A Multi-Variate Pattern Analysis Investigation of Strategic Thinking and Deception in a Dynamic, Competitive Game

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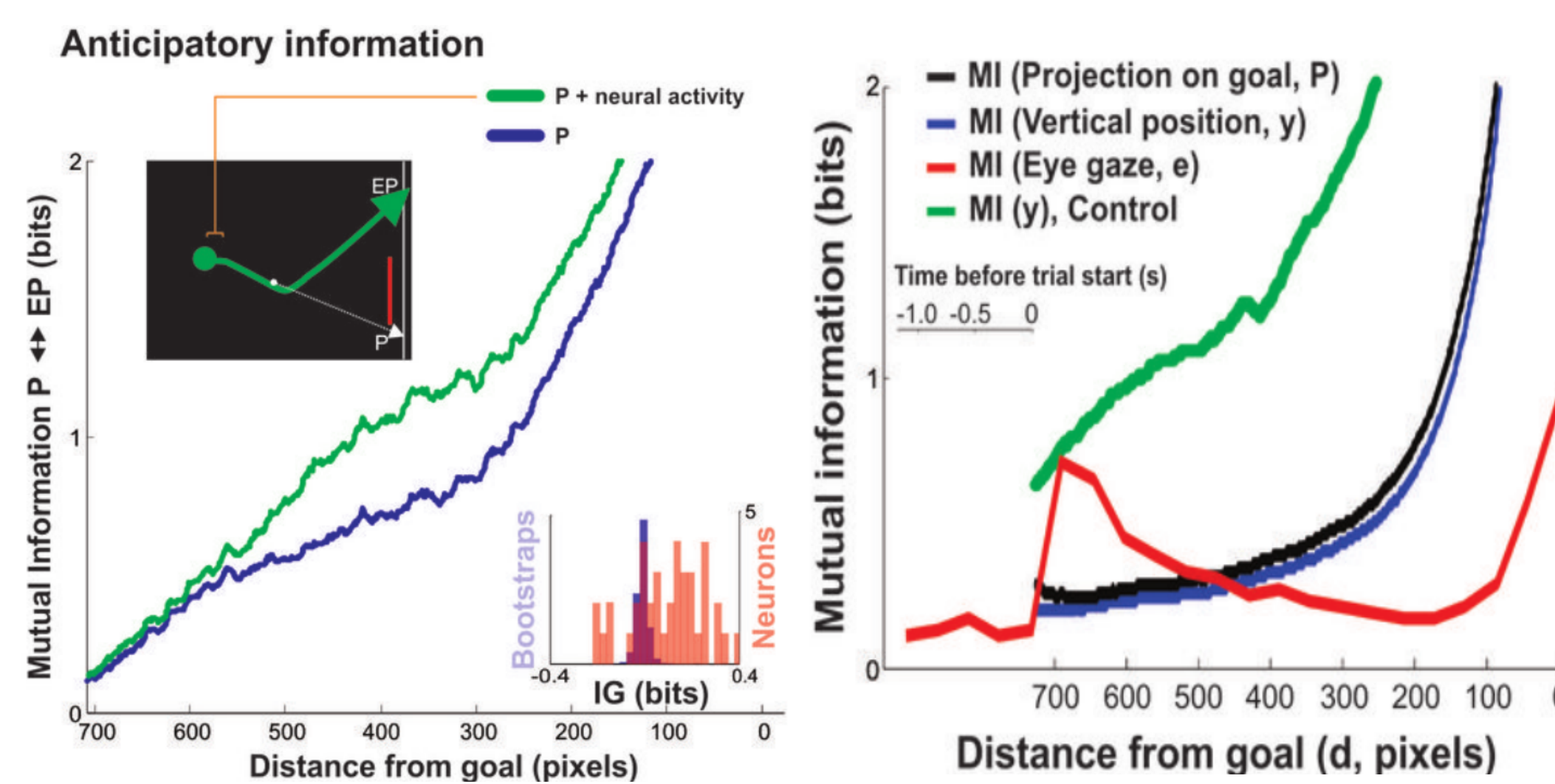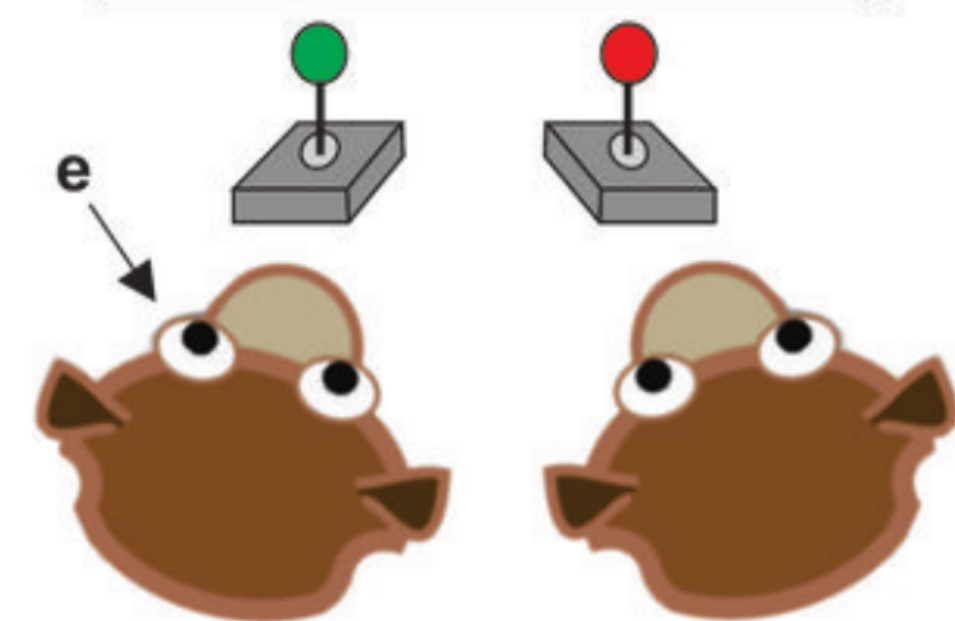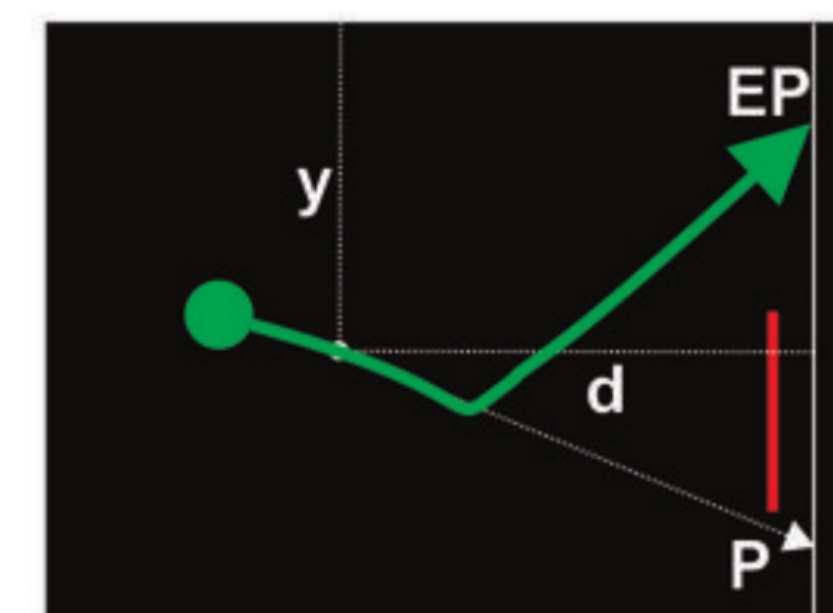4. Department of Psychology, University of Pennsylvania

