



Optimizing stimulation protocols for prosthetic vision based on retinal anatomy

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INTRODUCTION

- Degenerative retinal diseases such as retinitis pigmentosa and macular degeneration cause irreversible vision loss in more than 10 million people worldwide.

- Retinitis pigmentosa:
 - occurs at ~40 years
 - genetic: ~1/4,000

- Macular degeneration:
 - occurs at 70+ years
 - risk factors: environmental, risk alleles



RETINAL IMPLANTS

- Analogous to cochlear implants, retinal implants electrically stimulate surviving retinal cells in order to evoke neuronal responses:

Argus II

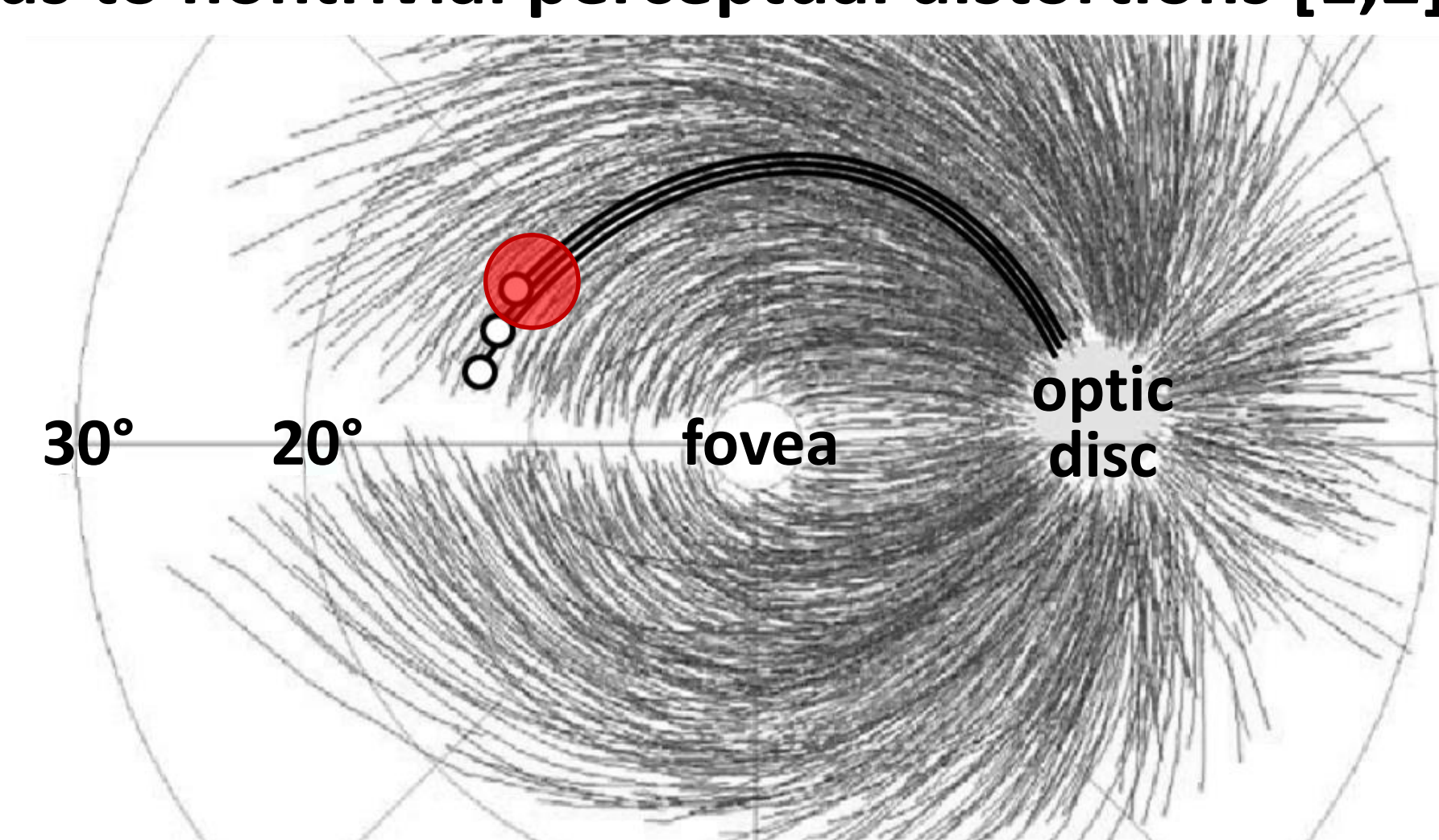
- epiretinal
- FDA approved
- Second Sight Medical Products

