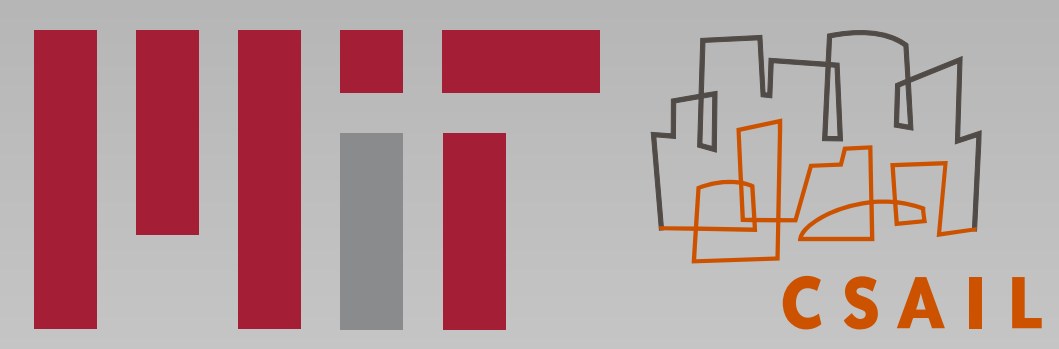




# Plug-and-Play Supervisory Control Using Muscle and Brain Signals for Real-Time Gesture and Error Detection

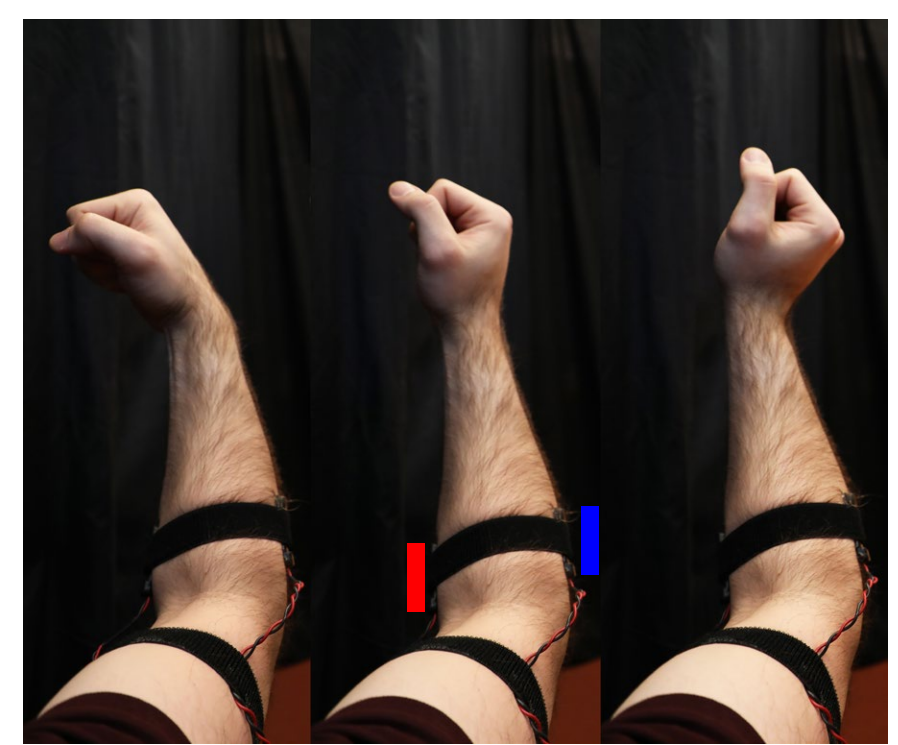


Joseph DelPreto, Andres F. Salazar-Gomez, Stephanie Gil, Ramin M. Hasani, Frank H. Guenther, and Daniela Rus