Motivation

- Competitive games require one to deceive or outmaneuver one's opponents to achieve goal.

- Most deceptive tasks are static, with a turn taking structure that results in limited interaction between players.
- A simplified penalty shot task allows us to investigate dynamic deception as it happens in real-time.

- Monkeys playing this task show pre-planned deception[1].

Anticipatory information

- Eyegaze and DLPFC neuron activity of the monkey controlling the ball at the beginning of the trial predict ball's final location[1].

1. Gariépy, JF et al."Neuronal basis of deceptive behavior in rhesus macaques". Working paper.
2. Stelzer, J., Chen, Y., & Turner, R. (2013), "Statistical inference and multiple testing correction in classification-based multi-voxel pattern analysis (MVPA): random permutations and cluster size control." Neuroimage, 65, 69-82.
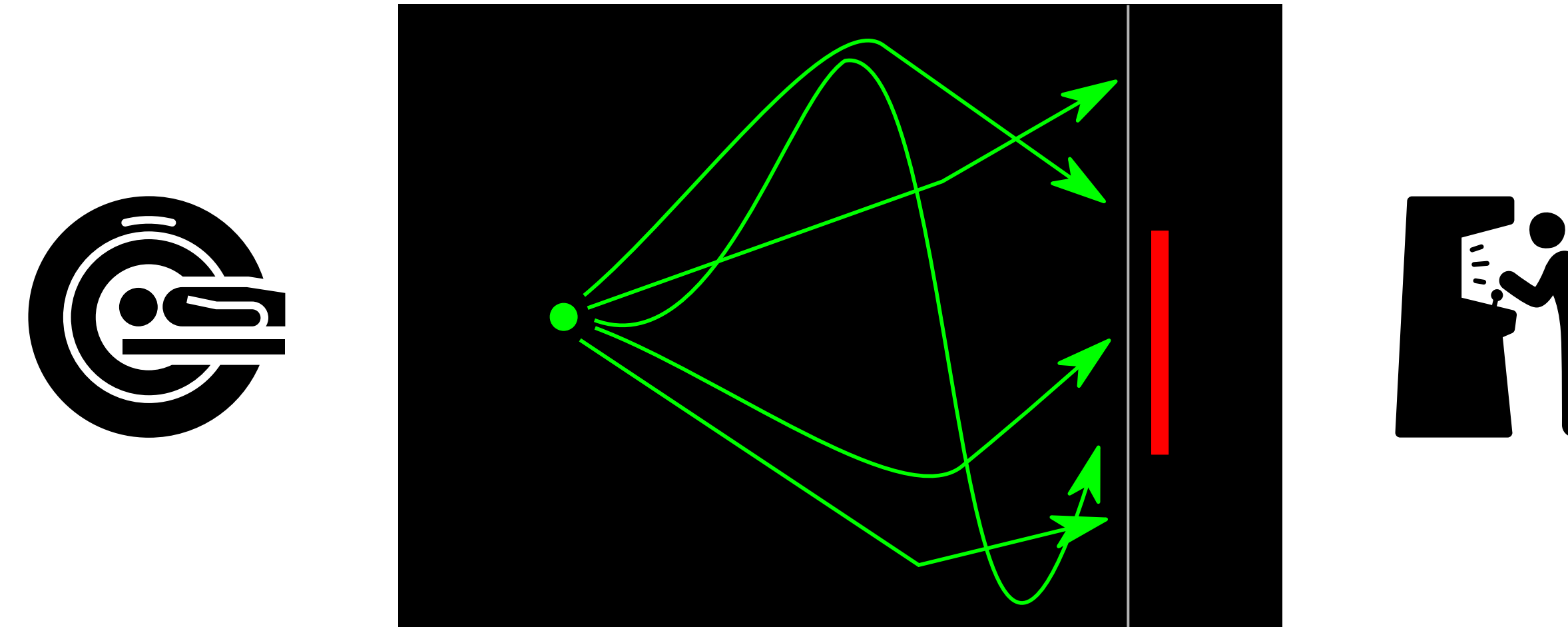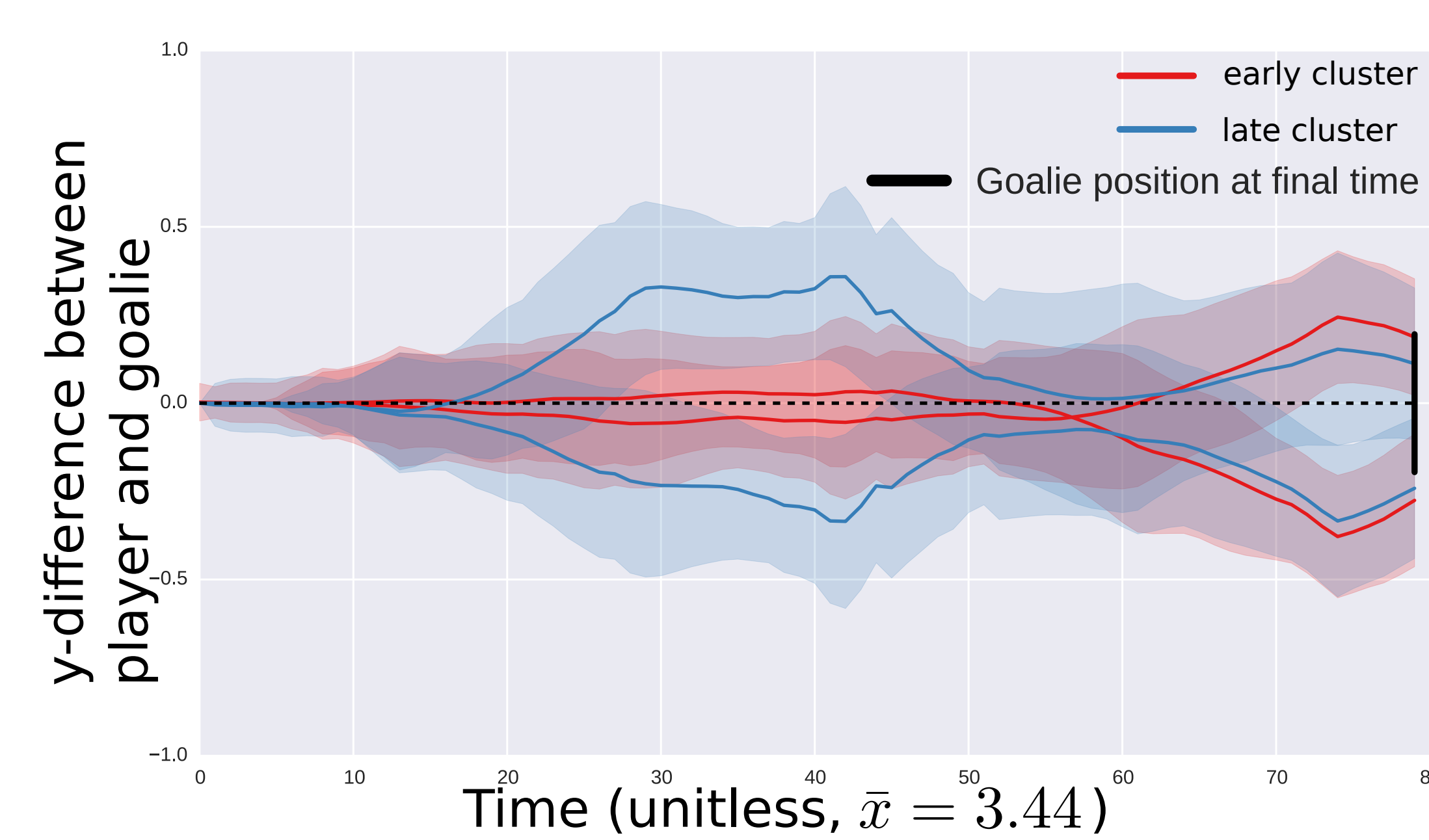
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Penalty Shot Task

