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Review Article

Forensic optometry: A new era called bionic eye

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ABSTRACT

The discipline of visual bionics has seen tremendous advancements during the past ten years. The article provides a full and pertinent account of the work made thus far. The study identifies and analyses the main traits and limitations of the patient studies that have been attempted internationally.

Perhaps the biggest hope in the realm of sensory is to give blind people their sight physiology back. There has been and still is significant scepticism among the vision community over the viability of a comparable & Bionic approach to vision.

An artificial retina is created to restore photoreceptor function that has been impaired due to retinal degeneration. The artificial eye catches light and transforms it into a digital signal using devices like surveillance footage, desktops and laptops and electrodes. The cerebral cortex receives this electrical signal, which generates a fresh simulation of vision. This is distinct from implanted lenses or low-vision equipment, which aim to improve a person's current eyesight.

The present initiatives seek to supply enough electricity to operate several electrodes safely. New material development and manufacturing techniques will be essential in overcoming these obstacles. This requirement emphasises how interdisciplinary researches and studies are important for human vision; For instance, product researchers are equally crucial as electrical professionals, BTech Bio Tech Professionals and vision specialists in the development for the Bionic or artificial eye.

1. Introduction

Light stimulation takes place and the experience of vision is produced by the retina, a layer of tissue containing nerves that covers the inner surface of the rear part share a majority of the globe of the eye. Because it was created from neural tissue during embryonic development and is linked to the Cerebral Cortex via the nerve that supplies vision, the photosensitive layer of retina is truly a growth of the brain.[1]

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The two different types of photoreceptor cells—Photoreceptors— separated from one another both physically and both operationally through their different responses to illumination. Light-sensitive photoreceptor cells may be found in one of the layers of the retina, a transparent tissue that is finely stratified. The two types of photoreceptor cells—rods and cones—are distinguished physically by their distinctive shapes and functionally by their receptiveness to different wavelengths of light.

For light to reach the photoreceptor cells, it must travel through the overlapping layers. The majority of rods are found in nocturnal species, which are particularly sensitive

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to low light levels. In humans, rods assists in orientation in the dark. Cones provide detailed vision (such for reading) and colour perception and are more prevalent in people and animals who are active throughout the day. In general, the ability to distinguish fine detail increases with the number of cones per unit area of your sense of sight. The macula lutea, a ring of yellow-pigmented tissue, and the retinal fovea, an opening at the posterior part of the eye and retina that lacks rod-like structures and has the highest density of cones of various sizes in the eye, wherever cones like structures prefer to accumulate, that is 5 to 6 mm (0.2 to 0.24 inch) in diameter, which surrounds it. Although cones tend to cluster at two places, rods are generally dispersed uniformly over the whole retina.[2]

Light that enters the eye is refracted as it travels between the cornea and lens, focussing a picture onto the retina. Nerve impulses are sent by luminescent molecules in the rods and cones in response to certain light wavelengths.[3] Synapses, which are intricate connections between retinal cell layers, allow these impulses to be merged into a coherent pattern. Once in the visual parts of the brain, this structured pattern is further processed and transported down to the optic nerve.[4,5]

The retina, or visual cortex, comprises the area of the human eye that receives and transmits impulses related to light. It is composed of several distinct cell types, each of which contributes differently to vision. In response to light, photoreceptor cells initiate an electrical signal. The optic nerve, an intermediate layer containing cells in the retina, and eventually the cerebral cortex, where a picture is created; all carry the signal. In many kinds of retinal deterioration, including hereditary retinal illnesses including RP, choroideremia, Leber congenital amaurosis, and AMD, damage to or diminished retinal photoreceptor cells results in visual loss.[6]

2. Discussion

Generally speaking, by giving suitable multi-site patterns of electrical stimulation (i.e. defining the shape of the intended visual target and mirroring the neural structure & geometrical visual perceptions (retinotopic organization). This makes it possible to perceive visual pictures, much like when watching an electronic scoreboard at a sporting event or viewing ink jet printer graphics. Analysing a digital camera picture or in reaction to images taken by the eye's optics directly determines the pattern of electrical stimulation that is provided. This "scoreboard" strategy clearly oversimplifies visual perception in a significant way.[4] It is obvious that a visual scene is characterized by a variety of elements, including colour, motion, and form. Visual prosthesis is only intended to address one of the most fundamental aspects of vision, namely spatial detail, as they are currently conceptualized.[2]

The Boston retinal implant project is now exploring the sub-retinal visual neuro-prosthesis design.[7] The sub-retinal method offers more intrinsic mechanical stability since it is positioned next to the layer that contains the closest remaining neurons (i.e., bipolar cells). This occurs as a result of the ultra-thin electrode array being "sandwiched" between the RPE layer and the inner segment of the retina. This strategy also theoretically benefits from using retinal signal pre-processing built into the bipolar cell layer in addition to being closer to surviving neural components (possibly needing lesser levels of electrical stimulating current).[8,9] Extensive and difficult surgical procedures are necessary for the implantation of a sub-retinal device. This involves making an incision on the scleral wall of the ocular globe and placing an ultra-thin flexible microelectrode array for the Boston Retinal Implant device through it.[10]