## Correct Errors

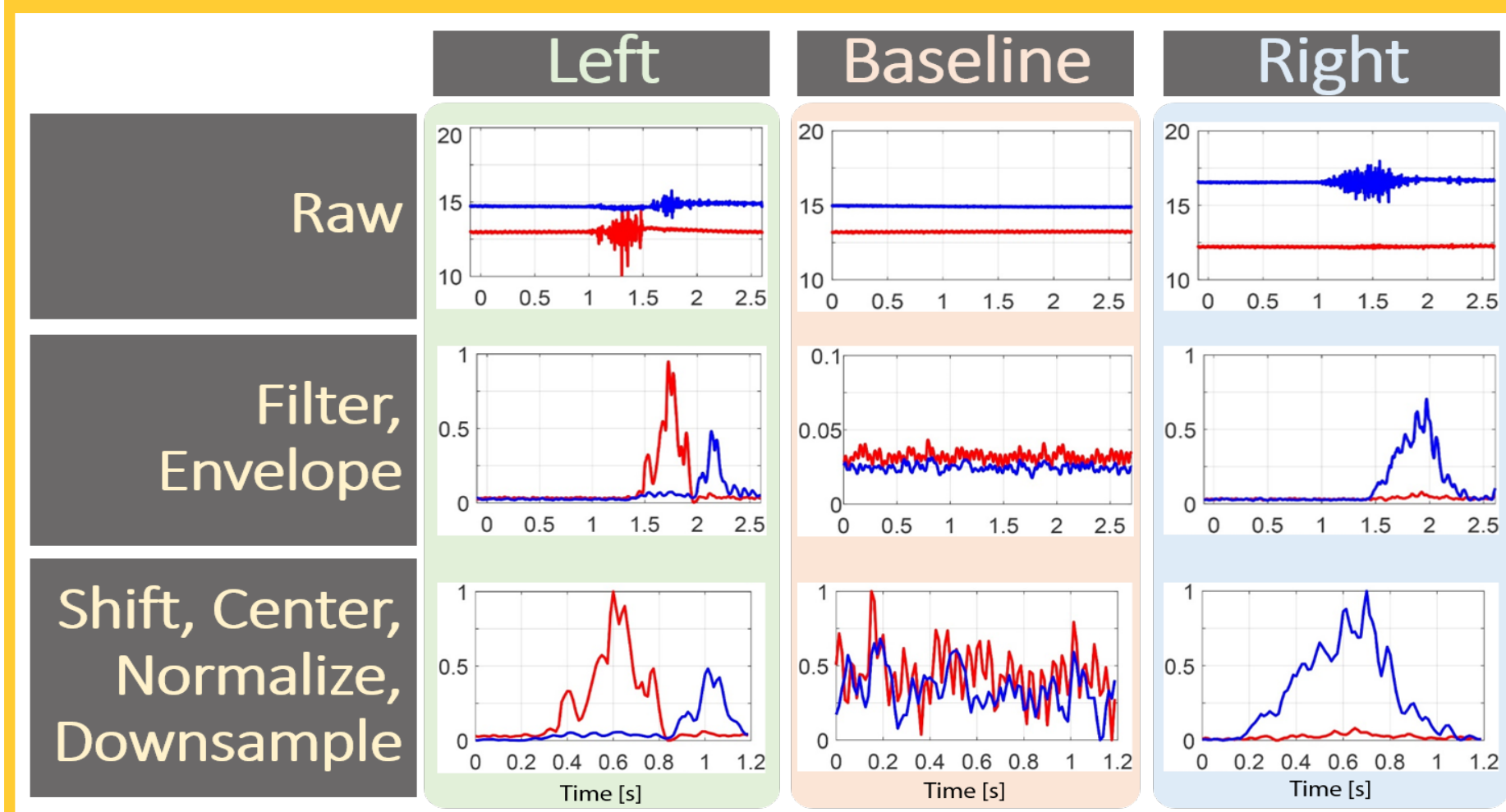


Muscle signals for reliable and natural target selection



Left and right gestures naturally scroll through possible targets at any time. Two forearm EMG electrodes are worn.

## EMG Signal Processing and Feature Extraction



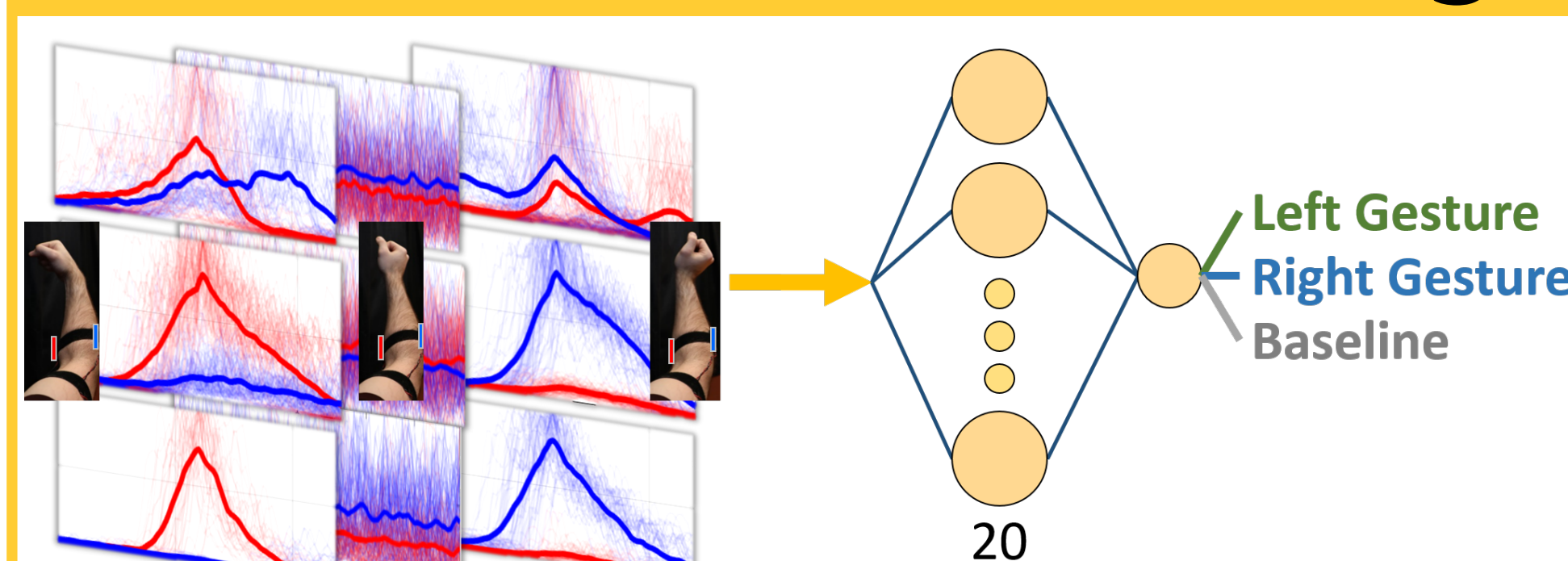
Rolling buffers of 1.2s (96 samples) from each processed EMG channel are concatenated to form a feature vector.