- fMRI data gathered from 29 participants while they controlled the ball in a penalty shot task.
- Participants attempted to score against a human goalie (same player for all participants).
- If the participant gets past the goalie, they win. If they hit the goalie, they lose. If they spend more than 10 seconds without winning or losing, they time out.
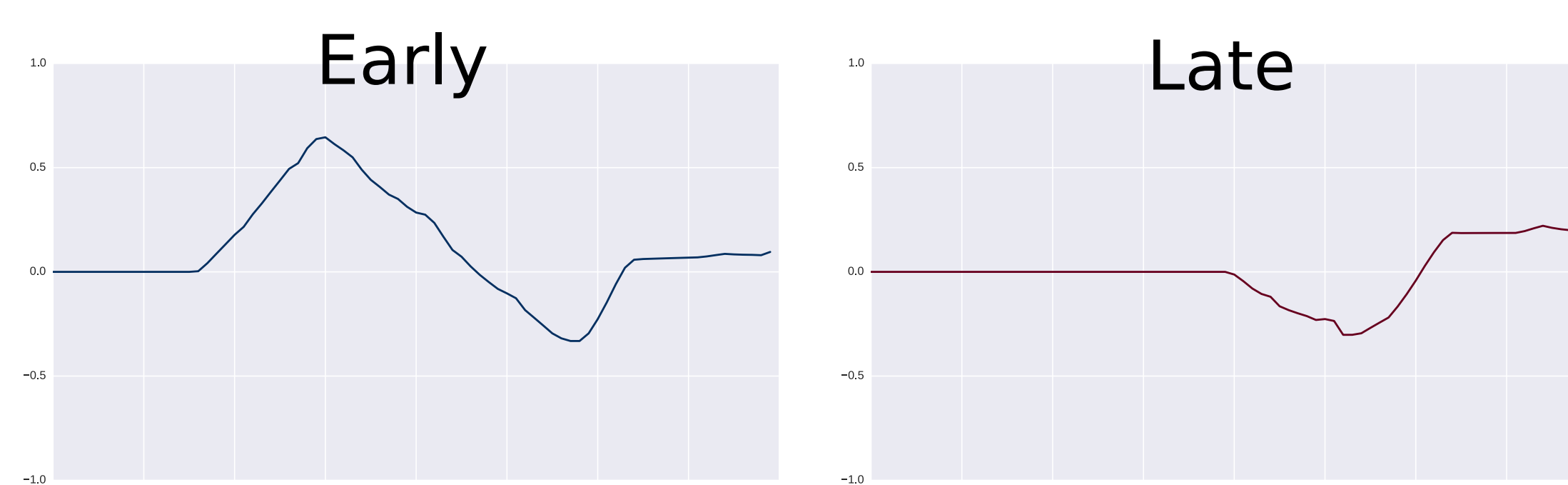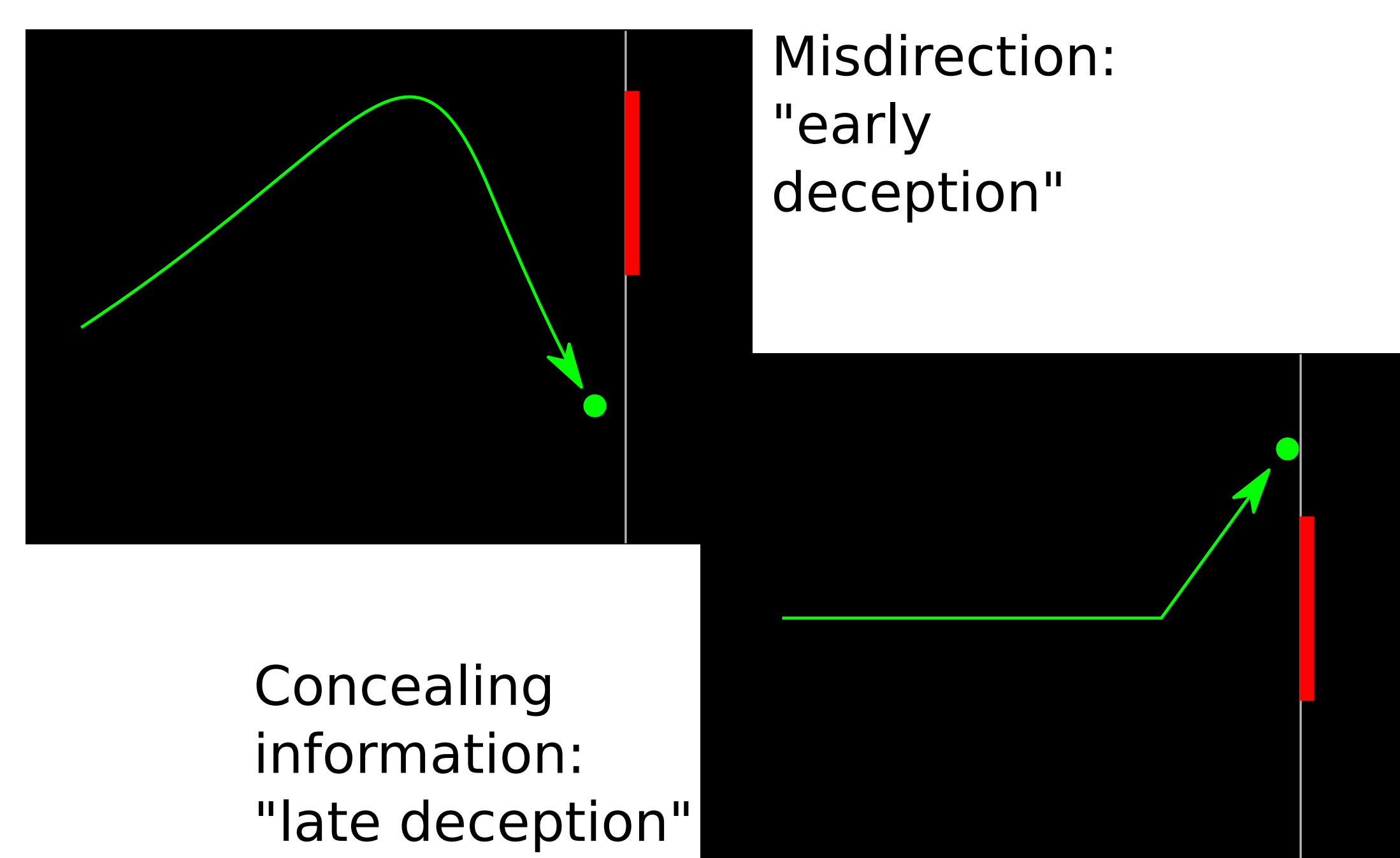