Alpha-IMS

- subretinal
- CE mark approved
- Retina Implant AG

- Several others in clinical trials.

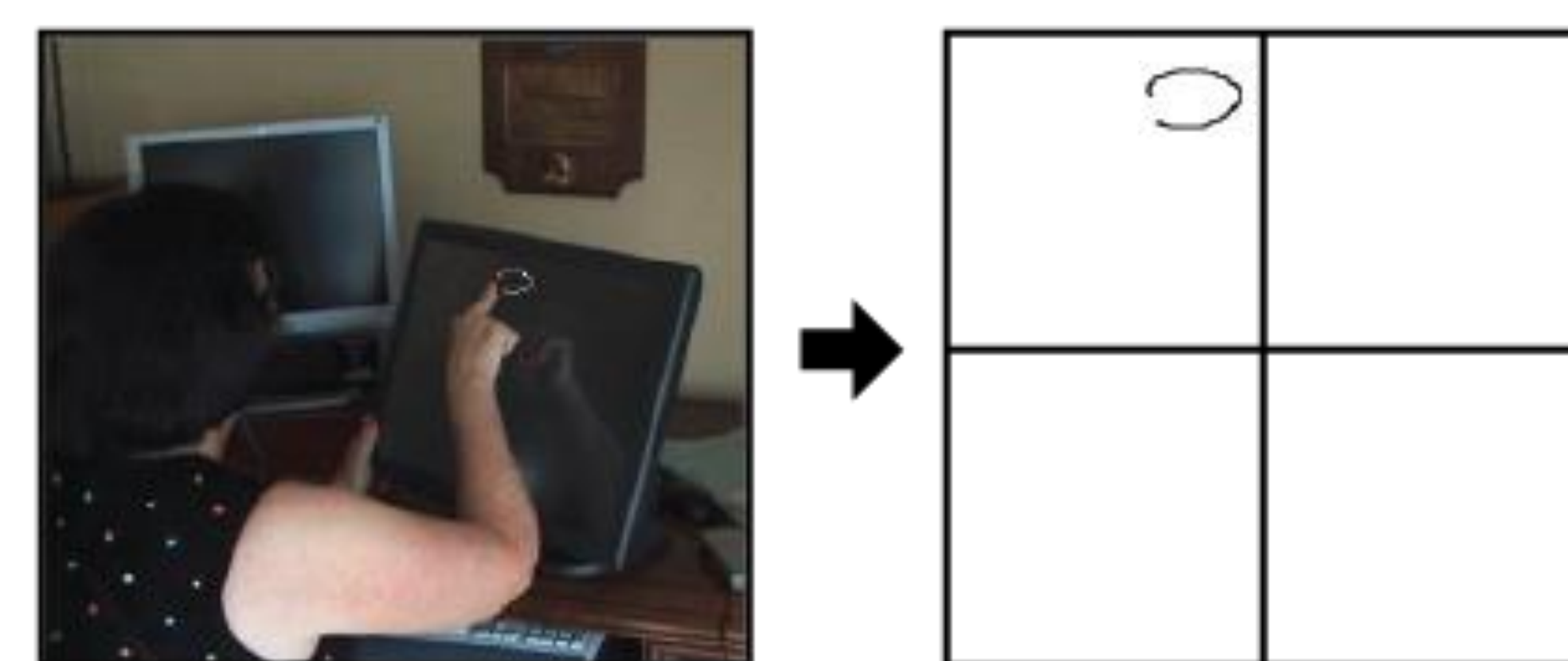
- Inadvertent stimulation of passing axon fibers leads to nontrivial perceptual distortions [1,2]:



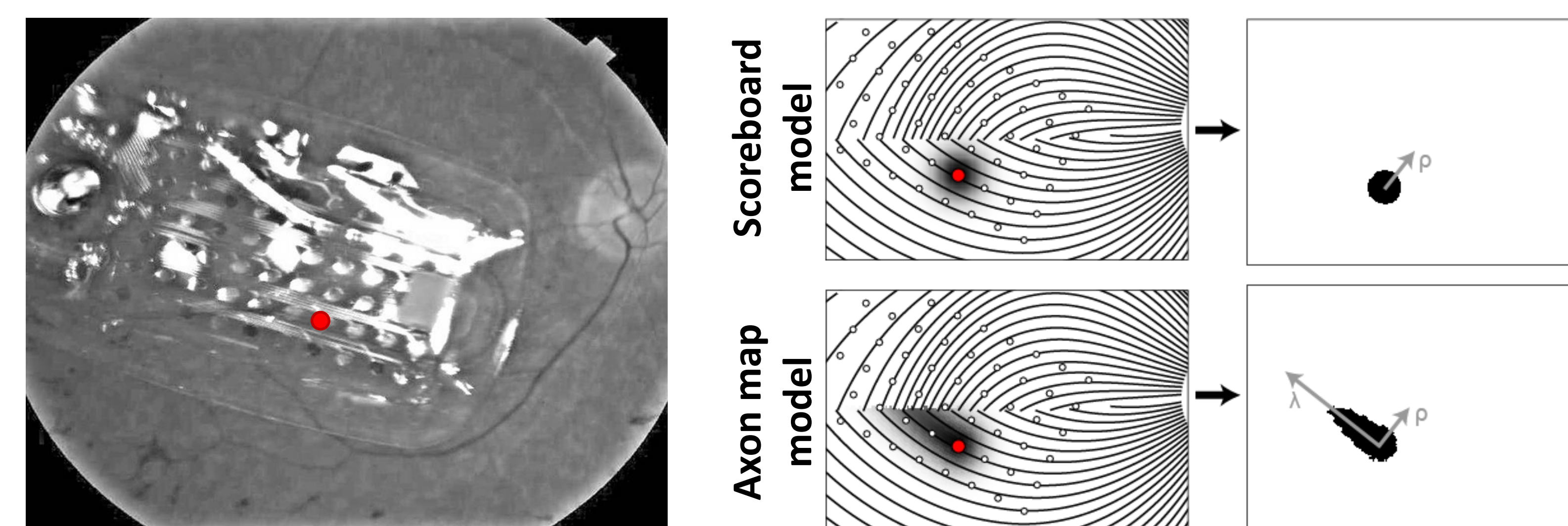
1660 fiber bundles sampled from 55 human retinas [3]

METHODS

In response to single-electrode stimulation, we asked subjects to outline perceived phosphene shape on a touch screen:

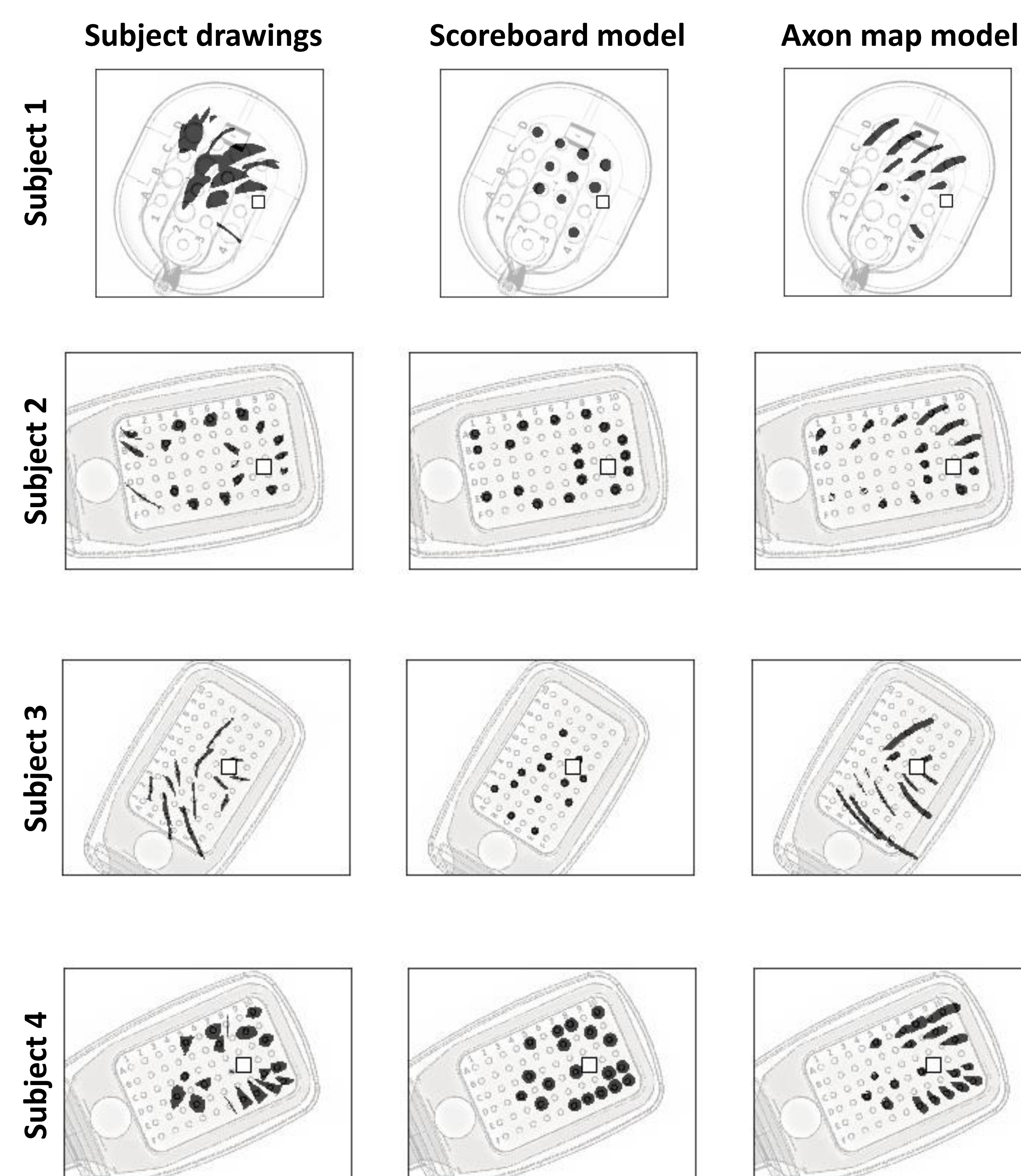


Fundus images were used to estimate array location/orientation for each subject. Two different models were used to predict phosphene shape:

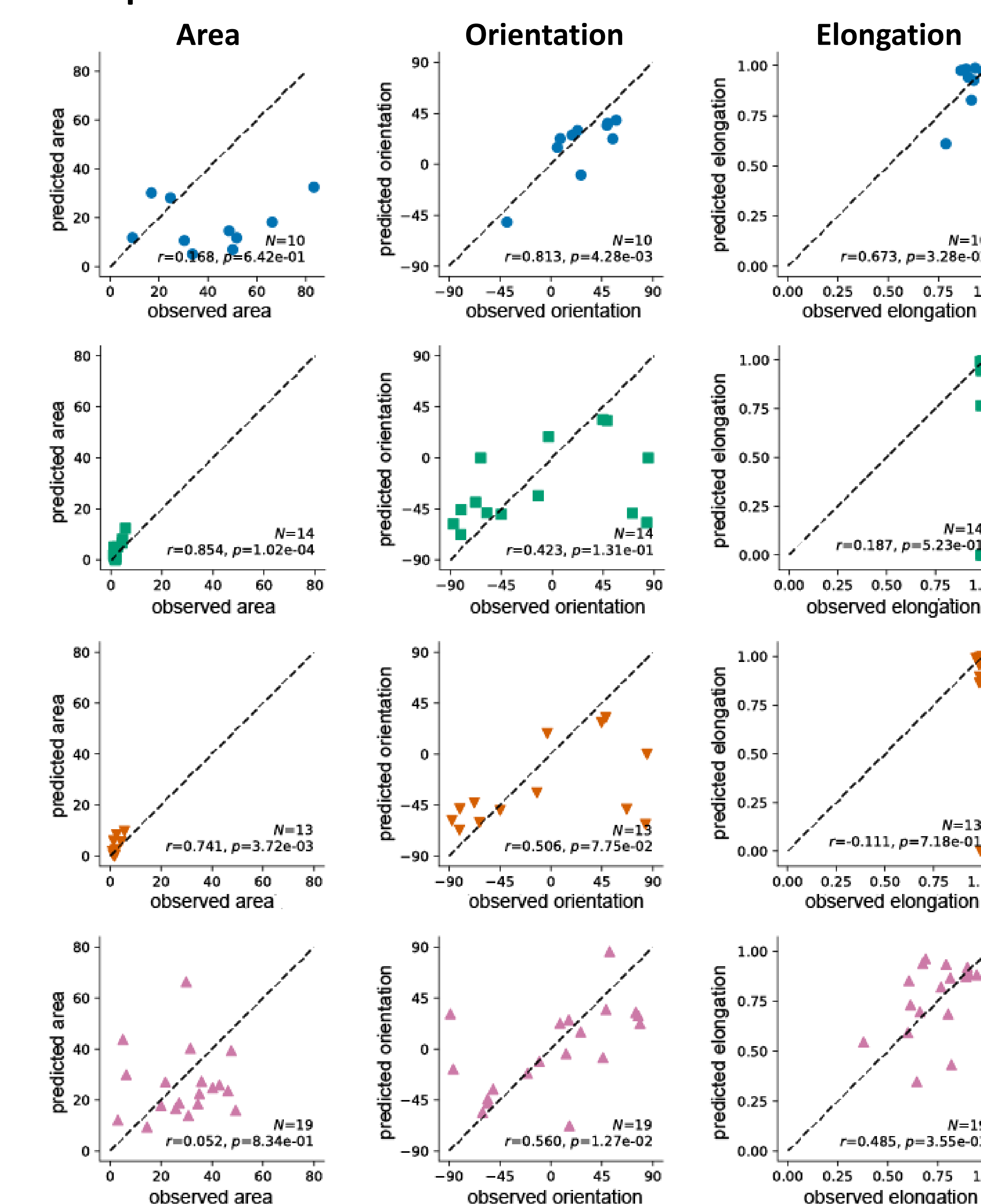


RESULTS

Model predictions from a leave-one-electrode-out cross-validation:

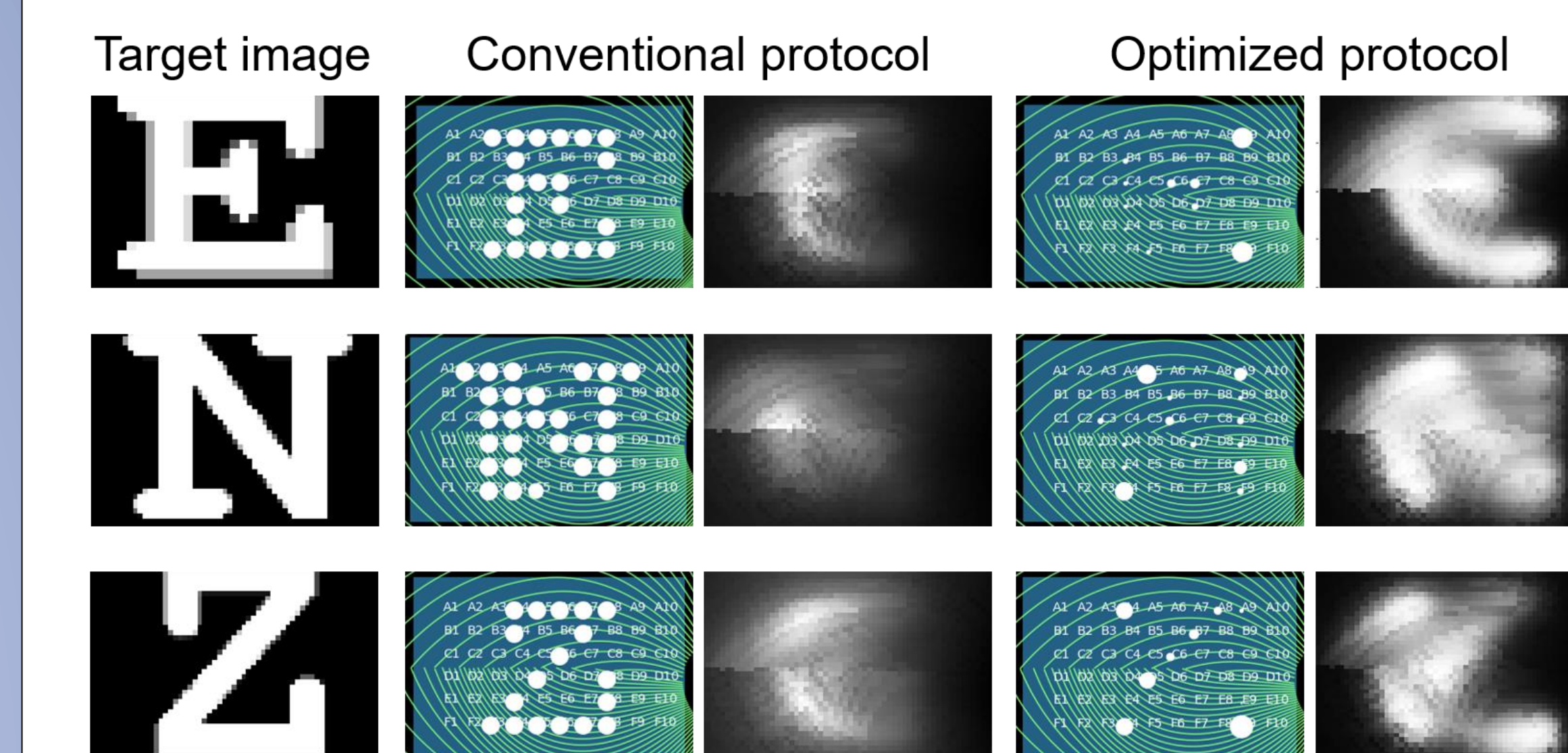


The axon map model accurately predicts phosphene shape descriptors:



OPTIMIZING STIMULATION PATTERNS

The predicted, synthetic percepts were then used as features in a regularized regression optimized to find spatial stimulation patterns that would minimize perceptual distortions of Snellen letters.



CONCLUSIONS

- Phosphene shape can be accurately predicted by a simple computational model that takes into account the spatial layout of ganglion axon pathways in the human retina.
- Optimized stimulation patterns might compensate for the perceptual distortions caused by axonal stimulation, leading to more readily interpretable percepts and reduced overall delivered charge.

APPENDIX

Software

All our software is publicly available:

- <https://github.com/uwescience/pulse2percept>

References

- J. Rizzo, et al, IOVS 44, 2003
- I. Fine & G.M. Boynton, Phil Trans R Soc B 370, 2015
- N.M. Jansonius, et al, Vis Res 49, 2009

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