## Data Augmentation for Rolling Classification

Creating new training examples by shifting original gesture examples left and right guides the network towards only predicting gestures when they are centered in the classification window.



## Neural Network Training

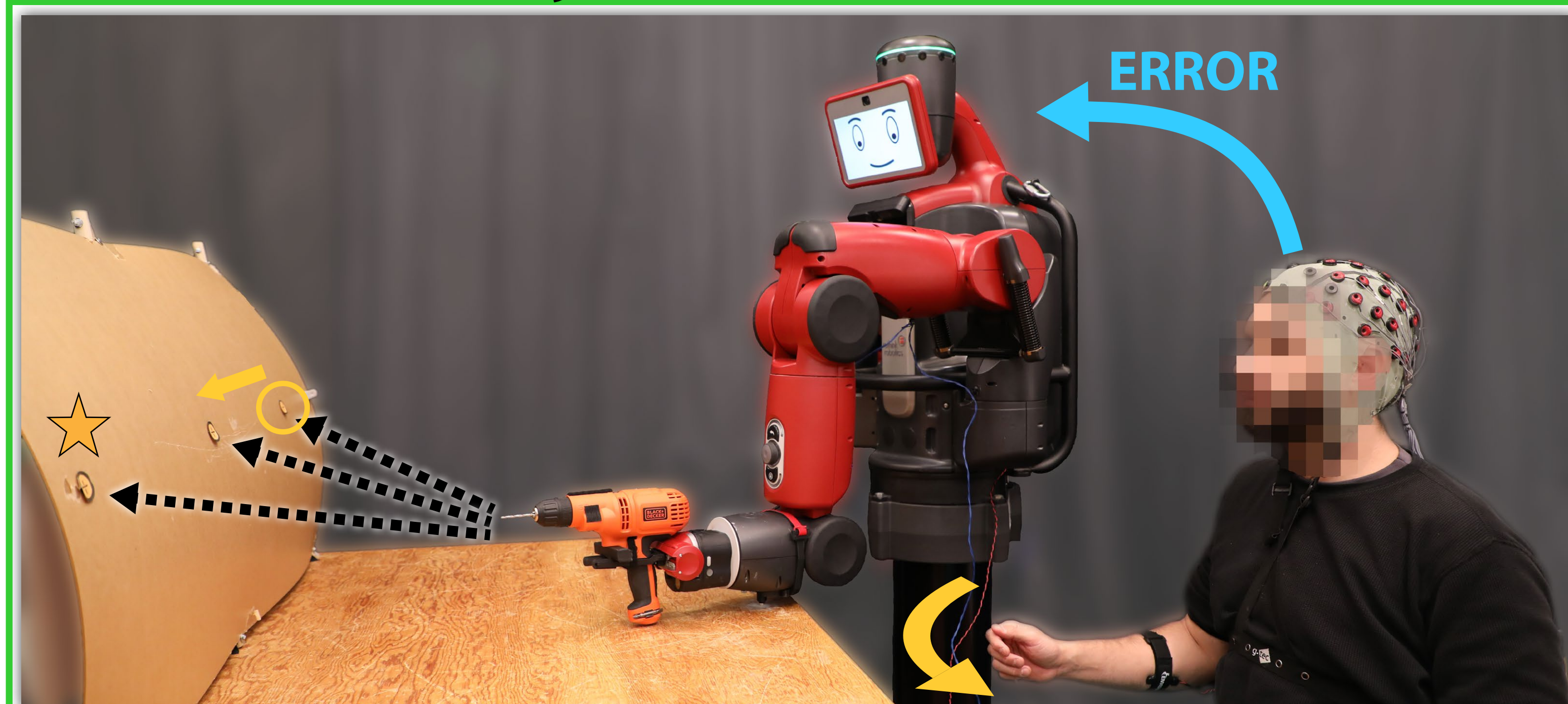


A single-layer neural network was trained on augmented examples from all previous users.

