

## Brightness as a function of pulse width during retinal electrical stimulation

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**Purpose:** Retinitis Pigmentosa (RP) and Macular Degeneration are characterized by progressive vision loss due to the deterioration of photoreceptors in the retina. Although the remaining bipolar and retinal ganglion cells do not receive input from the damaged photoreceptors, and are neurally disorganized, it is still possible to elicit percepts in patients with advanced RP by electrically stimulating the retina (Humayun et al, 1999; Marc et al, 2003), and researchers propose that useful sight may be restored by systematically stimulating these remaining cells with electrical current from an implanted, microelectronic prosthesis. Over the last few years Doheny/USC/Second Sight have epiretinally implanted six patients with a 4x4 electrode array that directly contacts the ganglion cell layer. One of the goals of this initial trial was to determine the optimal electrical pulse parameters to reliably and safely produce phosphenes while using the least possible amount of electrical charge. We examine here the effect of varying pulse duration in a subset of these patients.

**Methods:** Stimuli were single, biphasic, cathodic-first, charge balanced pulses. Pulse width varied between 0.075 and 0.975 ms. Thresholds were measured psychophysically with a 2-AFC yes/no paradigm where patients were required to judge whether or not they had been electrically stimulated on that trial. Each threshold was measured using a 3down1up staircase procedure containing 125 trials, half of which were catch-trials where no stimulation occurred. Threshold was defined as the current amplitude that elicited a percept on 50% of the trials, corrected for the false alarm rate. Suprathreshold isobrightness curves were measured by finding the amplitude at which a pulse of variable duration matched the brightness of a suprathreshold standard pulse of 0.975ms.

**Results and conclusions:** We show here that strength-duration curves can be measured accurately in human patients. Threshold and brightness matching data were well fit by the strength-duration equation typically used to describe the responses of individual neurons  $\{I=r/(1-e^{-\tau D})\}$ . It has been shown that strength-duration curves differ significantly depending on the cell type (ganglion vs. bipolar) being stimulated. In our data, the parameter  $\tau$  tended to be less than 1 ms, consistent with stimulating either axons or ganglion cells according to recent retinal electrophysiology data from rabbit and primate (Jensen et al, 2005; Sekjernak and Chichilnsky, personal communication), with the caveat that this requires comparing degenerated human retina with non-degenerate non-human retinae.