Clustering of Trial Strategy

- Unsupervised k-means clustering of the y-difference between player and goalie reveals two basic strategies, each expressed in up and down directions.
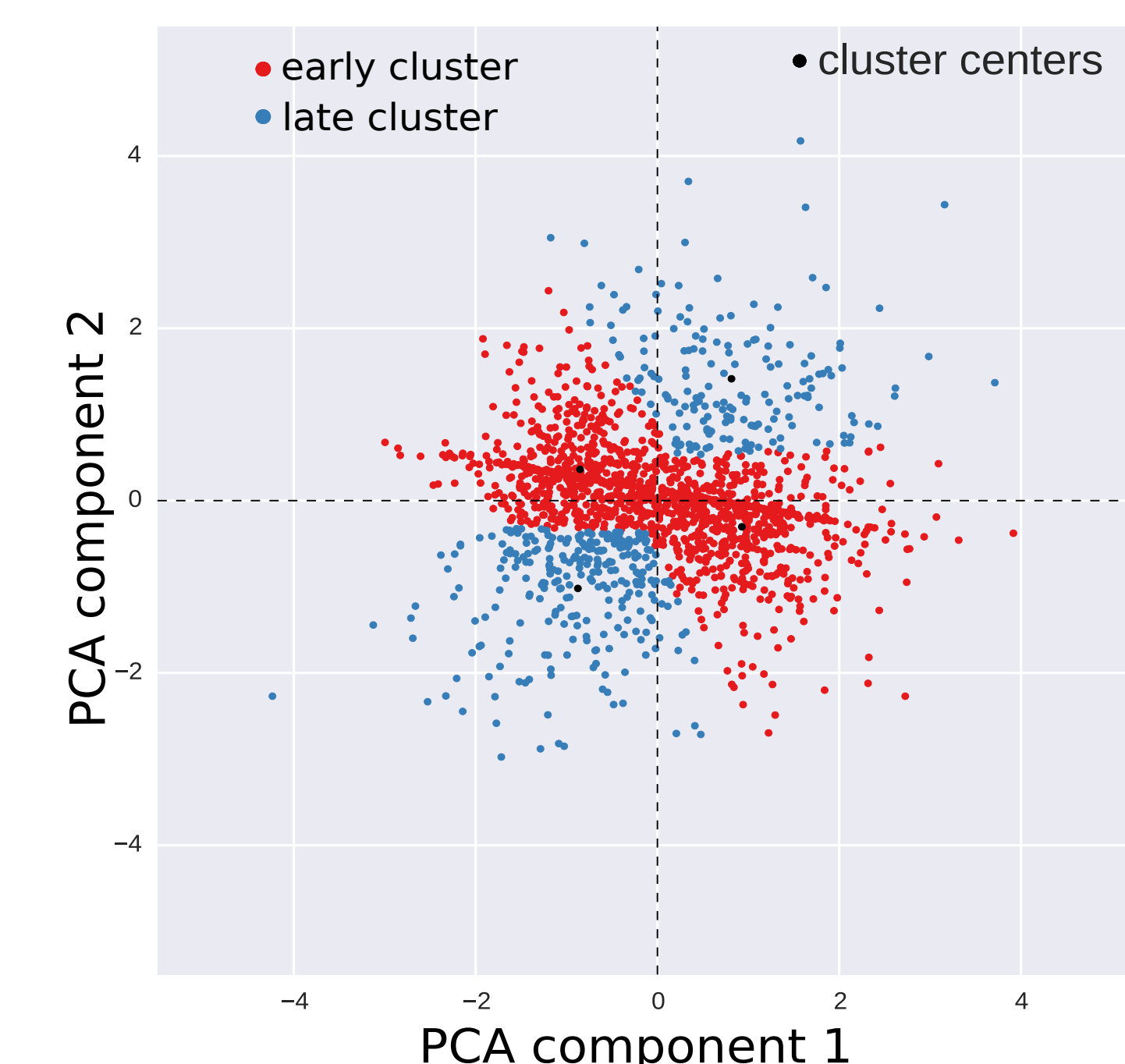
Example trials:

- This data-driven categorization seems to correspond to two archetypical strategies.