## Contact Information

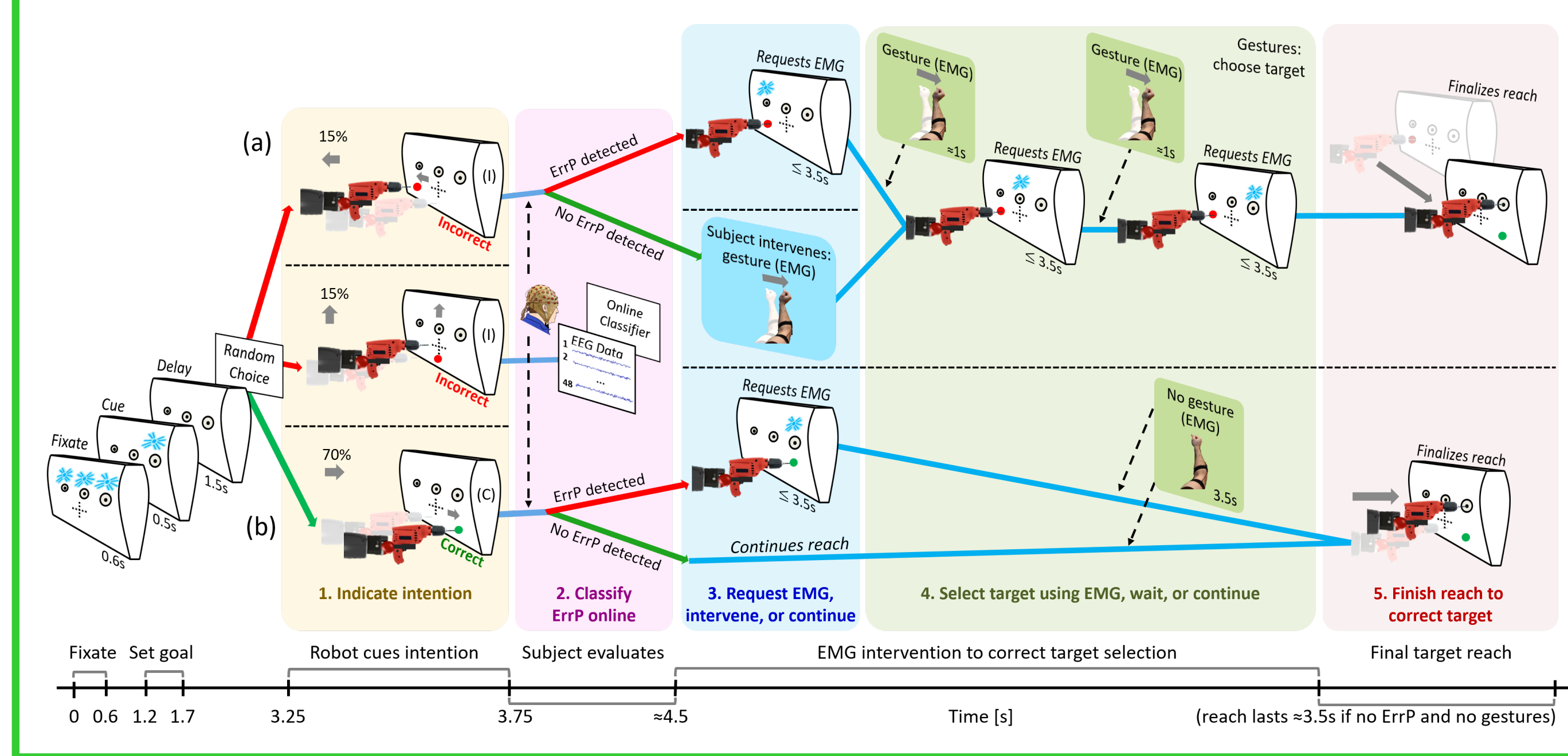
Joseph DelPreto delpreto@csail.mit.edu  
<http://people.csail.mit.edu/delpreto/rss2018>

