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# Pupil dynamics as a covert measure of conscious perception in a visual no report paradigm

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## 1. Introduction

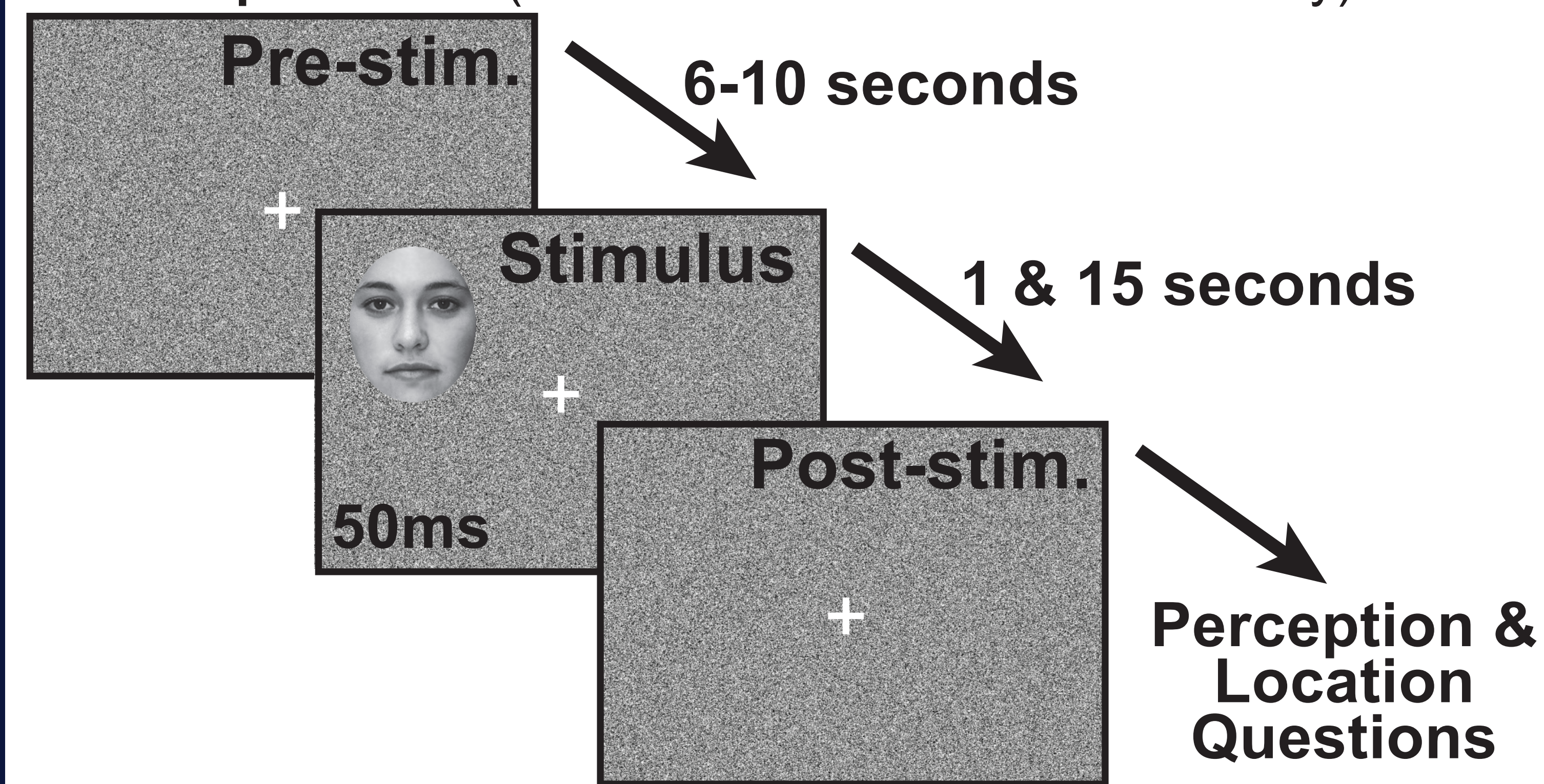
Pupil diameter, blink, and eye gaze (e.g., saccades and microsaccade - involuntary, small eye movements) are predictors of cognitive and behavioral states (1,2,3). These measures may also predict conscious perception (4). Correspondingly eye measurements may provide a suitable covert measure of consciousness that can be utilized in experimental and clinical settings.

### Primary Aim

Determine if eye measurements can be applied as a covert measure of conscious perception.

