

Statistical Analysis Plan (SAP)

TITLE: The perceptual experience of Argus II users

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Introduction

This study evaluates spatiotemporal interactions between electrode pairs in Argus II retinal prosthesis users to understand how stimulation delay and retinal distance influence visual perception. The primary aim is to investigate the number of phosphenes elicited by varying spatial offsets (dist_ret) and temporal delays (abs_delay) between electrode pairs. The analysis explores both the main effects of these variables and their interaction on phosphene perception. As a Basic Experimental Study Involving Humans (BESH), the focus is on understanding the mechanisms of prosthetic vision in controlled experimental settings rather than direct clinical outcomes.

Study Design

- **Goal:** To measure the influence of spatiotemporal parameters on phosphene perception.
- **Hypothesis:** The number of phosphenes (num_phosphenes) elicited by paired-electrode stimulation varies as a function of stimulation delay (abs_delay) and retinal distance (dist_ret), with the interaction of these variables hypothesized to modulate the response.
- **Approach:** Participants underwent paired-electrode stimulation while varying spatial offsets and temporal delays. A total of 35 conditions were tested, including combinations of delays (0 ms to 50 ms) and distances (proximal to distal electrodes). Stimulation protocols used single pulses on pairs of electrodes to probe responses at different time scales. Each participant's responses were recorded and analyzed for the number of phosphenes elicited under each condition.

Analysis Framework

- A **linear mixed model (LMM)** was selected to account for the hierarchical structure of the data, with subject_id modeled as a random factor to capture inter-subject variability. Fixed effects included abs_delay, dist_ret, and their interaction (abs_delay:dist_ret).
- This model allows for the evaluation of the main effects of stimulation delay and retinal distance, as well as their combined interaction, on phosphene perception.
- No formal power calculation was conducted due to the rarity of the clinical population; the study leveraged within-subject comparisons to maximize statistical power.

Sample Size and Statistical Methods

- **Sample Size:** The study included data from 1,485 trials across 6 subjects, representing a unique dataset of rare clinical cases.
- **Primary Statistical Test:** Coefficients were estimated using Restricted Maximum Likelihood (REML). Statistical significance was assessed with a pre-specified threshold of $p < 0.05$.
- **Adjustment for Multiple Comparisons:** No corrections were applied, as the analysis was limited to a small set of predictors.

- **Validation:** All analysis code was reviewed externally to ensure appropriate statistical methods and reproducibility.

Outcomes

- **Primary Outcome:** The number of phosphenes elicited (num_phosphenes) as a function of abs_delay and dist_ret.