## Hybrid Control

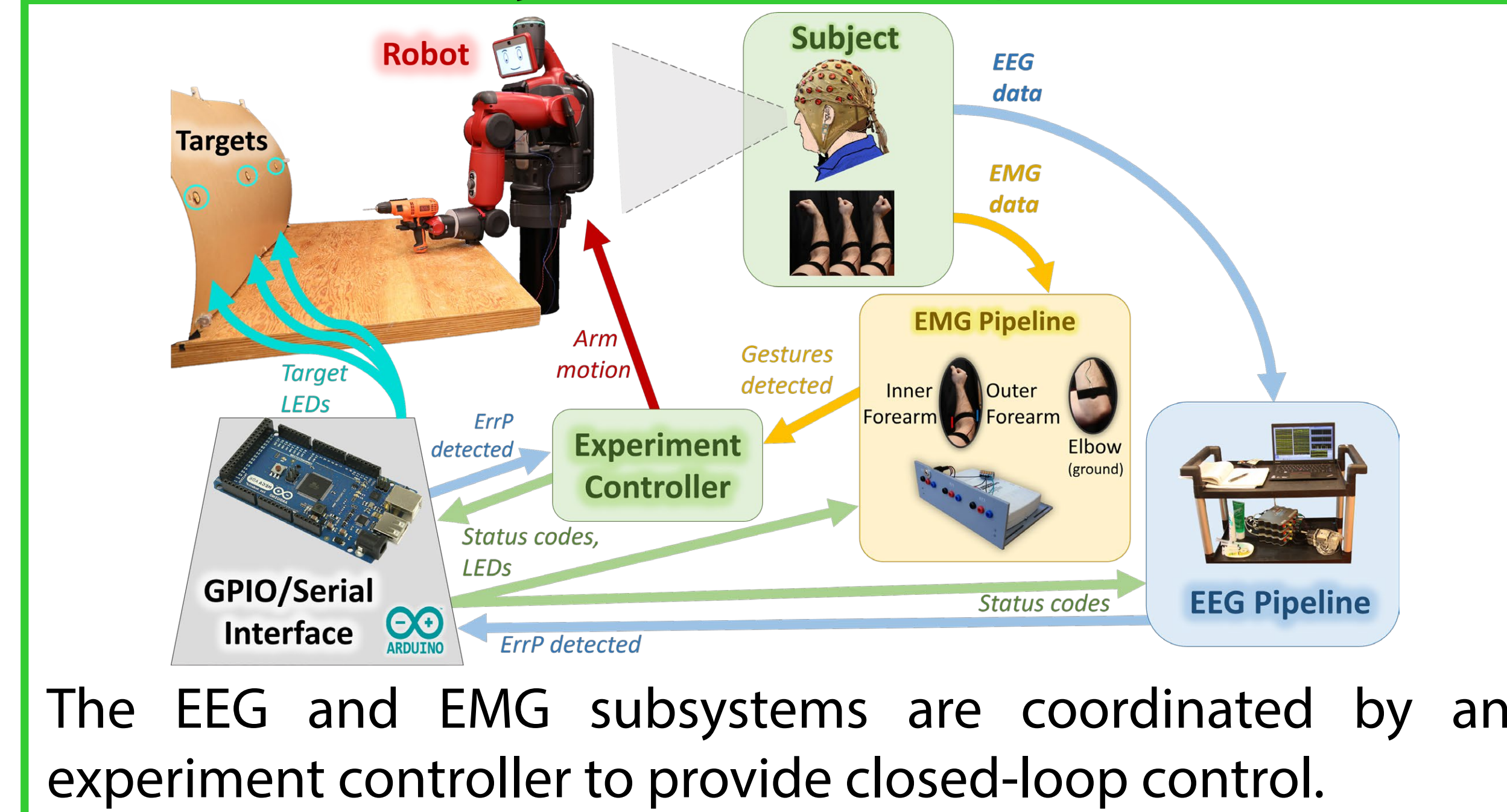


A person supervises an autonomous robot performing a target selection task. Brain signals detect mistakes quickly without requiring users to learn new behaviors, and muscle signals provide refined and reliable corrective control.

## Experimental Paradigm

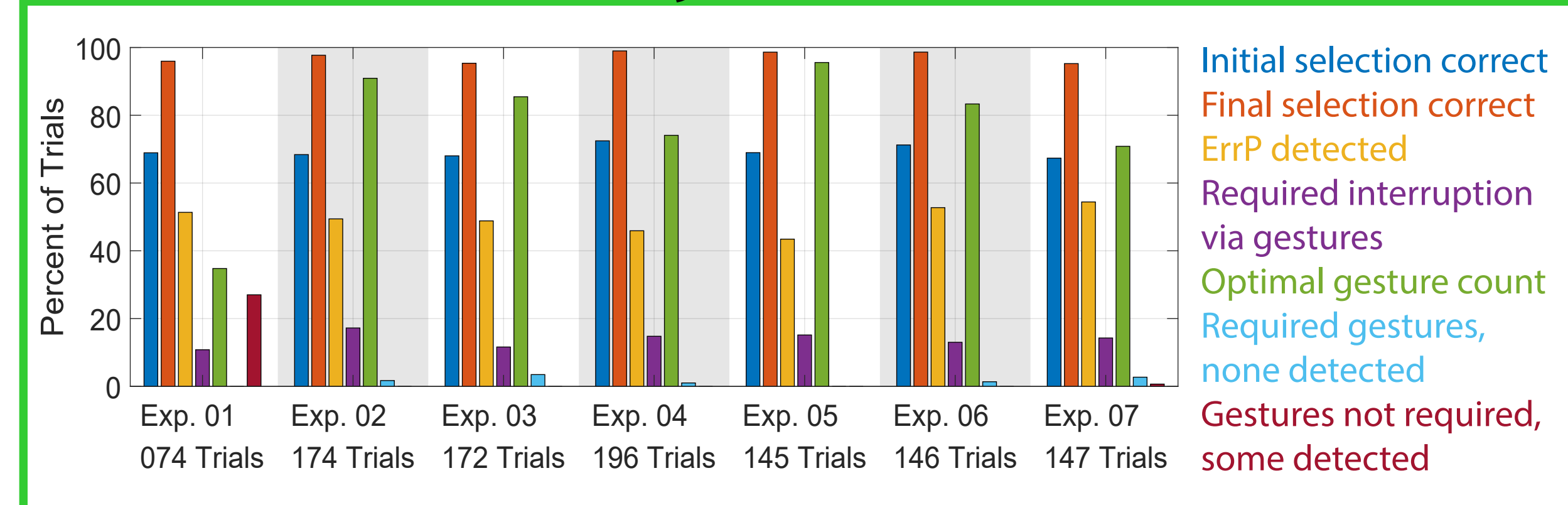


## System Design



The EEG and EMG subsystems are coordinated by an experiment controller to provide closed-loop control.