## 2. Behavioral Task

Participants were presented face stimuli for 50ms and stimulus opacity calibrated to individual perceptual threshold. A portion of trials (12.5%) did not display a stimulus. Two categories of trials are defined: **perceived** (seen and located accurately) and **not perceived** (not seen and located inaccurately).



## 3. Pupillometry Recording Parameters

### Pupillometry (SR Research)

Software: EyeLink; Sampling rate: 1000Hz; Head Fixed  
Data processing: Linear blink interpolation

## 4. Participants & Behavioral Results

88 healthy participants  
(52 females)

Age: 26.1 yrs (19-57 yrs)

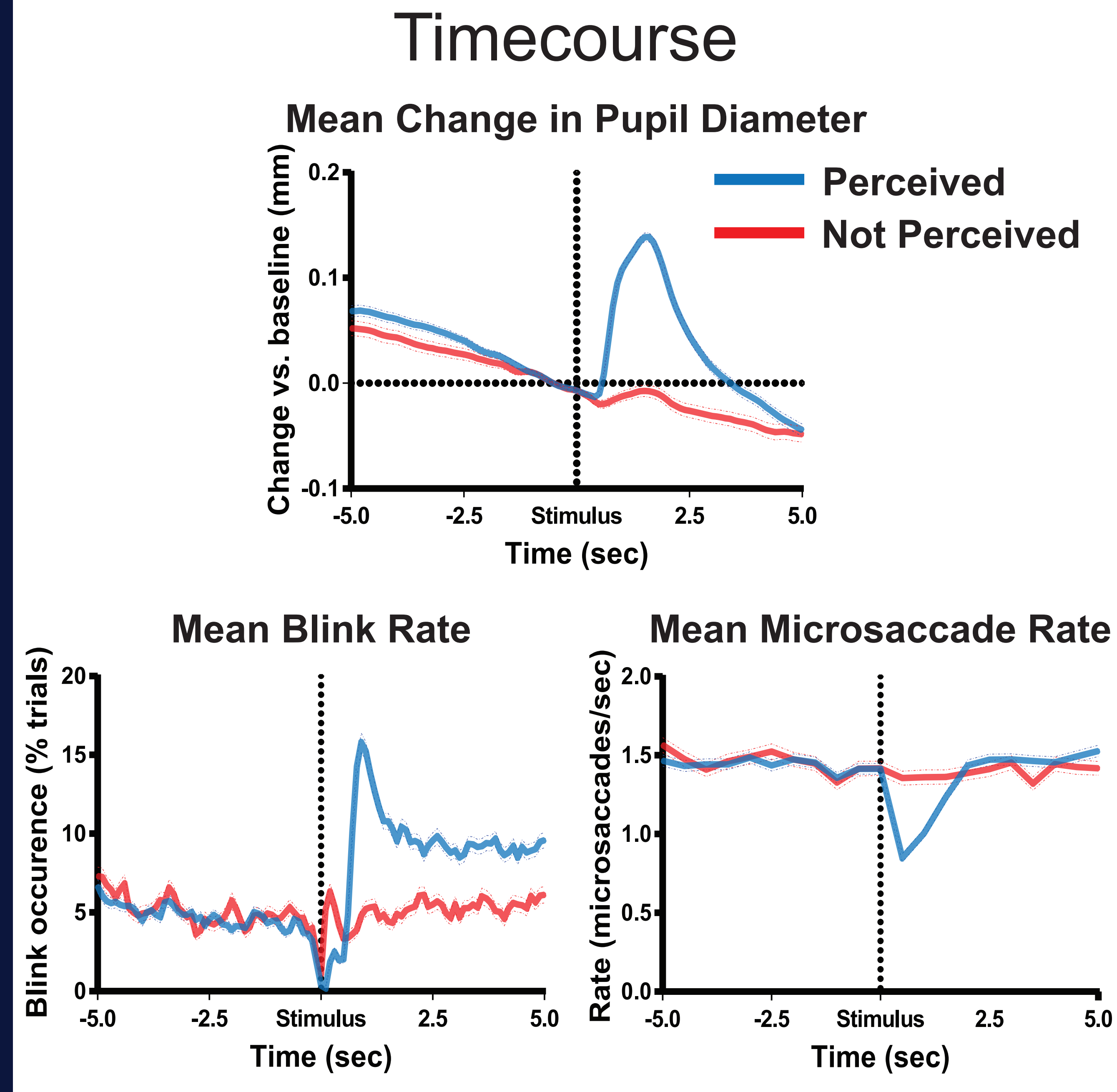
Perceived Trials: 3,700

Not Perceived Trials: 2,122

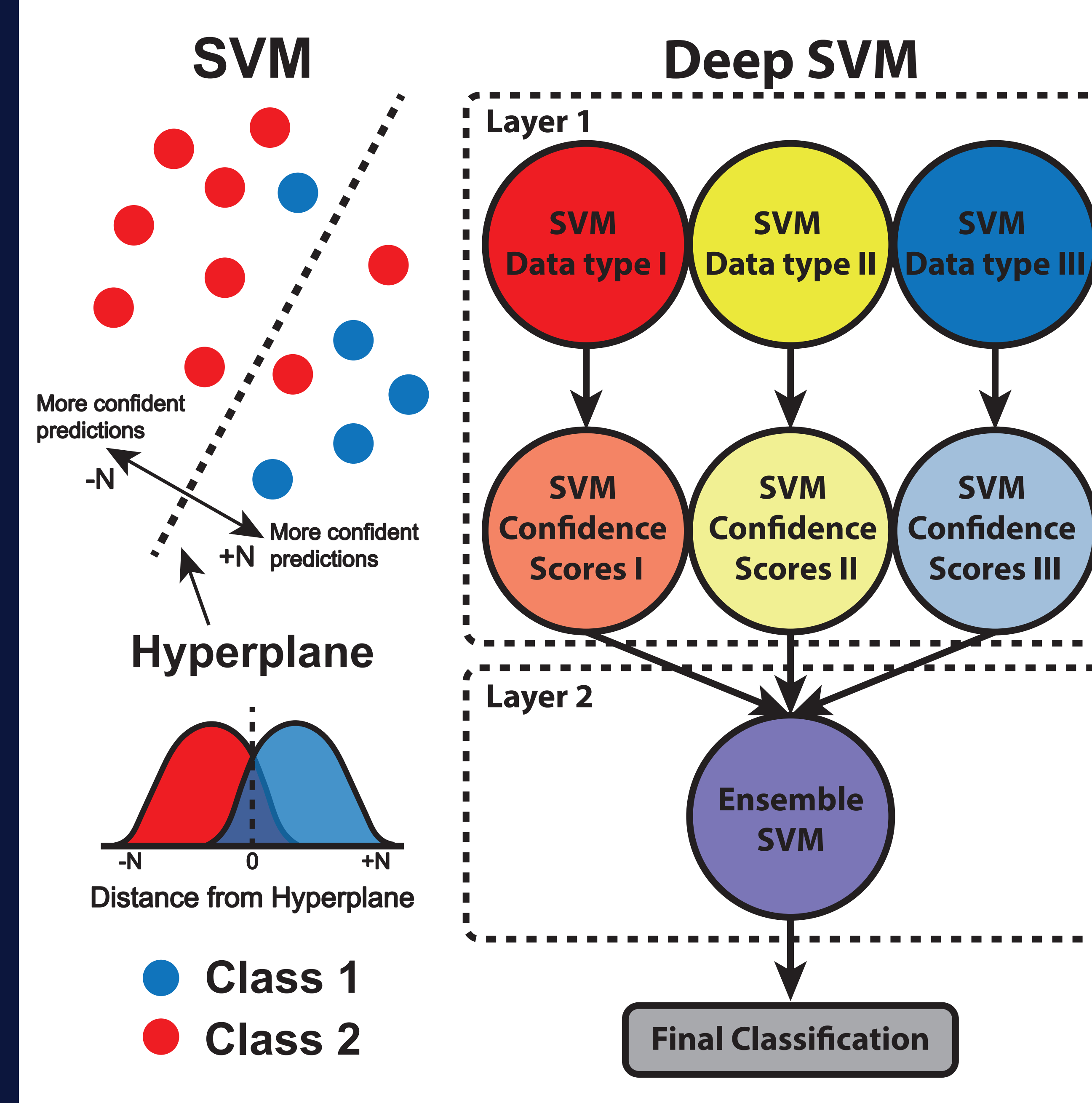
### Data Types

- (1) Pupil Diameter
- (2) Gaze
- (3) Microsaccade
- (4) Blink
- (5) Features
  - Pupil dilation magnitude
  - Baseline pupil, blink, etc.
  - Pre-post amplitude change
  - FFT coefficients