Misdirection: "early deception"

Concealing information: "late deception"

Trial-by-trial Strategy Metric

- Principal Components Analysis (PCA) dimensionality reduction to 2 dimensions maintains clusters.
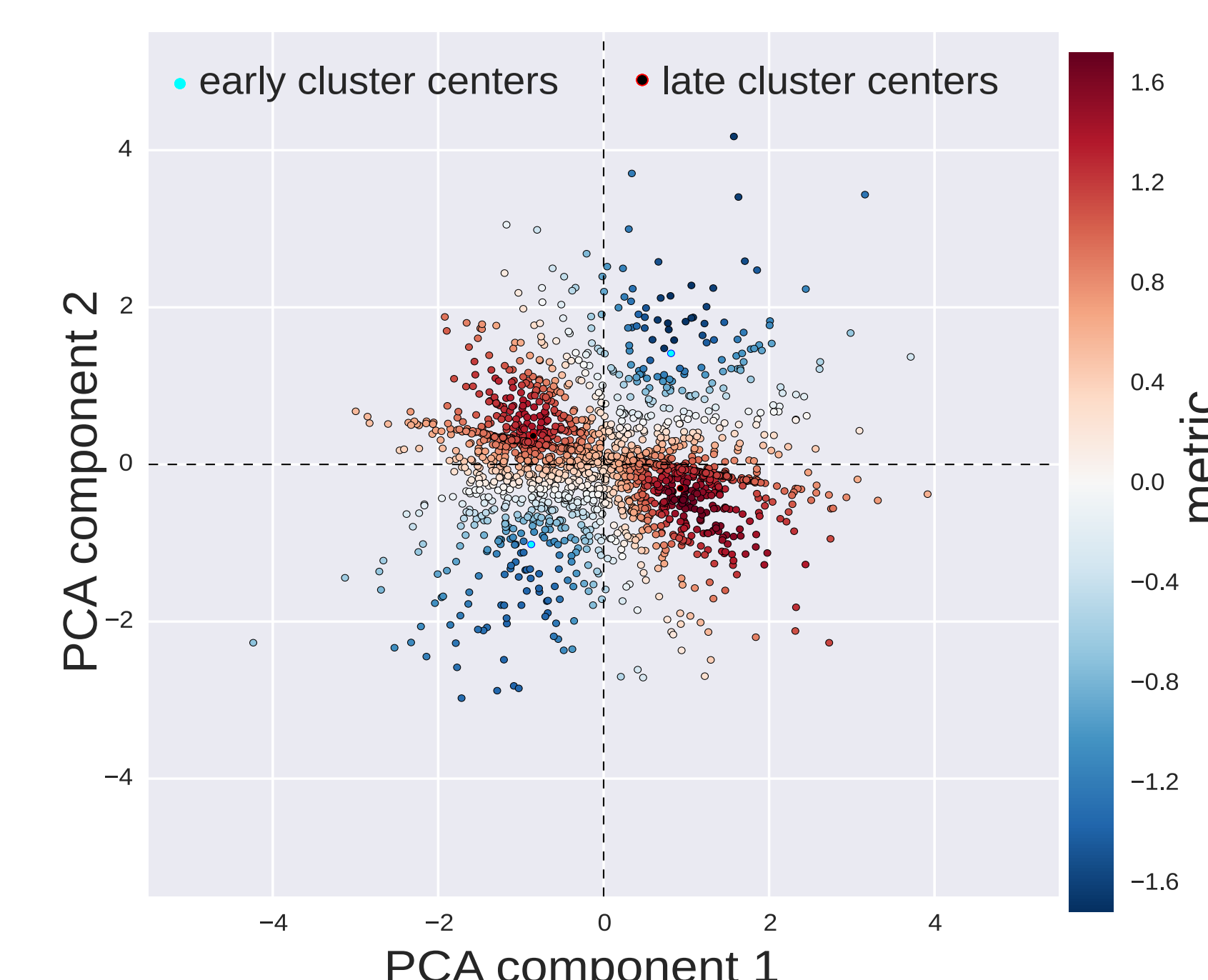- Reveals trials vary continuously between these two extremes.