## Results: System Behavior



## Detect Errors

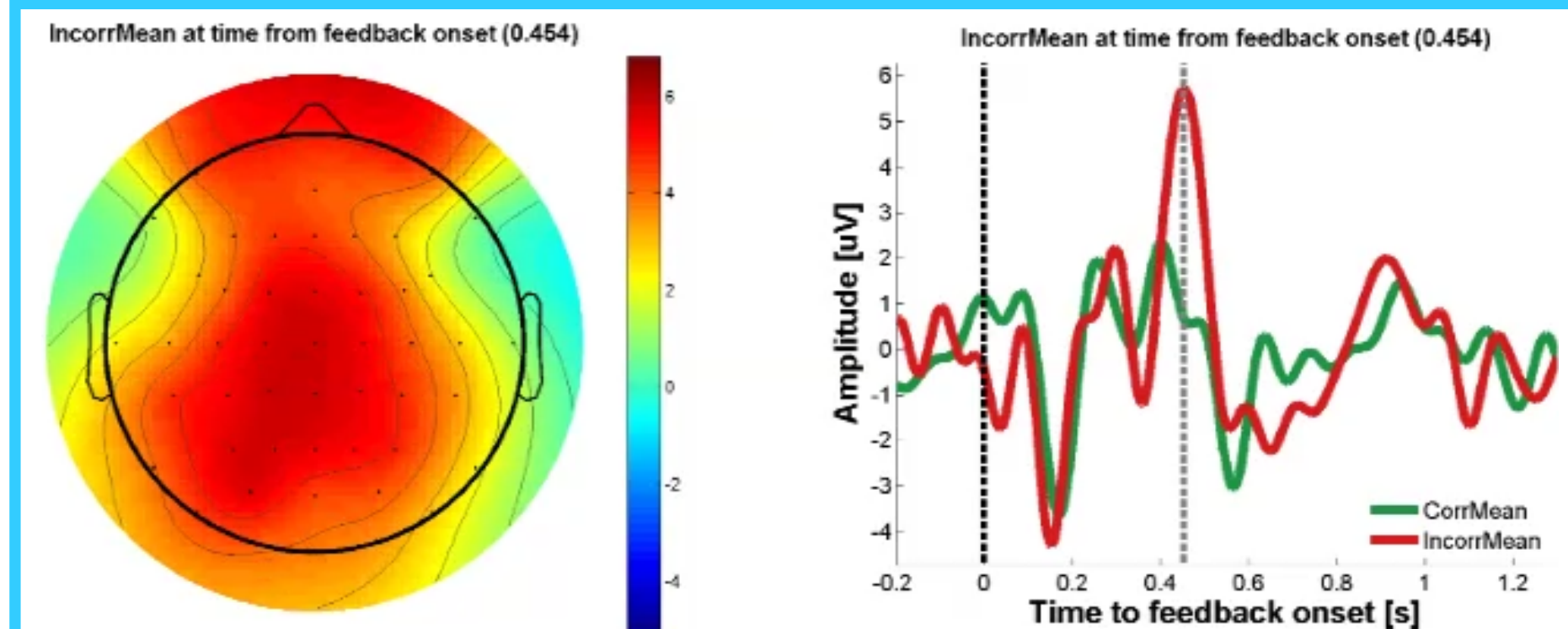


Brain signals for fast detection of error judgments



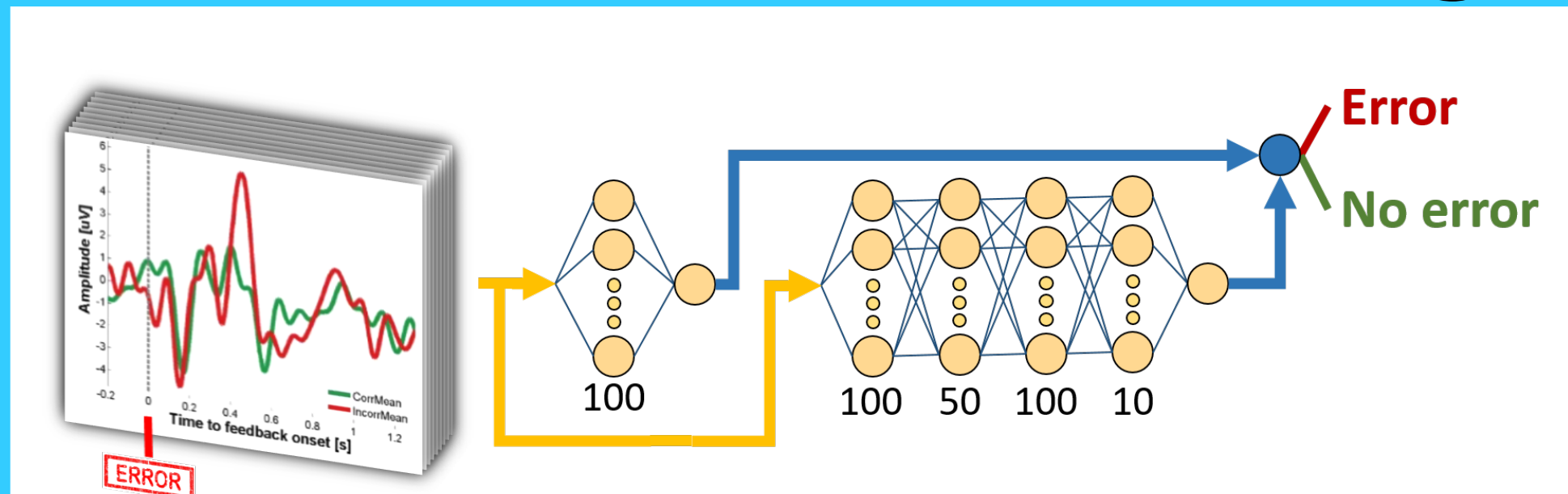
The person mentally evaluates the robot's chosen target while wearing an EEG cap.

