

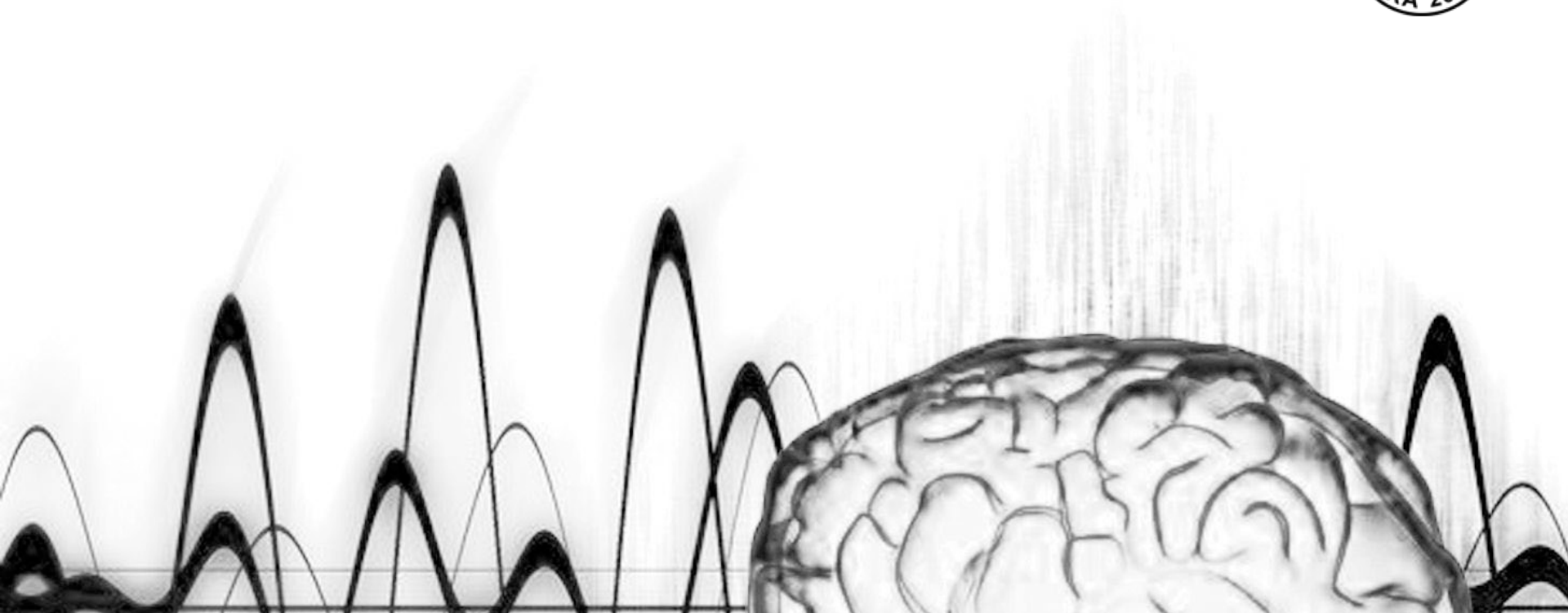
# Design and Experimental Evaluation of a Skin-Stretch Haptic Device for Improved Control of Brain-Computer Interfaces

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# Background

## Haptics for BCI?

### VIBROTACTILE

### KINESTHETIC

PROS

devices are...

- small, portable
- low-cost
- low-power and safe

feedback is...

- natural
- intuitive
- known to improve BCI

CONS

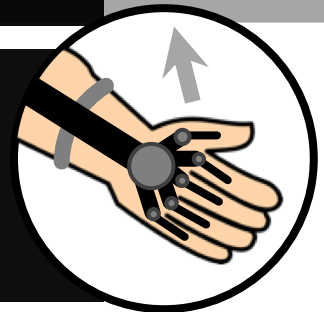
feedback is...

- unnatural
- hard to interpret
- no better than visual



devices are...