- Strategy metric defined to summarize participant behavior on a trial-by-trial basis.

$$metric = dist_{early} - dist_{late}$$
thus
$$metric > 0 \Rightarrow trial\ is\ more\ late$$
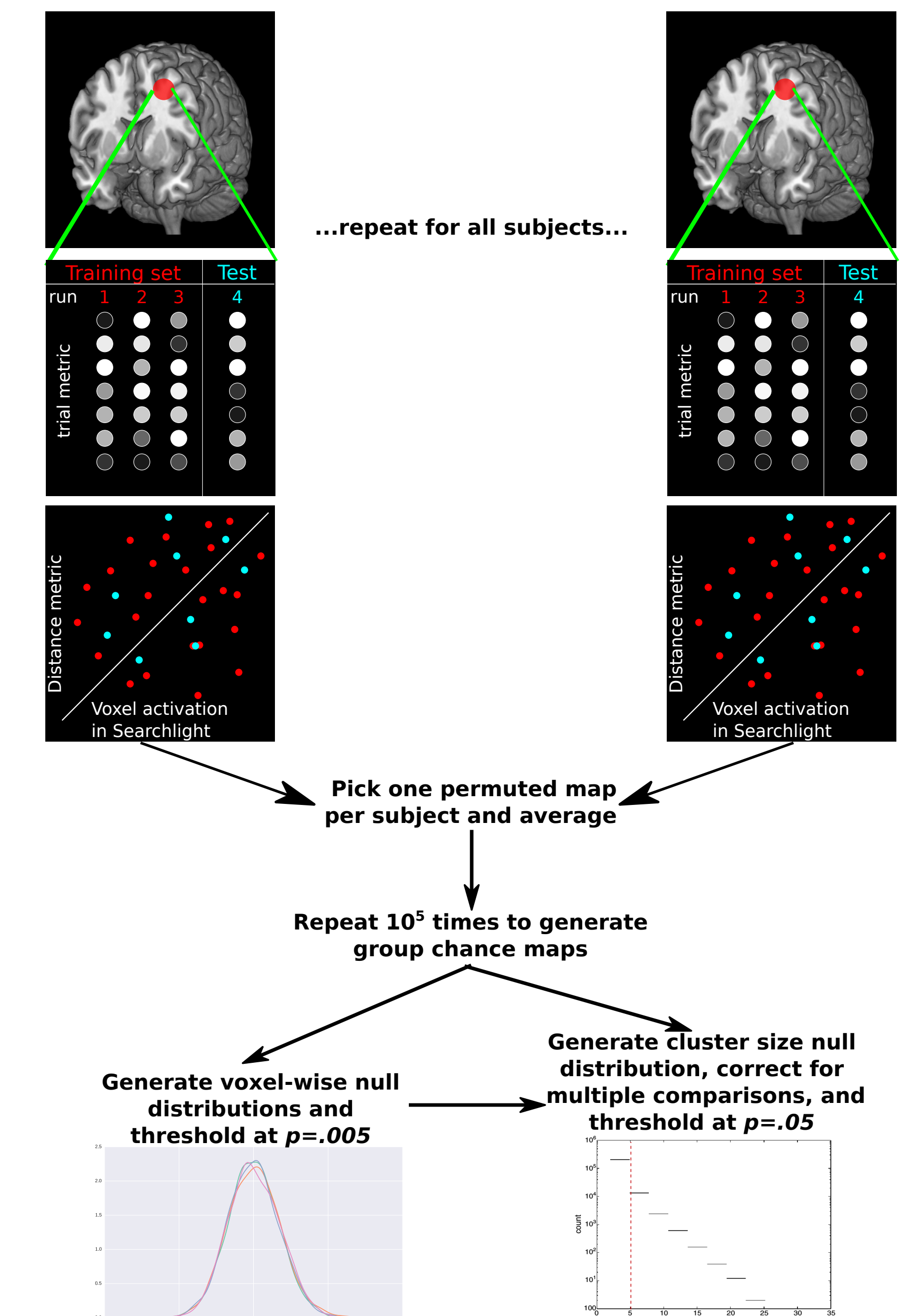$$metric < 0 \Rightarrow trial\ is\ more\ early$$