## Error-Related Potentials



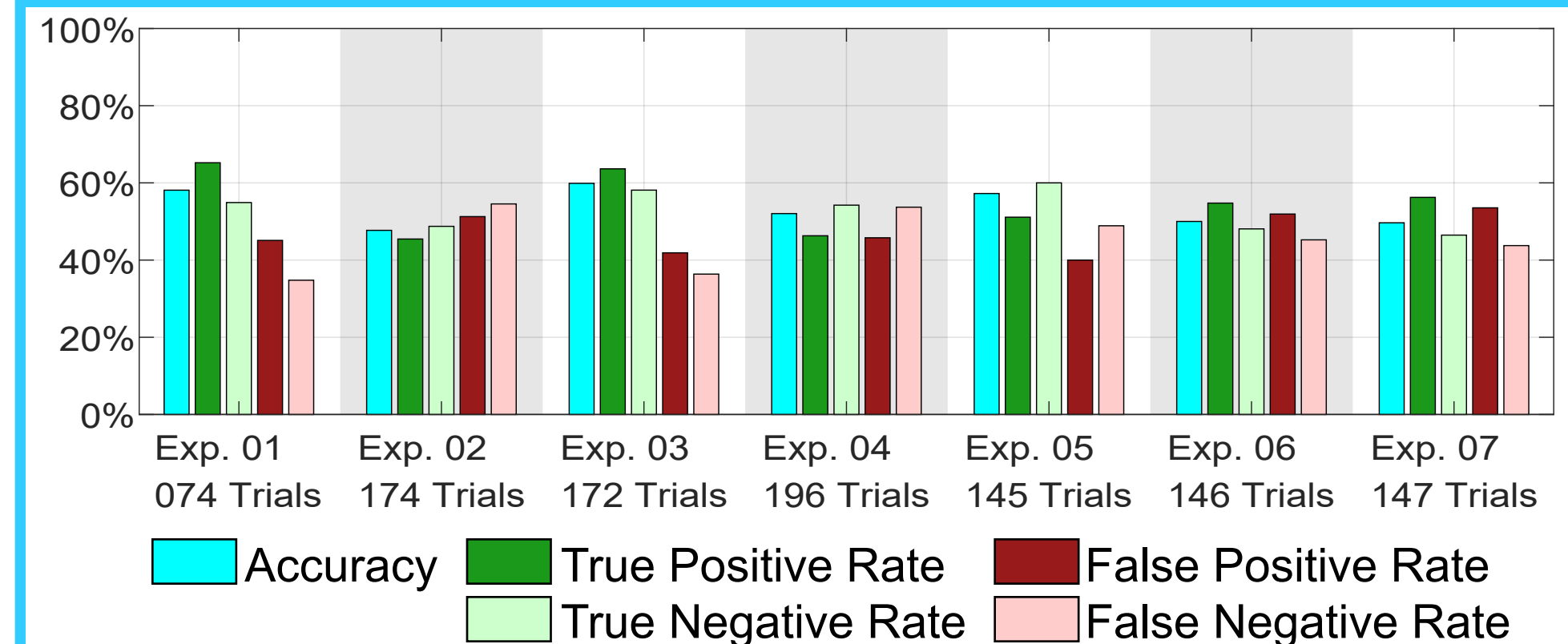
Error-related Potentials (ErrPs) are generated unconsciously in the brain when a person notices an unexpected mistake.