Several significant consortia projects have also attempted to modify the sub-retinal implant design. About 5,000 micro-photodiodes, each having a stimulating electrode, make up the Artificial Silicone Retina (ASR) created by Optobionics Corporation, However, the obvious enhancement of vision was not due to actual prosthetic vision per itself, instead being due to a potential neurotrophic (or "cell rescue") impact related to the micro-electric currents produced by the device.[10] Photocurrents produced by absorbed light excite nearby retinal neurons in a multi-site manner when placed under the retina. individuals reported an improvement in visual function following implantation in a phase 1 trial of safety and effectiveness conducted in six individuals with substantial vision loss from RP (followed from 6 to 18 months after implantation).[11] The capacity to name more letters on a standardized visual acuity chart and a larger visual field size were indicators of these findings.[12]

This is despite the device's relatively simple design being intuitively appealing (note that no camera and subsequent image processing are required with this device). A German partnership (Retina Implant AG) is now working on a multi-layered sub retinal chip device that incorporates signal amplification in response to this constraint. The most recent outcomes of this device have been encouraging in individuals with RP who are profoundly blind.

Technology uses a digital camera mounted on a pair of eyeglasses, similar to the Boston Retinal Implant concept, to capture a picture that is then transformed into an electrical signal and sent to the retina.[13] Human volunteers with advanced RP have undergone successful first testing with a 16 electrode device.[3] A second generation implant (Argus II; 60 electrodes) is now being tested in the biggest cohort of visual prosthesis patients in a large-scale, multi-centred phase II FDA-sponsored clinical research. According to results, people who have this device implanted in their bodies for an extended period of time can distinguish between rough forms when several electrodes are stimulated and simple stimuli provided by a head-mounted camera.[14,15]

3. Conclusion

In conclusion, the bionic eye technologies that are presently available in the market are only the initial steps towards a future when bionic eyes are a reality. In a decade, bionic eyes will offer high-fidelity functional vision. Like other technological fields, progress is not expected to slow down for a long time, especially after the first profitable gadgets with high functionality are introduced. In only a few years, being & bionically assisted will be the norm. The need for bionic eyes, ears, limbs, legs, and a variety of other microelectronic prostheses will increase as populations age. I find it difficult to believe that bionic gadgets will not eventually become common place.

4. Source of Funding

None.

5. Conflict of Interest

None.

References

1. Marc RE, Jones BW, Anderson JR, Kinard K, Marshak DW, Wilson JH, et al. Neural reprogramming in retinal degeneration. *Invest Ophthalmol Vis Sci*. 2007;48:3364–71.
2. Crowder NA, Price NSC, Hietanen MA, Dreher B, Clifford CWG, Ibbotson MR. Relationship between contrast adaptation and orientation tuning in areas V1 and V2 of cat visual cortex. *J Neurophysiol*. 2006;95:271–83.
3. Chader GJ, Weiland J, Humayun MS. Artificial vision: needs, functioning, and testing of a retinal electronic prosthesis. *Prog Brain Res*. 2009;175:317–32.
4. Zrenner E, Bartz-Schmidt KU, Benav D, Bruckmann A, Gabel VP, Gekeler F, et al. Subretinal electronic chips allow blind patients to read letters and combine words. *Proc Roy Soc B- Biol Sci*. 2011;278:1489–97.
5. Costello F. The Afferent Visual Pathway: Designing a Structural-Functional Paradigm of Multiple Sclerosis. *ISRN Neurol*. 2013;2013:134858.
6. LOlivares-González, Velasco S, Campillo I, Rodrigo R. Retinal Inflammation, Cell Death and Inherited Retinal Dystrophies. *Int J Mol Sci*. 2021;22(4):2096.
7. Shire DB, Kelly SK, Chen J, Doyle P, Gingerich MD, Cogan SF, et al. Development and implantation of a minimally invasive wireless subretinal neurostimulator. *IEEE Trans Biomed Eng*. 2009;56(10):2502–11.
8. Humayun MS, Dorn JD, Ahuja AK, Caspi A, Filley E, Dagnelie G, et al. Preliminary 6 month results from the Argus II epiretinal prosthesis feasibility study. *Annu Int Conf IEEE Eng Med Biol Soc*. 2009;2009:4566–8.
9. Zouache MA. Variability in Retinal Neuron Populations and Associated Variations in Mass Transport Systems of the Retina in Health and Aging. *Front Aging Neurosci*. 2022;14:778404.
10. Merabet LB. Building the bionic eye: an emerging reality and opportunity. *Prog Brain Res*. 2011;192:3–15.
11. Weiland JD, Humayun MS. Retinal Prosthesis. *IEEE Trans Biomed Eng*. 2014;61(5):1412–24.
12. Knöpfel T, Boyden ES. Optogenetics: tools for controlling and monitoring neuronal activity. Amsterdam: Elsevier; 2012.
13. Yanai D, Lakhanpal RR, Weiland JD, Mahadevappa M, Boemel GV, Fujii GY, et al. The value of preoperative tests in the selection of blind patients for a permanent microelectronic implant. *Trans Am Ophthalmol Soc*. 2003;101:223–8.
14. Veraart C, Wanet-Defalque MC, Gerard B, Vanlierde A, Delbeke J. Pattern recognition with the optic nerve visual prosthesis. *Artif Organs*. 2003;27(11):996–1004.
15. Winter JO, Cogan SF, Rizzo JF. Retinal prostheses: current challenges and future outlook. *J Biomater Sci Polym Ed*. 2007;18(8):1031–55.

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