- Use this metric as target for whole brain MVPA searchlight regression.

MVPA regression

- Performed whole-brain multi-variate pattern analysis (MVPA) searchlight (3-voxel radius) regression to strategy metric on each subject.
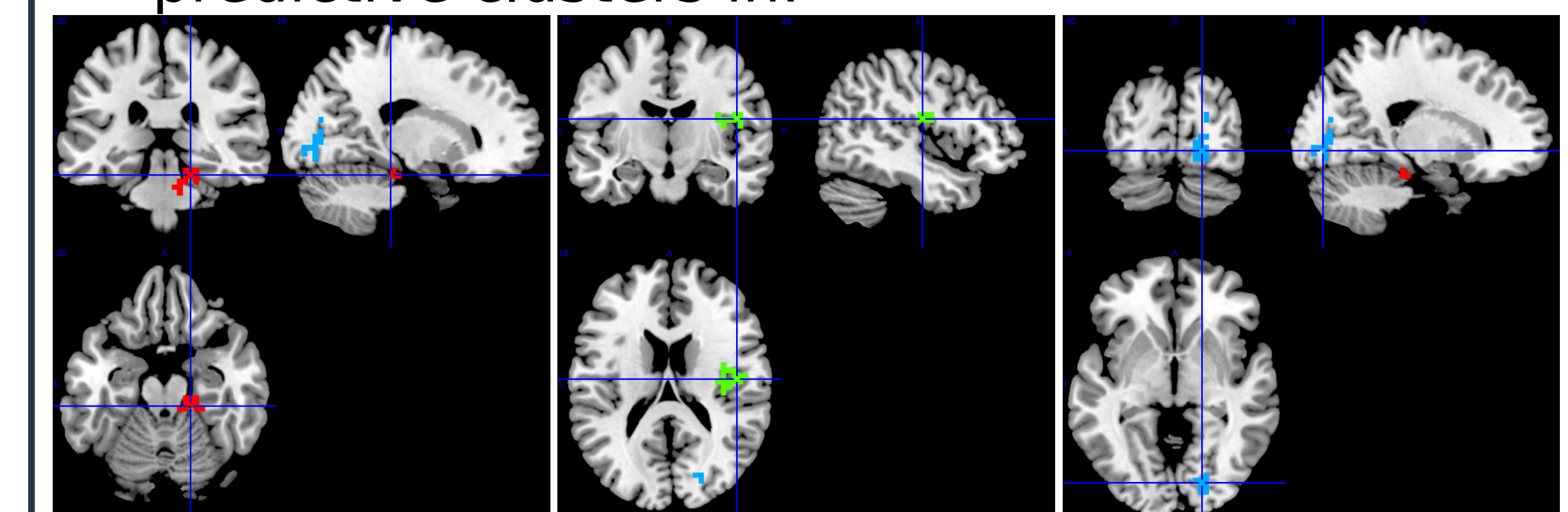- Between-run (4-fold) cross-validation.

Group Cluster Thresholding[2]

- Permute trials 50 times (all subjects, searchlights and cross-validation folds have same permutation).
- Boot-strap 10^5 group chance accuracy maps.

Preliminary Imaging Results

- Regression to the metric reveals significantly predictive clusters in:

Right ventral temporal cortex

Right inferior parietal cortex

Right occipital cortex

Conclusions

- Subject behavior reveals 2 strategy archetypes.
- Metric summarizes strategy on each trial.
- Preliminary MVPA regression results show significant clusters in occipital, inferior parietal, and ventral temporal lobes.