

Single-electrode phosphene characteristics of the Orion™ Visual Cortical Prosthesis System

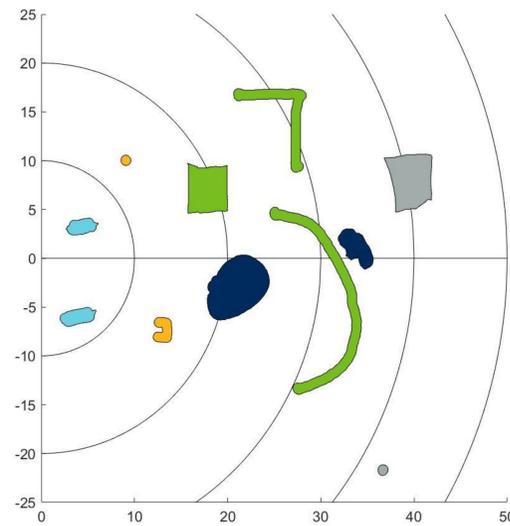
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Purpose

Characterize single-electrode phosphenes generated by the Orion Visual Cortical Prosthesis.

Methods

- Five of six blind Orion implantees participated.
- Subjects were implanted with the Orion between January 2018 and January 2019.
- Stimulating arrays were implanted over the left medial occipital cortex.
- Data were collected within 12 months of surgery.
- Subjects sat 30 cm away from a touchscreen monitor, such that the left edge of the monitor was directly in front of the subject's midline.
- Subjects were asked to fixate on the edge of the touchscreen during stimulation and while responding.
- For each trial, 2–6 stimulus pulses at 6, 20, or 120 Hz, 0.8–7.5 mA, with 0.2 ms phase widths, were provided through a single electrode.
- Subjects drew perceived phosphenes on the touchscreen.
- Point phosphenes and lines were interpreted as being at least 1° wide.

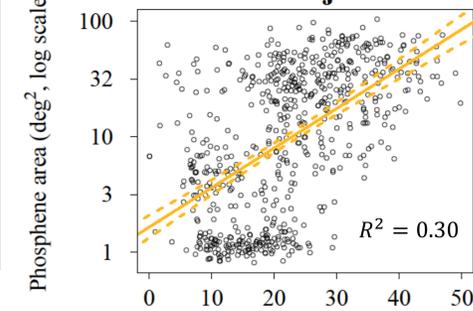


Sample phosphene drawings (above): Each shape shows a subject drawing in response to single-electrode stimulation. Electrodes differed across these examples. Units shown are in degrees of visual field. S1's responses are shown in gray, S2 in yellow, S3 in dark blue, S4 in green, and S6 in light blue.

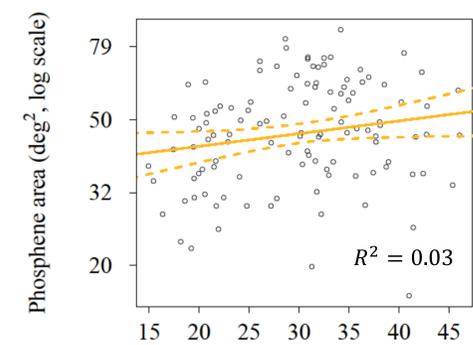
Percept Characteristics	Mean	Minimum	Maximum
Area	21 deg ²	0.8 deg ²	105 deg ²
Eccentricity	22°	0.03°	50°
Azimuth	-6°	-83°	90°
Distinct phosphene count	1.05	1	3

Summary statistics table (above): Characteristics of subject responses were averaged within subjects, electrodes, and frequencies, then pooled together across these groups to calculate summary statistics. A total of 625 distinct data groups were included in this analysis. Data were collected for 26–60 different electrodes for each subject. Azimuth is defined as the polar angle relative to the horizontal meridian extending into the right visual field. Subjects reported seeing only one phosphene for almost all trials. Trials in which multiple phosphenes were reported tended to be located near the calcarine sulcus.

