have been left with some form of hemi-spatial neglect.

Dr Sakel said: "We have had to advise sufferers not to go out because they can walk into traffic, lampposts and other people. But this is not a solution. We have also told people to try to remember to keep turning to the left to see things but again, this is not an ideal way for them to live their lives."

Medical experts have been trying to find an answer to



Dr David Wilkinson

recovery from the condition. The Medical Research Council grant - the first of its kind for the East Kent Hospitals Trust - will allow the team to carry out a randomised controlled trial, which will last for 12 months.

# Patient Testimonials

My husband has a tutor to help him learn how to use his computer. Previously, he could only see as far across as G on the keyboard. His tutor noticed that since taking part in the trial, no keys have been missed.

Emma, it's a miracle, my awareness to the left has improved vastly. I no longer bump into things all the time around the home. I can read and I am now able to walk down Canterbury high street alone. In the past I had to take my husband with me as I could not see the low bollards.

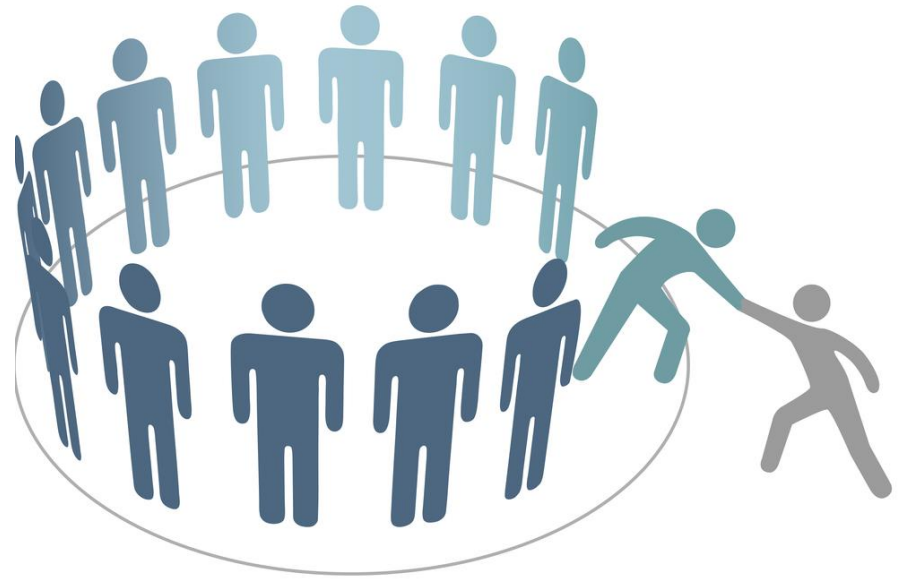
I have stopped leaving dinner on my plate at meal times and have started to dress myself.

I have definitely noticed positive effects, following testing. Most noticeable is an improvement of my spatial awareness in confined spaces. A measure of this is the ability to put on my socks and trousers whilst standing, which I had to sit down to do before the trial.

Since taking part in the study my husband has become far more confident walking. He will now walk with his personal assistant, previously he only felt safe with me there. Additionally, he took part in a sponsored walk for the stroke association and walked 300 yards with his stick and then about 50 yards to the bar!

## Volunteers Needed!

Help our research by getting a relative or friend with Parkinson's Disease or migraine involved.



Contact Dr. David Wilkinson: [dtw@kent.ac.uk](mailto:dtw@kent.ac.uk)