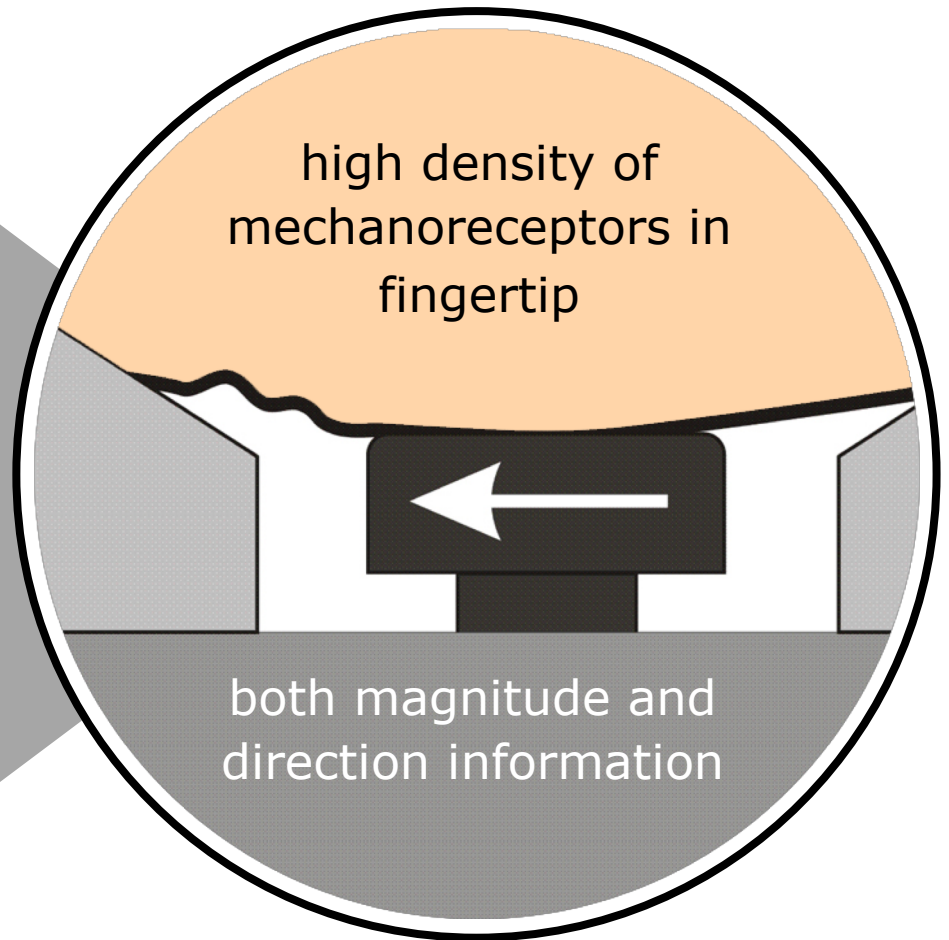
- unwieldy
- expensive
- potentially unstable