## Neural Network Training

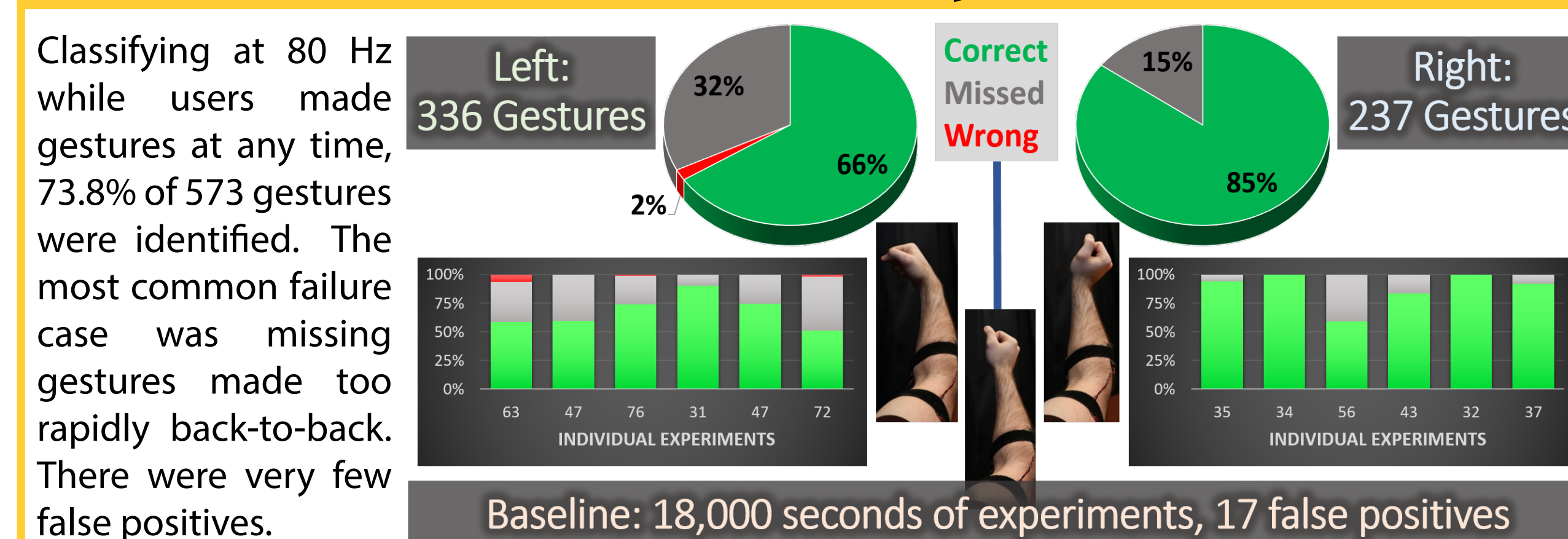


Two networks operating in parallel were trained on buffers of 600ms (154 samples) of filtered EEG data from 9 central electrodes. Only data from 3 previous users was included.

## Results: ErrP Detection

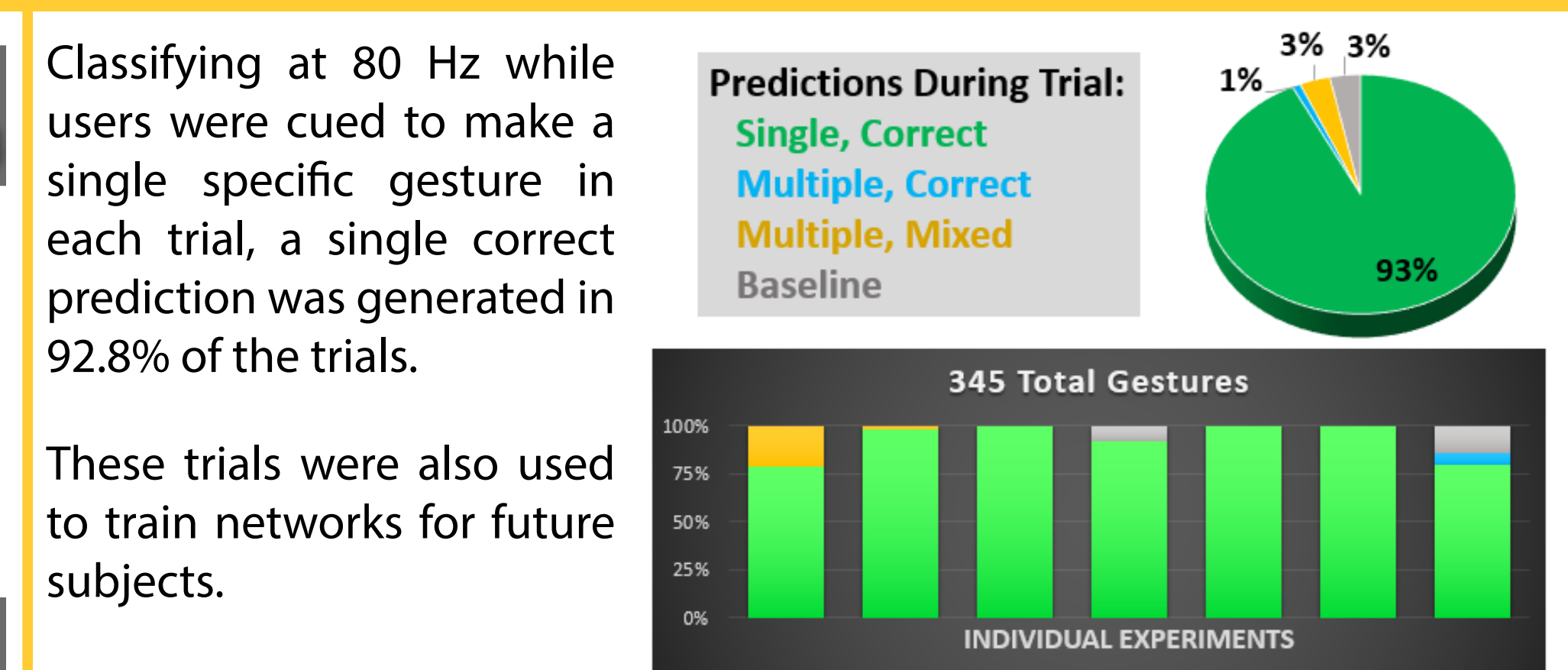


## Results: Arbitrary Gestures



Classifying at 80 Hz while users made gestures at any time, 73.8% of 573 gestures were identified. The most common failure case was missing gestures made too rapidly back-to-back. There were very few false positives.

## Results: Cued Gestures



Classifying at 80 Hz while users were cued to make a single specific gesture in each trial, a single correct prediction was generated in 92.8% of the trials. These trials were also used to train networks for future subjects.