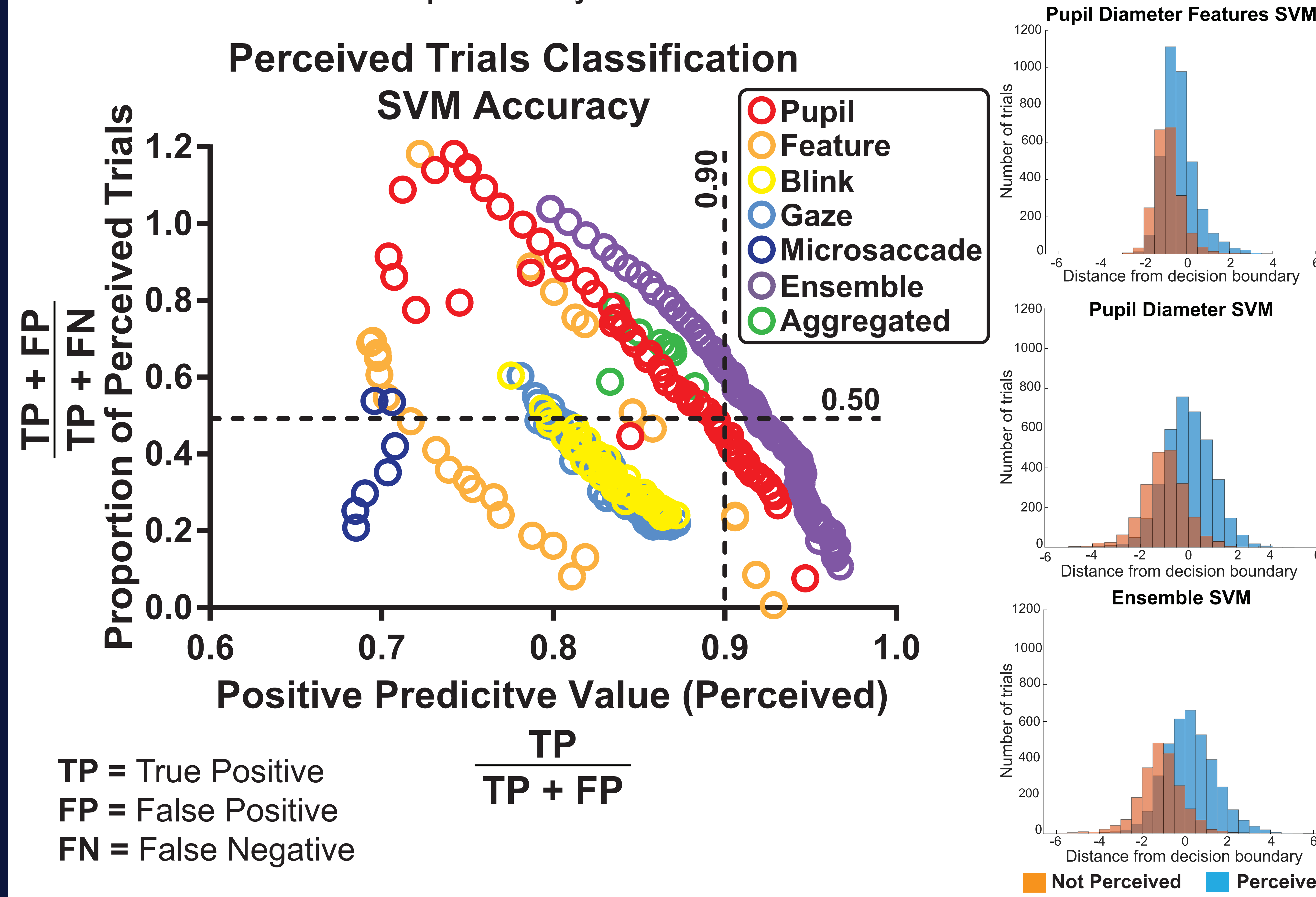
## 5. Pupil, Blink, and Microsaccade Timecourse