# Background

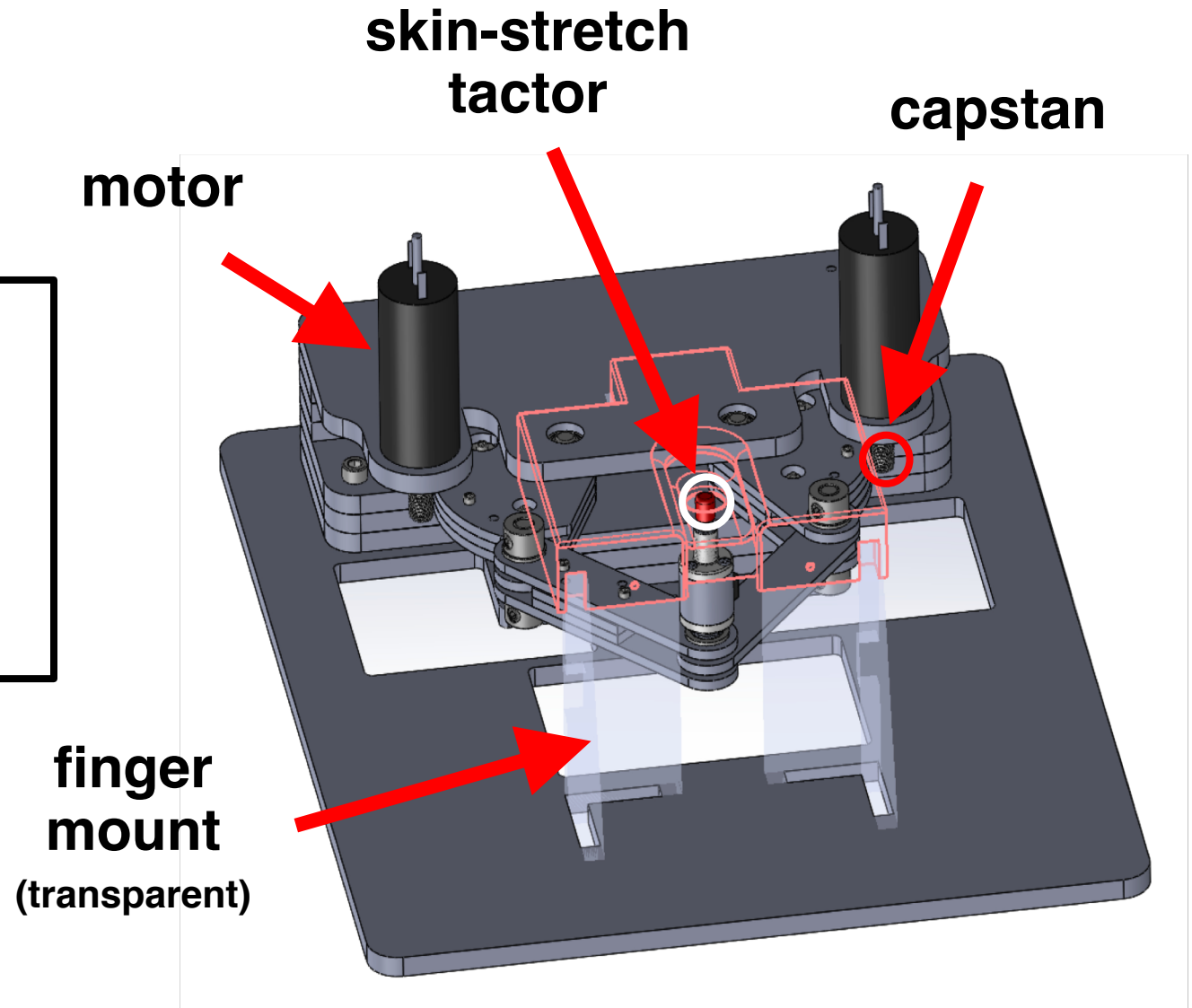
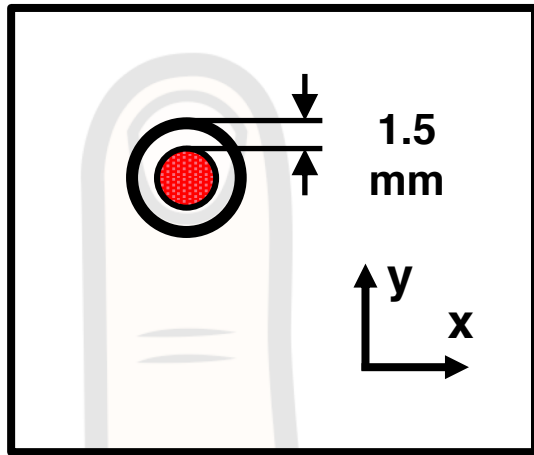
## SKIN STRETCH

- natural trajectories
- small actuators
- highly portable



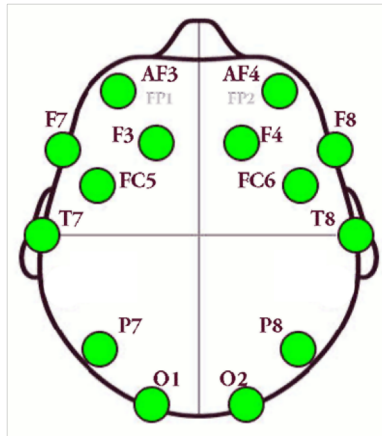
(Gleeson, Stewart, & Provancher, 2011)

