Vestibular System – Galvanic stimulation of mastoid process

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Objectives:

- Explain how the vestibular system receives input from vision and vestibular sensors in the inner ear to maintain one's sense of balance
- Describe otoliths and semicircular canals and how they provide vestibular feedback
- Demonstrate disruption of the vestibular system using the mastoid stimulator

Materials and Supplies Needed:

Item	Quantity	Notes (Vendor, price, purpose, etc.)
Jars	2	One for the otolith and one for the semicircular canal
Corn syrup	1 jar	For the otolith
Chunk of Styrofoam	Varies	For the otolith – anything that can float on the corn syrup will do
Glitter	2 tbsp	For the semicircular canal
Mastoid stimulation boxes	2	See blueprints on how to make your own. Project box and electronics parts available at Radio Shack/Digikey. ~$40
9-volt batteries	4	2 per unit, best to have spares
Cables with snap ends	4	Can be switched out depending on electrode type? But MUST have banana-plug endings to interface with the stimulator.
Sticky electrodes	Lots	2.2 x 2.2cm; Kendall Soft-E, Mansfield, Massachusetts. The stickiness
Screwdriver	1	Keep on-site in case batteries need to be changed.
Alcohol wipes	Lots	To scrub behind the ear of participants. Decreases impedance for stimulation, also preserves the life of the electrodes.
Waivers	At least 300	All participants must sign a waiver beforehand for legal reasons.

Background Information / Activity Explanation:

The vestibular system involves the parts of the brain that are responsible for maintaining our sense of balance, keeping us upright and preventing us from falling over. The vestibular system receives inputs from both the visual system, so we know where we are in space, and from special parts of the inner ear that can detect mechanically where we are relative to the ground.

Otolith/Semicircular Canal demonstration:

The semicircular canals are located in the inner ear and consist of three fluid-filled tubes, each tube going in a different direction (or axis) representing our acceleration in space. Whenever we move, the

fluid within the tubes moves and tells us how fast we are going in space. When we twirl around in circles, the reason we get dizzy is because the fluid in the tubes continues to move even though we physically are not moving. This sends confusing messages to the brain, resulting in a sense of disorientation. (To illustrate this, swirl the glitter-water in the jar for a few seconds and then stop. Point out that although the jar is not moving, the fluid inside is still swirling.)

Otolith organs are another apparatus in the inner ear that are responsible for coding the position of our heads relative to the ground. The receptors for the otoliths are located in a gelatinous membrane (represented by the corn starch) which is topped with heavy mineral deposits (represented by the Styrofoam). The mineral deposits produce weight, so that when the head is tilted, the rocks tilt forward and pull the membrane with it. The pulling of the membrane stimulates the receptors inside, sending messages to the brain that the body is not vertical. The brain can then send messages to the rest of the body to right itself.

We have two otoliths and two semicircular canals, one in each ear. Both of them are required to communicate with one another to preserve our sense of balance. If we disrupt one side while facilitating the other, what do you think will happen?

Procedures:

Semicircular canals: To make the semicircular canal demo, take one jar and fill partway with water – enough for the water to visibly swirl inside the jar. Add the glitter. Seal tightly.

Otoliths: To make the otolith: Take the other jar and fill partway with corn syrup. Put the Styrofoam pieces on top so the pieces are floating on top of the syrup. Seal tightly. Always keep this jar upright; do not keep on its side. The Styrofoam is supposed to stay on top at all times.

Refer to background to learn how to use these.

Mastoid Stimulator:

THIS IS A PARENTS-ONLY ACTIVITY. Electrical stimulation is involved. Participants must be over 18 and must sign a copy of the waiver (children, while they cannot participate, can flip the switch on the stimulator).

After the waiver is signed, participants will be asked to take an alcohol wipe and scrub at the bony prominence behind the ears. This is called the Mastoid Process (refer to picture below).

Make sure the stimulator is set to Off. Polarity can be set in either position.