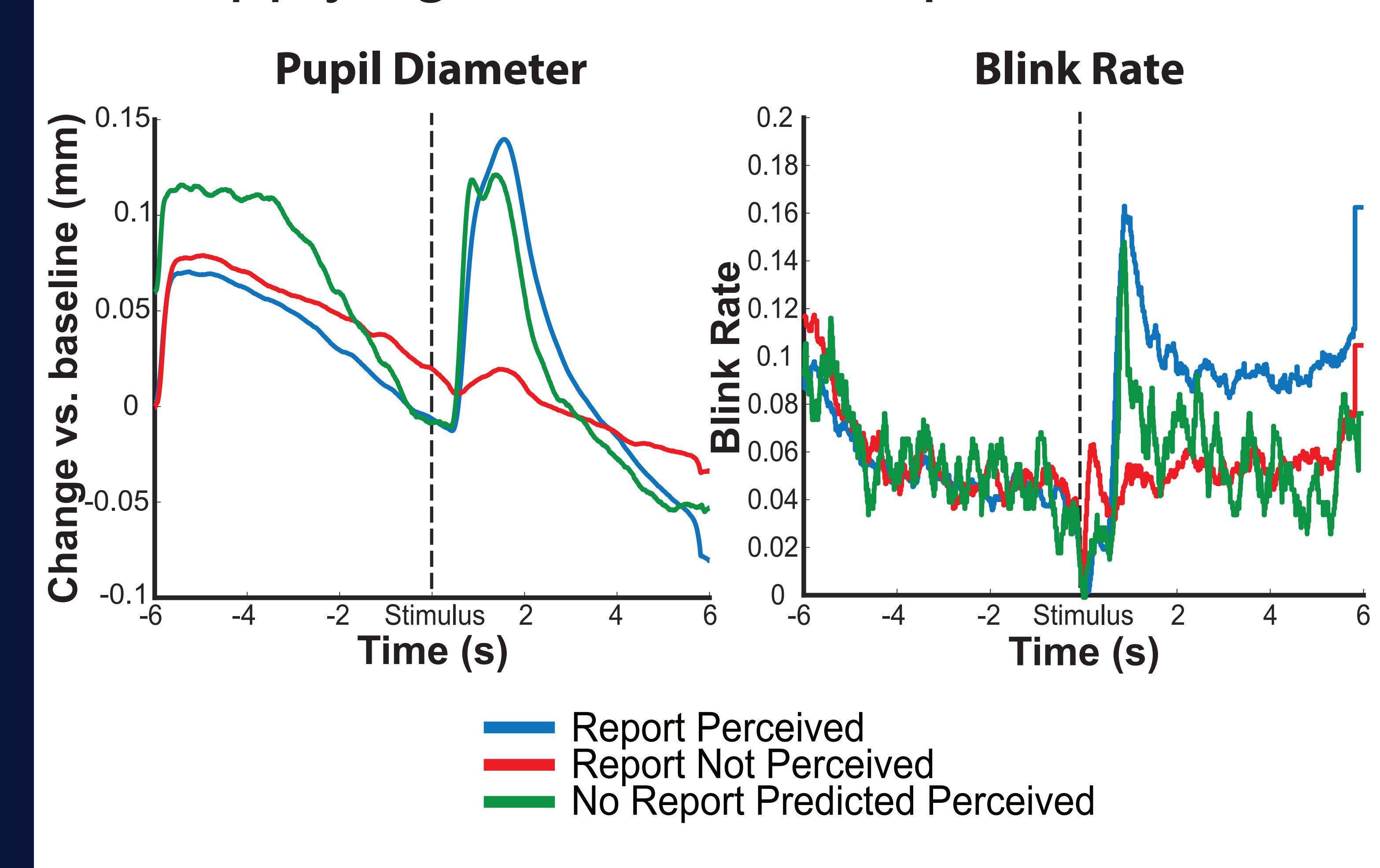
## 6. Classification Approaches



## 7. Pupillometry Classification Results



## 8. Applying SVM to No Report Trials



## 9. Conclusions

- (1) On average, increased pupil dilation and blink rate, and a decrease microsaccade rate about 1 to 2 seconds post-stimulus corresponds with conscious perception.
- (2) The Deep SVM classification approach classifies perceived trials with PPV = 0.90 while retaining ~67% of perceived trials.
- (3) This approach may be used as part of a covert perception task to determine perception without overt report.

## 10. Future Directions

- (1) Improve method for classifying perceived and not perceived trials, including updating SVM parameters, utilizing alternative classifiers, and extracting novel features.
- (2) Develop a covert perception task that replaces overt perceptual report with trials predicted as perceived according to the classification approaches developed here.

## 11. References

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2. Lee, A. M., et al. (2014). "Identification of a brainstem circuit regulating visual cortical state in parallel with locomotion." *Neuron* 83(2): 455-466.
3. Einhauser, W., et al. (2010). "Pupil dilation betrays the timing of decisions." *Frontiers in Human Neuroscience* 4: 18.
4. Einhauser, W., et al. (2008). "Pupil dilation reflects perceptual selection and predicts subsequent stability in perceptual rivalry." *Proc Natl Acad Sci U S A* 105(5): 1704-1709.

**Acknowledgments**  
Thank you to our participants!