# Design



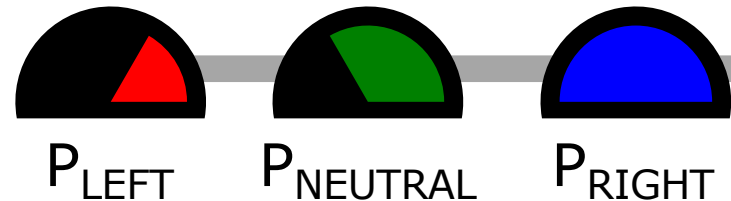
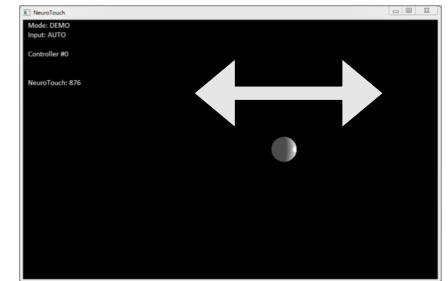
# Design

EEG readings  
at 14 locations



Machine-Learning  
Algorithms

**GUI**



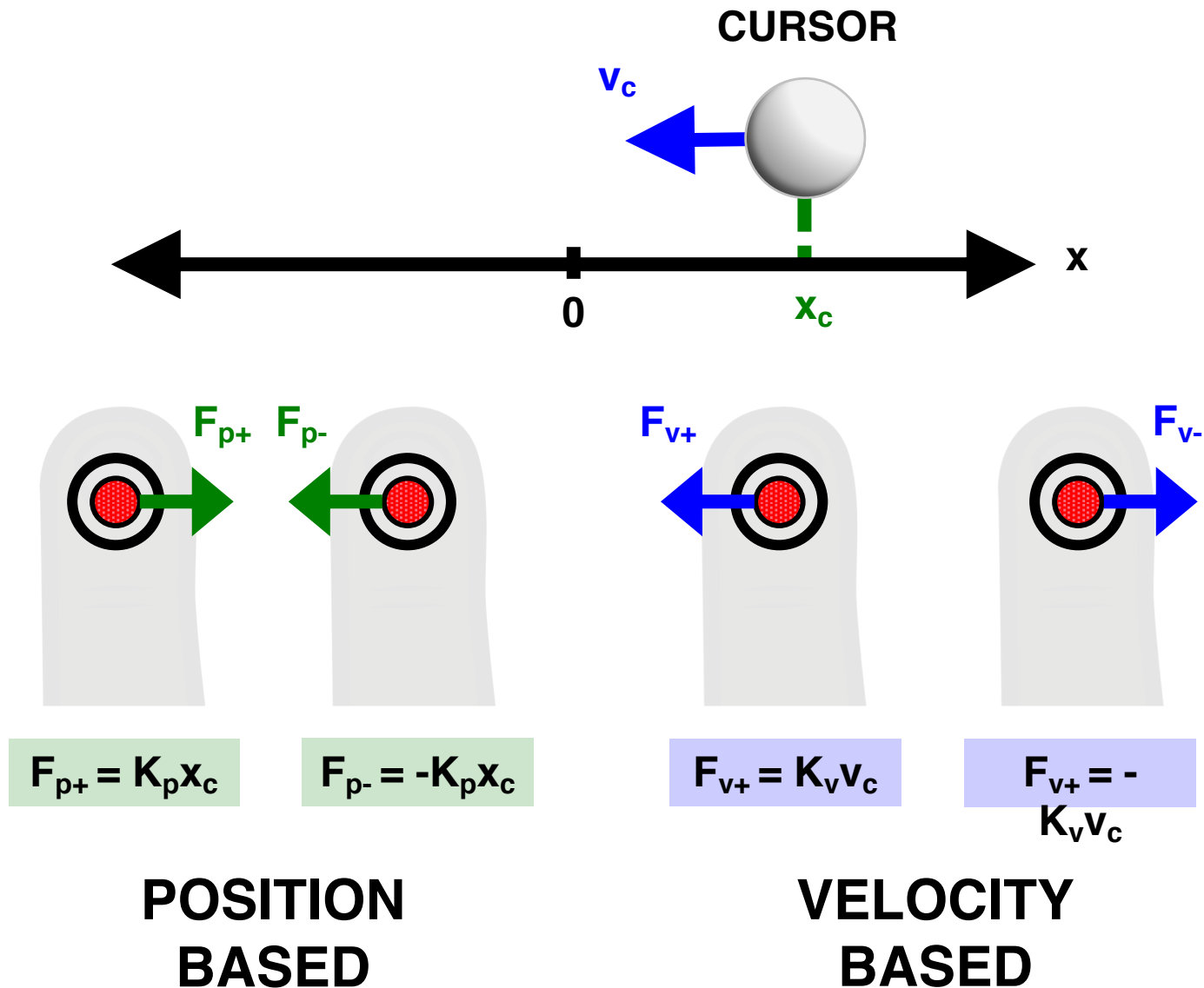
**COGNITIVE POWERS**

$$P \in [0,1]$$

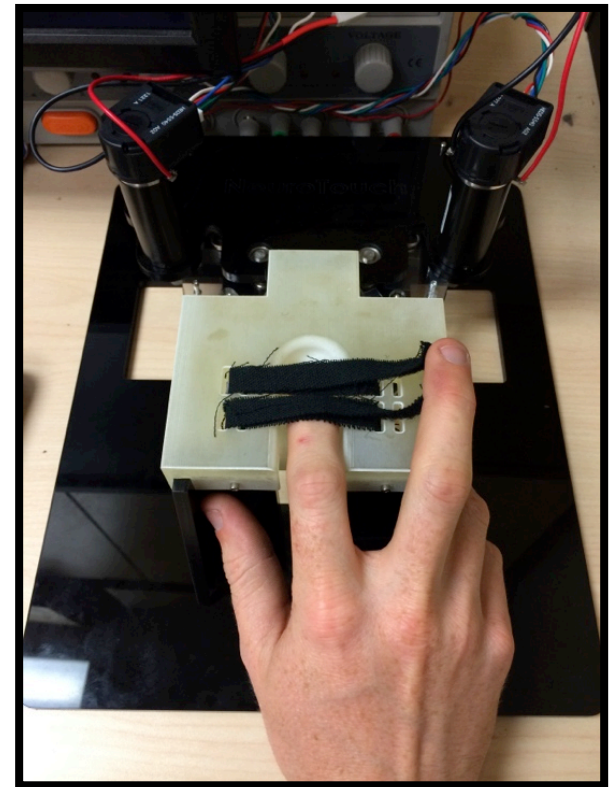
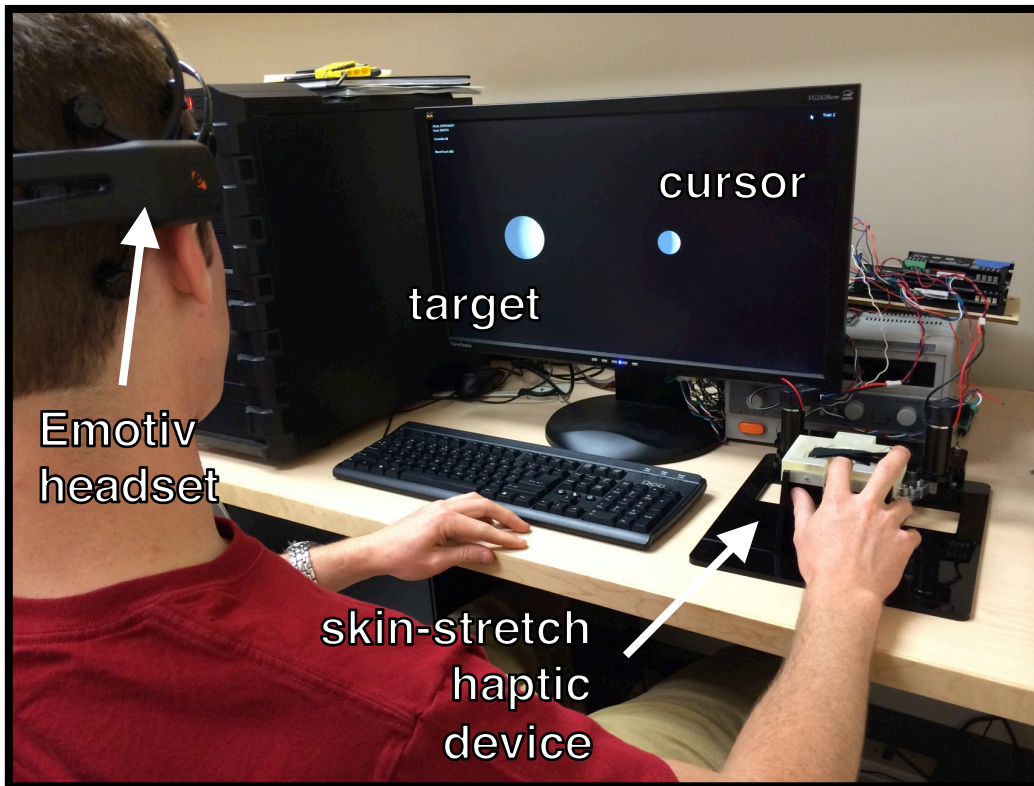


