

## Amanda's Science Seminar Presentation

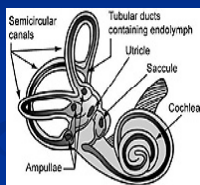
### The Effects of Vision, Proprioception and the Vestibular System on Balance

## Balance

- Bipedalism, the ability to stand upright, is one of the most important traits humans have.
- Balance is a key factor of bipedalism. Without it, we would not have the basic coordination to put one foot in front of the other and walk. Balance is considered to be a "sixth sense" controlled by a combination of three other senses: the vestibular system, vision and proprioception. Without these three senses, we would not have the ability to balance, and it would therefore be difficult to do almost anything else.

## The Vestibular System

- The vestibular system is the basis of our three-dimensional model of the world. It is the unifying system in our brain that coordinates information received from other systems. It enables us to recognize our static position, velocity, and acceleration .
- Located in the inner ear, it is composed of five organs: the utricle and saccule (otolith organs), and the three semi-circular canals.
- The otolith organs sense the head's linear acceleration and position relative to gravity
- The semicircular canals enable us to be aware of our three-dimensional dynamic position.



## Vision

- Vision plays a huge role in balance. Not only does vision give context to the movement the vestibular system detects, it constantly updates the nervous system about the position and movements of the body.
- If the eyes do not send accurate information to the brain (due to poor vision, binocular deficiencies, poor vestibulo-ocular reflex, etc), it is very difficult for the brain to get a precise picture of the outside world, and balance generally suffers from it.
- When an individual stands with his eyes closed, postural sway increases between 20% and 70%. It has also been found that moving visual fields can induce a powerful sense of self-motion and misleading visual cues induce significant increases in sway, causing dizziness and motion sickness.

## Proprioception

- Proprioception is the awareness of position and movement. Skin pressure, muscle and joint sensory receptors inform the brain what part of the body is touching the ground and what parts of the body are in motion. Proprioceptors are nerves in the skin, muscles, tendons and almost all parts of the body, which send signals to the vestibular system and the brain. The vestibulo-spinal reflex controls the movement of muscles so that we can actually maintain balance . Postural sway is an example of vestibulo-spinal reflexes.

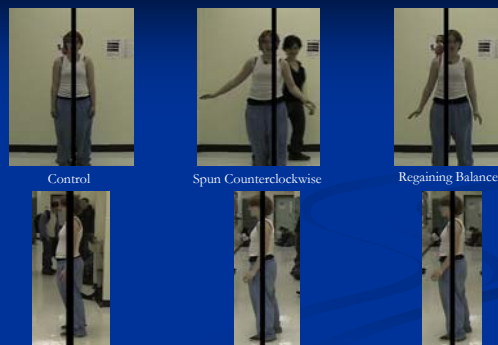
## Hypothesis

- My experiment will test the effects of interferences on the different senses that regulate balance: the vestibular system and vision, in particular.
- I predict that when the vestibular system is interfered with by being spun (causing the endolymph in the semicircular canals to rotate at a different velocity than the body), an individual's ability to balance will decrease.
- I predict that when vision is restricted by blindfolding, an individual's balance will decrease.
- I predict that the combination of being blindfolded and spun will have the largest effect on an individual's ability to balance

## Methods

- Two video cameras were set up, perpendicular to each other, 10 feet away from the subject
- The subject was asked to perform 5 tasks
  - control - to test basic postural sway
  - spun counterclockwise 10 times
  - spun clockwise 10 times
  - blindfolded and filmed standing still
  - spun counterclockwise and blindfolded
- The subject was filmed from anterior and lateral positions while being tested

## Left-Handed Female



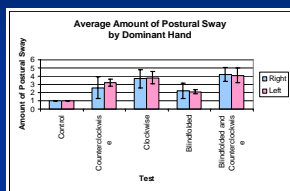
## Right-Handed Female



## Cumulative Averages of the Effects of Different Interferences of Balance

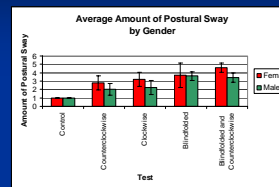
Subject	Gender	Dominant Hand	Control Average	Counter Clockwise Average	Clockwise Average	Blindfolded Average	Blindfolded and Counter Clockwise Average
1	Female	Right	1	2	4	1.5	5
3	Female	Right	1	5	5	3	5
5	Male	Right	1	2	2	1	3
7	Female	Right	1	2	3.5	2.5	4
9	Male	Right	1	2	4	3	4
2	Male	Left	1	3	3.5	2	3.5
4	Male	Left	1	3	3.5	2	3
6	Female	Left	1	3	5	2	5
8	Female	Left	1	4	4	2	5
10	Male	Left	1	3	3	2.5	4

## Results



When the subjects were blindfolded, there was, on average, less postural sway than when they were spun. When the subjects were blindfolded and spun counterclockwise, the amount of postural sway was greatest. There is no apparent relationship between the dominant hand and ability to balance.

## Results



In general, males had better balance than females. However, as my test group was fairly small (5 males and 5 females), it is difficult to draw any definitive conclusions from these results.

## Conclusions

- My tests showed that interferences on the senses that regulate balance significantly decrease an individual's ability to balance. My experiment focused primarily on the effects of the vestibular system and vision on balance, and my results show the importance of those two senses.
- When the subjects were spun – when the vestibular system was unable to accurately process their three-dimensional dynamic position – postural sway always increased.
- When the subjects were blindfolded – when the brain did not receive accurate (or any) information about their position in relationship to their physical environment – postural sway generally increased.
- Because interferences on the vestibular system always resulted in increased postural sway, the vestibular system probably plays a larger role in regulating balance than vision does.

## Conclusions

- When the subjects were both blindfolded and spun – when neither the vestibular system nor the eyes were sending accurate information to the brain – postural sway always increased. In four cases (40% of those tested), the subjects actually lost their balance completely; two of the subjects actually fell.
- This demonstrates how the vestibular system and vision work together to regulate balance; when one of the system's ability to process information is restricted, an individual's ability to balance suffers and postural sway always increases. However, when both systems were interfered with, the individual's balance suffered significantly

## Future Studies

- My experiment focused on the subjects losing their balance. In future studies, I would focus on the amount of time it takes to regain balance, rather than the degree to which balance was lost. I would also like to examine the effects of how many times the individual was spun on how long it takes to regain balance.
- My experiment also focused on stationary balance. What would happen if after being spun and/or blindfolded, the individual was then instructed to walk 10 feet in a straight line? Would he be able to? Would he even walk in the correct direction?
- Moving visual fields have been shown to increase motion sickness. What would happen if an individual who often suffered from carsickness was blindfolded when in the car?