Reading Visual Braille with a Retinal Prosthesis

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Abstract. Retinal prostheses can restore partial vision to patients blinded by outer retinal degeneration. The Argus II retinal prosthesis system, used in this study, includes a 10 x 6 electrode array implanted epiretinally, a tiny video camera mounted on a pair of glasses, and a wearable computer that processes the video and determines the stimulation current of each electrode in real time. This study investigates the possibility of using the retinal prosthesis to stimulate visual braille as a sensory substitution for reading written letters and words. Single letters were stimulated in an alternative forced choice (AFC) paradigm, and short 2–4-letter words were stimulated in an open-choice reading paradigm. The subject correctly identified 89% of single letters and 70% of all presented words. This work suggests that text can successfully be stimulated and read as visual braille in retinal prosthesis patients.

Keywords: Retina, Epiretinal Prosthesis, Sensory substitution, Retinitis Pigmentosa, Blindness, Perception, Degeneration, Sight Restoration.

1 Introduction

Retinal prostheses restore partial vision to people blinded by outer retinal degenerative diseases such as Retinitis Pigmentosa (RP) [1]. Recent results have demonstrated the ability of prosthesis users to read large letters and short words and sentences for some subjects [2-4]. But with the current spatial resolution of prosthetic vision, reading takes seconds to tens of seconds for single letters and short words, and requires letters to be ~1-20 cm high at normal (approximately 30 cm) reading distance [2-4]. While these results are by themselves impressive, and the performance is expected to improve significantly with future prosthesis development, their practical application at the current level is limited. For example, signs one might read while walking...
around have letters of a few centimeters in height, but are intended to be read from several meters distance.

An alternative is to use the prosthesis to create percepts in the form of braille letters (to be read visually rather than tactually). For example, letter recognition software could identify text, which could then be converted into braille and stimulated directly to the eye via the retinal prosthesis. This project addresses the feasibility of reading visual braille with a retinal prosthesis. The specific device used in this study is the Second Sight Argus® II System (Second Sight Medical Products Inc, Sylmar, CA).

The Argus II System consists of a surgically implanted 60-channel stimulating microelectrode array and inductive coil link used to transmit power and data to the internal portion of the implant, an external video processing unit (VPU), and a miniature camera mounted on a pair of glasses. The video camera captures a portion of the visual field and relays the information to the VPU. The VPU digitizes the signal in real time, applies a series of image processing filters, down-samples the image to a 6 by 10 pixilated grid, and creates a series of stimulus pulses customized to the individual user based on pixel gray-scale values. Currently, the Argus II System is the only commercially available retinal prosthesis.

Here, we present results showing that a subject implanted with the Argus II Retinal Prosthesis System can read visually-stimulated braille. Performance is 89% correct for individual letters at 500ms presentation, and 60-80% correct for short words, proving the feasibility of reading via visual braille.

2 Methods

2.1 Description of the Argus II Retinal Prosthesis System

The Argus® II System consists of an implantable device surgically placed on and in the eye, and an external unit worn by the user (Fig. 1). The external unit consists of a small camera and transmitter mounted on a pair of sunglasses, and a video processing unit (VPU) and battery that can be worn on a belt or shoulder strap. The implanted portion consists of a receiving and transmitting coil and a hermetically sealed electronics case, fixed to the sclera outside of the eye, and an electrode array (a 6 by 10 array of 60 electrodes, 200 µm in diameter, 525 µm between nearest neighbor center to center cardinal axes) that is secured to the surface of the retina (epiretinally) inside the eye by a retinal tack. The electrode array is connected to the electronics by a metallized polymer cable that penetrates the sclera in the pars plana. The camera captures video and sends the information to the processor, which converts the image to electronic signals that are then sent to the transmitter on the glasses. The implanted receiver wirelessly receives these data and sends the signal to the electrode array via a