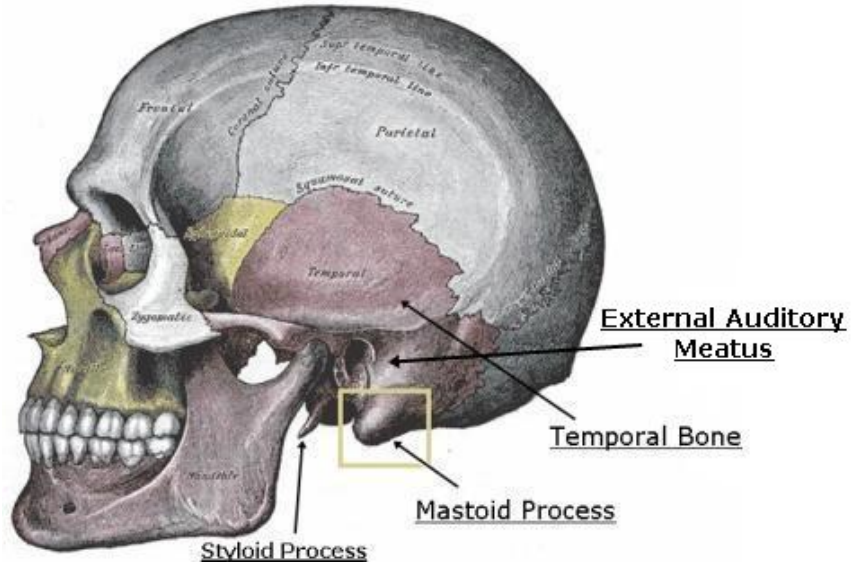
Affix each sticky electrode to the Mastoid Process. If the electrode is not sticking well, the participant can hold the electrodes in place with their fingers. **Have the participant stand with feet together and with their eyes closed (if their eyes are open, visual feedback will override any disruption the stimulator will make).**

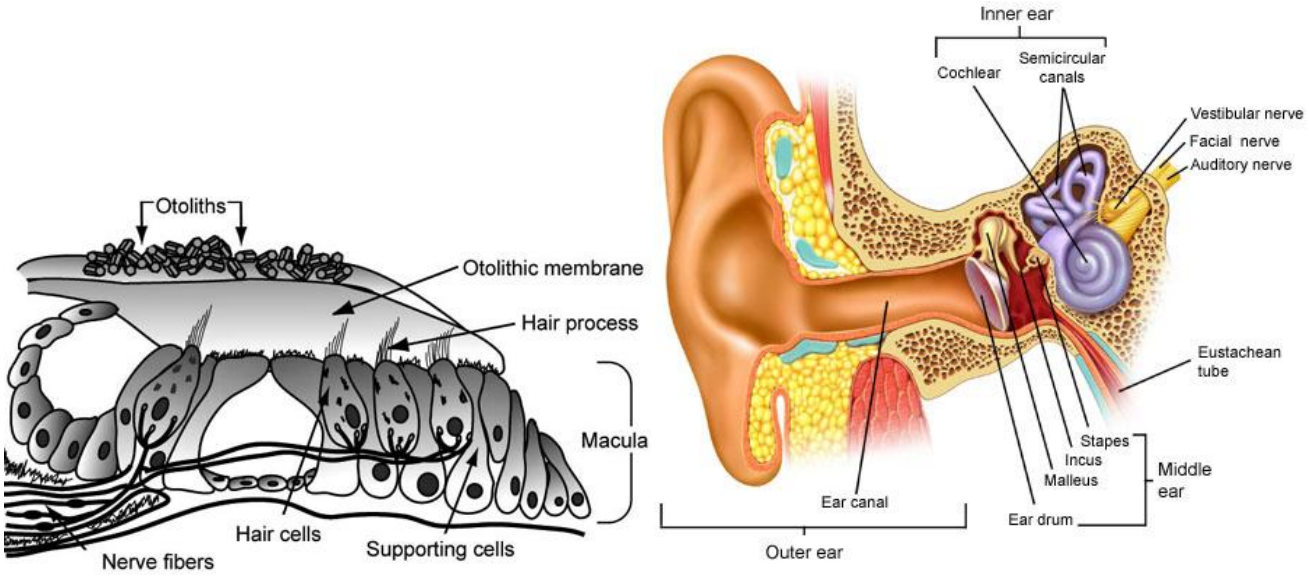
Flip the ON switch. The participant may feel faint pins and needles underneath the electrodes. Based on the polarity indicated on the box, the participant may start tilting one way or the other. It's a very gentle stimulation so they won't fall very hard, just stumble. If you turn the polarity the other way, the participant should tilt the other way.

Additional Information (advice, spiel, links, figures, etc.)