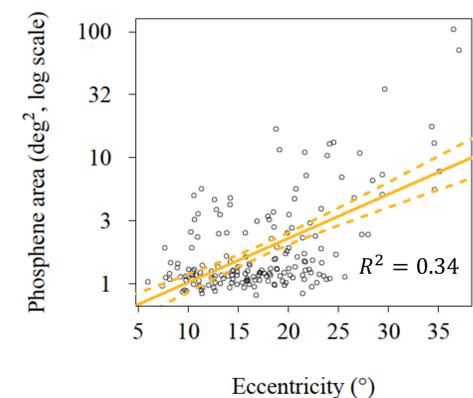
Area vs. Eccentricity: All subjects



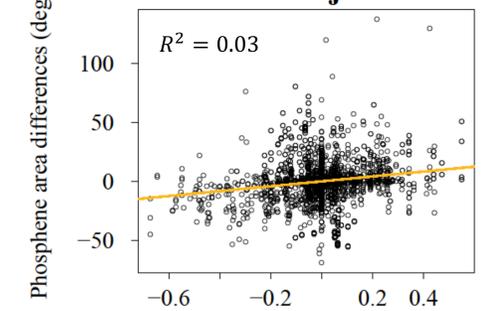
Area vs. Eccentricity: S1



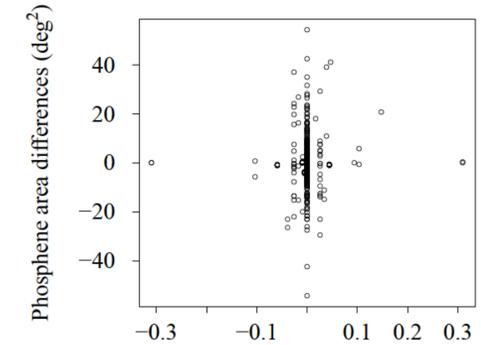
Area vs. Eccentricity: S2



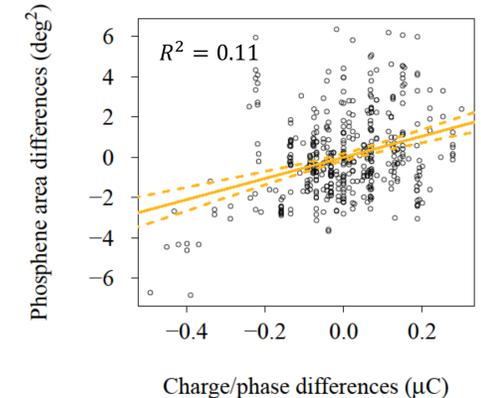
Area vs. Charge: All subjects



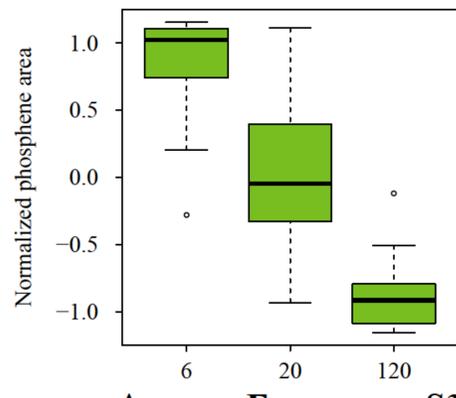
Area vs. Charge: S4



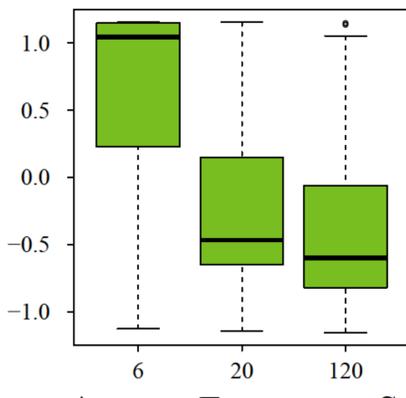
Area vs. Charge: S6



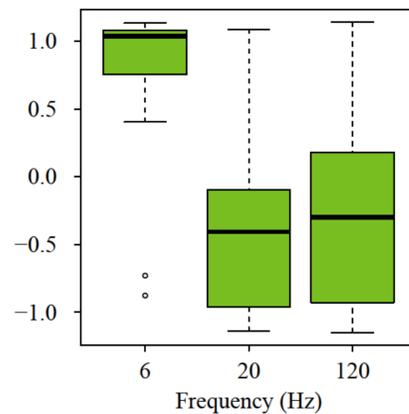
Area vs. Frequency: S1



Area vs. Frequency: S2



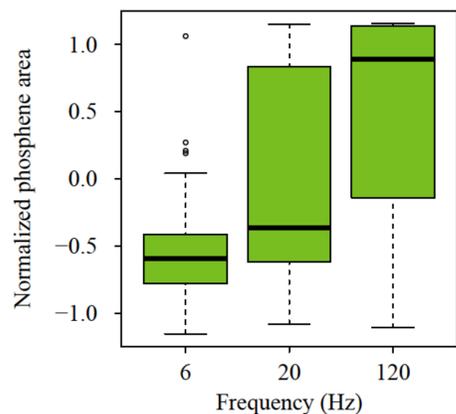
Area vs. Frequency: S6



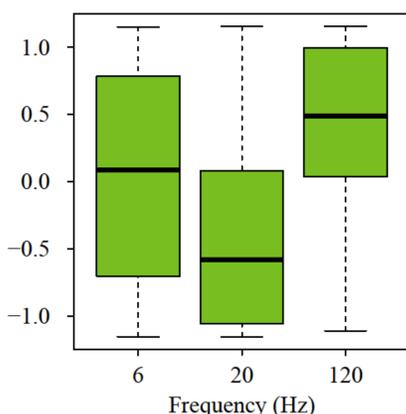
Area vs. eccentricity figures (right):

All subjects for whom phosphene eccentricities spanned more than 30° reported larger phosphenes with increasing eccentricity. Subject 6 reported eccentricities spanning 23°, and no significant area-eccentricity relationship was apparent within that range. Points describe mean responses within subject, frequency, and electrode. Confidence bands show the 95% confidence region about each regression line.

Area vs. Frequency: S3



Area vs. Frequency: S4



Area vs. frequency figures (left and above):

Subjects 1, 2, and 6 tended to report smaller phosphenes with higher-frequency stimulation. Box-and-whisker plots reflect mean areas reported within subject, frequency, and electrode. Means were normalized across frequencies, within subject and electrode. When phosphenes were reported as larger at 6 Hz, subjects typically described them as being less distinct.

Area vs. charge figures (right and above):

Four of five subjects reported larger phosphenes with increasing charge per phase. No such correlation was found for S4. Points describe individual trial responses. Charges and areas shown were centered within subject, electrode, and frequency. Values are differences from the group mean. Confidence bands show the 95% confidence region about each regression line.

Conclusions

Single-electrode Orion cortical stimulation induced percepts of various sizes, shapes, and counts. Phosphene area tended to increase with eccentricity and charge per phase. Effects of increasing charge and frequency varied across subjects. More investigation will be required to guide Orion development.

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