**Emotiv™ EPOC Neuroheadset**

# Control



# Evaluation

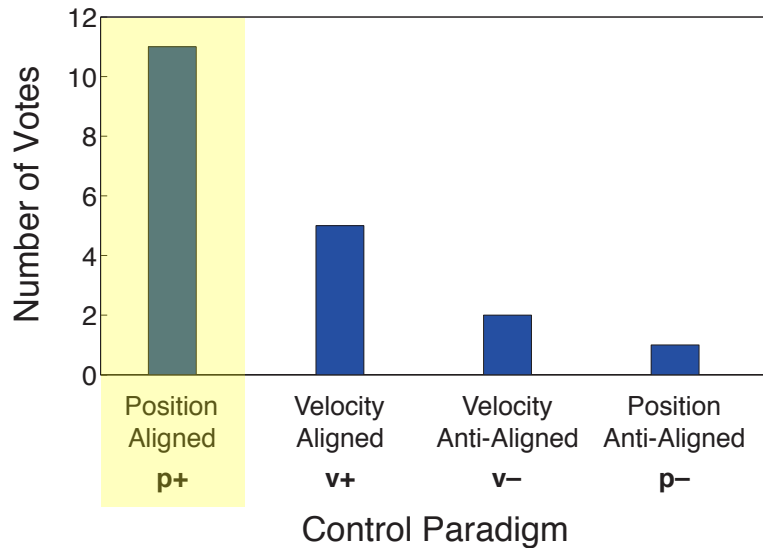


**2-4** sessions of **4** blocks of **20** trials each, with blocks alternating between control with and without haptic feedback



# Results

## Intuitiveness

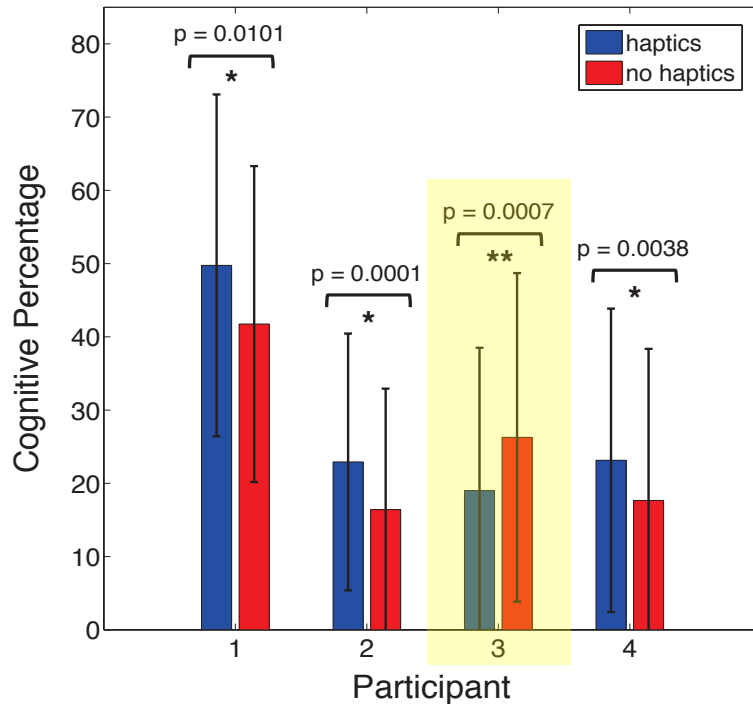


**Skin stretch is likely interpreted as a substitute for proprioception.**



# Results

## Performance



***Appropriately applied skin-stretch feedback has the potential to improve BCI control.***

# Thanks

## **Device Design**

Zhan Fan Quek & Andrew Stanley

## **Software Programming**

Dr. Tricia Gibo & Sam Schorr

## **Experimental Design**

Dr. Jaimie Henderson

## **Data Analysis**

Dr. Ilana Nisky

## **Seminal Work on Skin Stretch**

Dr. William Provancher

EMOTIV

Stanford University

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