APPLIED SCIENCES WEBINAR SERIES

THE BIONIC EYE

POST WEBINAR HANDOUT 3 - PROFESSOR GREGG SUANING

Thank you for attending our Applied Sciences Webinar! Here's a quick recap of some of the highlights and some further reading you might be interested in.

BACKGROUND - NEUROMODULATION

Neuromodulation is the alteration of the activity of nerve cells through electricity.

At the synapse, nerve cells send signals to one another by releasing chemicals – this results in a relay of information.

Alessandro Volta, the inventor of the electric battery, discovered that electrical stimulation in the ear can create a perception of sound. He described the sensation as "jolt to the head followed by the sound of thick soup boiling."

BIONIC EYE

There are currently two targets for the bionic eye:

- Retinitis Pigmentosa is a rare genetic disorder in young people that results in the breakdown of photoreceptors in the retina. It often begins with the loss of peripheral vision.

- Age-related Macular Degeneration affects the macula, located in the centre of the retina. It results in the loss of central vision.

The diseases on the previous page leave behind an intact optic nerve, which makes implants targeting the nerve still viable.

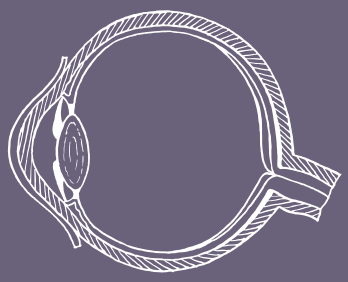
Other possible points for intervention include

- Optic nerve
- lateral geniculate nucleus (invasive)
- The visual cortex

RETINAL LAYERS

1. Nerve fibre layer - *axons of ganglion cells which leave retina in optic nerve*
2. Retinal ganglion cells- *end point of neuronal network*
3. Inner plexiform layer - *synapses bipolar cells to ganglion cells and amacrine cells*
4. Inner nuclear layer - *nuclei of bipolar, horizontal and amacrine cells*
5. Outer plexiform layer - *synapses photoreceptors to bipolar cells and horizontal cells*
6. Outer nuclear layer - *nuclei of photoreceptors*
7. Photoreceptor layer - *outer and inner segments of rods and cone*
8. Retinal pigment epithelium – *contain pigmented epithelial cells that absorbs light and supports retinal visual cells*

In the case of retinitis pigmentosa and macular degeneration, the photoreceptors die. However it is possible to start a signal by stimulating the bipolar and retinal ganglion cells.



The retinal prosthesis can be placed in the suprachoroidal area, placing it further away* from the retinal ganglion and bipolar cells.

This means that local reactions to the foreign device being placed does not damage the remaining nerve cells; a similar concept used in cochlear implants!

*Placed further away = need a slightly stronger signal to stimulate nerve cells

SUANING & TEAM'S IDEA (PHOENIX99)

- Small burst of electricity supplied by an implant placed behind the ear (inductor) - data is transmitting from here and will not need to be placed under the skin.
- These electrical bursts are sent to another implant placed behind the eye.
- The electrical impulses are then passed down to the V1 area of the brain.

WHERE ARE WE NOW?

The bionic eye was initially implanted in human cadavers, then in sheep.

A heat-map of cortical activation can be used to show that the sheep were getting visual information from the bionic eye, allowing us to test that it is actually working.

Currently, the implant is in the testing phase:

- Ethics approval - a lot of testing is required before they can safely insert the implant (so people aren't negatively affected)
- Patients with even a little bit of function are excluded from experimental trials to not risk making their condition worse

Some Further Reading

Suaning, G., Lovell, N., & Lehmann, T. (2014). Neuromodulation of the retina from the suprachoroidal space: The Phoenix 99 implant. 2014 IEEE Biomedical Circuits And Systems Conference (Biocas) Proceedings. doi: 10.1109/biocas.2014.6981711

Suaning, G., Lovell, N., Schindhelm, K., & Coroneo, M. (1998). The bionic eye (electronic visual prosthesis): A review. Australian and New Zealand Journal of Ophthalmology, 26(3), 195-202. doi: 10.1111/j.1442-9071.1998.tb01310.x