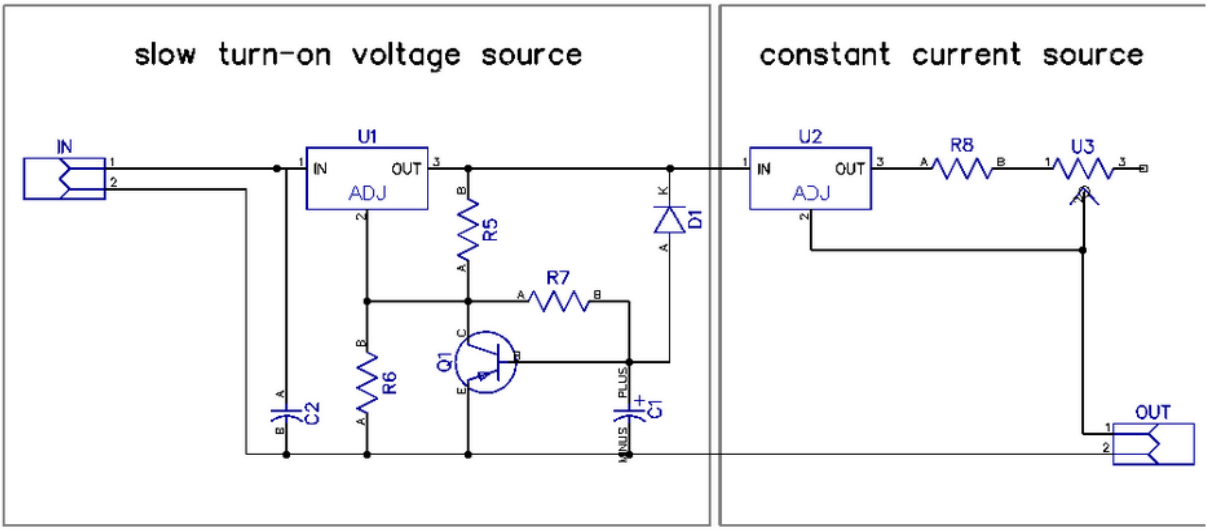
The mastoid process is the bony part that sticks out just behind the ear. The electrode should go right on the tip of the process. Depending on placement, some participants may only tilt with one polarity and not the other. This is okay.

DO NOT switch polarity while the stimulator is ON and connected to someone. If someone is being stimulated and you switch polarity, this sends a jolt of electricity through the electrodes which may be unpleasant. Always turn the stimulator OFF before switching polarity and then turn the stimulator ON again.





Mastoid Stimulator Circuit



C1 = 22 uF (electrolytic)
C2 = 0.1 uF (does not need to be electrolytic)
D1 = 1N4002 diode
R5 = 240 ohm R7 = 50k
R6 = 2.7k R8 = 1.5k
Q1 = 2N2905 transistor (I used TO-92 package)
U1/U2 = LM317 voltage regulators (pinout corresponds to TO-92 pkg)
U3 = 2k pot, set around 1k

Notes on assembling the mastoid stimulator:

The schematic is shown split into two parts just for visual organization. The important part is the constant current source - the slow-turn on voltage regulator simply gives you less of a zap when you turn it on though it still gives a bit of a prick when you change the polarity using the double pole/double throw switch (which is between the output of this circuit and the electrodes). For this reason, turn off the stimulator before switching polarities.

Both parts of this circuit came from the datasheet for the LM317.

The pot (U3 in the circuit) should be set so the output of the whole circuit is 1mA. You can test this by adjusting the pot until there is 1V across a 1k resistor that goes between output and ground.

Power source is two 9V batteries in series.

LIABILITY WAIVER FOR THE MASTOID PROCESS STIMULATION ACTIVITY AT

THE BRAIN FAIR, NETTELHORST SCHOOL, MARCH 16, 2013

In the Mastoid Process Stimulation activity, an electrical device is used to induce a small electrical current (1mA) in the vicinity of the subject's mastoid bone. This current stimulates the nearby vestibular organs, causing the subject's body to respond as if it were leaning to the side. The electrical stimulation is produced by two 9V batteries in series and may, in some subjects, produce a very slight tingling sensation around the stimulation site or dizziness that resolves immediately after cessation of stimulation.

As a participant in the Mastoid Process Stimulation activity, March 16, 2013, I recognize and acknowledge that there are certain risks of physical injury and I agree to assume the full risk of any injuries, damages, or loss that I may sustain. I also reserve the right to terminate my participation in the Mastoid Process Stimulation activity at any time.

I do hereby fully release and discharge Northwestern University and The Nettelhorst School, as well as these institution's officers, agents and employees from any and all claims from injuries, damages or loss that may accrue to me on account of my participation in the Mastoid Process Stimulation activity.

I further agree to indemnify, hold harmless and defend Northwestern University and The Nettelhorst School, as well as these institution's officers, agents and employees, from injuries, damages, and loss sustained by me and arising out of, connected with, or in any way associated with my participation in the Mastoid Process Stimulation activity.

I HAVE FULLY READ AND UNDERSTAND THE FOREGOING.

Signature _____

Name Printed: _____

Date _____