The Heads Hairy Hula: An Interactive Way to Learn the Vestibular System

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5 April 2004

Abstract

This demonstration was constructed as part of Brain Awareness Week's Kids Judge Neuroscience Fair. Our presentation focused on the vestibular system. Specifically, we demonstrated the function of the semicircular canals and the hair cells contained inside. We constructed a semicircular canal out of clear vinyl tubing and fixed paint brush bristles as hair cells inside. The circular tube was filled with fluid and the children were asked to spin in circles with the tube around them. When the children stopped, they were able to see that the hairs in the tube were still bent, telling their brain that they were still moving. Using this demonstration, the children learned how dizziness occurs. We taught them that these canals are located deep within the ears. Using wooden sticks of similar size, a switch, Christmas lights and a shoestring, we demonstrated how deflection of the cells towards the kinocilium sends a message to the brain. The children were able to see the "impulse" via a set of Christmas lights that were illuminated as the switch was flipped. The lights were connected to a paper brain. In this demonstration, children were able to summarize the concepts that they learned. They asked questions and participated well in the demonstration. Most of the children remained engaged during the length of the presentation. The Head's Hairy Hula scored fourth in the ratings but did somewhat better on the evaluations.

Introduction

From the sound of a drum to the dizziness during a roller coaster ride, hair cells are a key player in both hearing and the appreciation of body movement. A hair cell lacks both axons and dendrites and is continuously bathed in endolymph. A bundle of hair cells perform a receptor function as a single unit. Each bundle contains approximately 20 to 300 stereocilia, or individual hair cells, arranged in a beveled fashion. A single kinocilium made of microtubules is located at the tallest portion (Hackney and Furness, 1995). The hair cell bundle functions by way of mechanically gating ion channels.

Each stereocilia in the hair bundle are connected by filamentous structures call tip links. These tip links are probably attached to the molecular gates of ion channels and act to convey tension to the transduction channels of the hair cells (Assad, Shepherd, and Corey, 1991). A positive stimulus, or displacement of the hair bundle toward the tall end of the beveled structure, stretches the tip link and opens transduction channels. A negative stimulus, or displacement away from the tall end, causes the channels to close.

We intend to demonstrate to fifth and sixth grade students the gating mechanism and how a mechanical stimulus is transduced. We will construct a model of the hair cell bundle showing the tip links. The hair cell model will be attached to a switch that activates a strand of Christmas lights. When students deflect the hair cells, the switch will be activated and the Christmas lights will illuminate, demonstrating transduction.

Hair cells exist in the six organs of the human internal ear. We intend to show how the human body perceives angular acceleration as another demonstration of the importance of hair cells. Angular acceleration is detected by the semicircular canals. In order to give students an understanding of the semicircular canals, we will have an illustration of the canals on a poster. At the ampulla, or wide region of the canals, a gelatinous sheet of material called the cupula stretches across. In the canals, the hair cells are contained within the cupula. When the head is rotated at a fast speed, the endolymph inside the semicircular canals lags behind. The result is a deflection of the hair cells in the cupula. The thickened membrane of the ampulla is called the ampullary crista and contains endings from the vestibular nerve. Hair bundles at different sites on the crista exhibit differences in amplitude and time course of deflection (Rusch and Thurm, 1989).

We will demonstrate the motion of the fluid in the semicircular canals and its affect on the hair cells. We will use a clear plastic tube filled with water. Hair cells made from paint brush bristles will be attached. Students will place the tube around their body and spin in circles until they are dizzy. When the motion is stopped, they will be able to clearly see that the fluid is still moving and the hair cells are still deflected.

In this demonstration, we will educate students on the mechanical gating of hair cells and show a direct result of the action of the hair cells and endolymph in the semicircular canals. Since the hair cells are an integral part of the inner ear organs, students will have a better understanding of how the inner ear functions in both vestibular and auditory responses.

Methods

The setup consisted of two major parts. The first part consisted of a tube constructed to demonstrate how the hair bundles bend with fluid in the semicircular canals. We used clear vinyl tubing that measured one and a half inches in diameter. A plastic plug with threads on both sides connected the two sides of the vinyl tubing. To represent the actual hairs, we used paintbrush bristles. The bristles were too coarse and would not bend at first so we peeled some of the wax layering off with our fingertips. A pair of scissors would also suffice for this purpose. Using a .5 millimeter drill bit, we drilled tiny holes into the vinyl tubing and fed the paint brush hairs through. We used small strips of duct tape to secure the hairs in place. To ensure that the apparatus did not leak when filled, we painted over the edges of the tape with fingernail polish and allowed two hours to dry. Once the tube was constructed and the nail polish dried, we filled it with water and drop of dish soap to prevent the clear vinyl tubing from fogging up. See figure 2 for a picture of the completed semicircular canal model.

The next demonstration was an oversized model of a hair cell bundle. We used three wooden sticks approximately one and a half inches wide and height varying between nine to twelve inches long. The sticks were screwed onto hinges at one end. They were arranged from tallest to shortest and fixed to a large wooden block using other end of the hinges. We drilled a hole at the opposite end of each stick and connected all the sticks with a shoestring, which demonstrated the concept of tip links.

Next, we placed a switch next to the shortest stick. We attached the shoestring to the switch in a manner that would flip the switch on when the sticks were bent in the direction of the largest stick. The switch was attached to a strand of white Christmas lights that ran to a paper model of the brain. We constructed the brain model out of newspaper and placed the lights on the model so that they went from the ear to the hindbrain. When the switch was