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These are the slides for the talk presented at UIST 2025 by Yudai Tanaka.

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You can watch the live talk [here: https://youtu.be/ur-O6NihVY8](https://youtu.be/ur-O6NihVY8)

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If you need a PPTX/editable version for your class, email us hci@uchicago.edu

More on this paper (or others of our lab) at: <https://lab.plopes.org/#primed-action>



Primed Action: Preserving Agency while Accelerating Reaction Time via Subthreshold Brain Stimulation

Yudai Tanaka, Hunter Mathews, Pedro Lopes. In Proc. UIST'25 (paper)

We present Primed Action, a novel interface concept that leverages this type of TMS-based faster reactions. What sets Primed Action apart from prior work that uses muscle stimulation to “force” faster reactions is that our approach operates below the threshold of movement—it does not trigger involuntary motion, but instead it “primes” neurons in the motor cortex by enhancing their neural excitability. As we found in our study, Primed Action best preserved participants’ sense of agency than existing interactive approaches based on muscle stimulation (e.g., Preemptive Action). We believe this novel insight enables new forms of haptic assistance that do not sacrifice agency, which we demonstrate in a set of interactive experiences (e.g., VR sports training).



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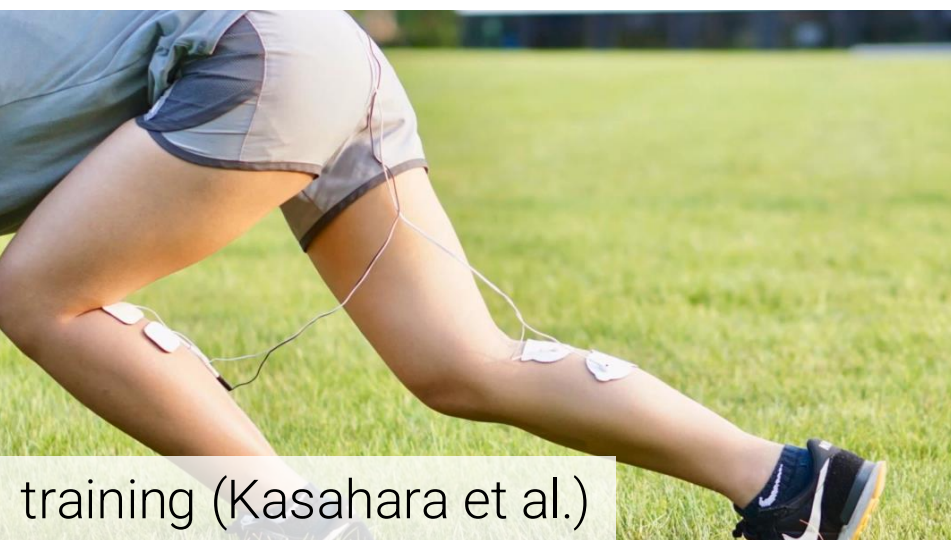
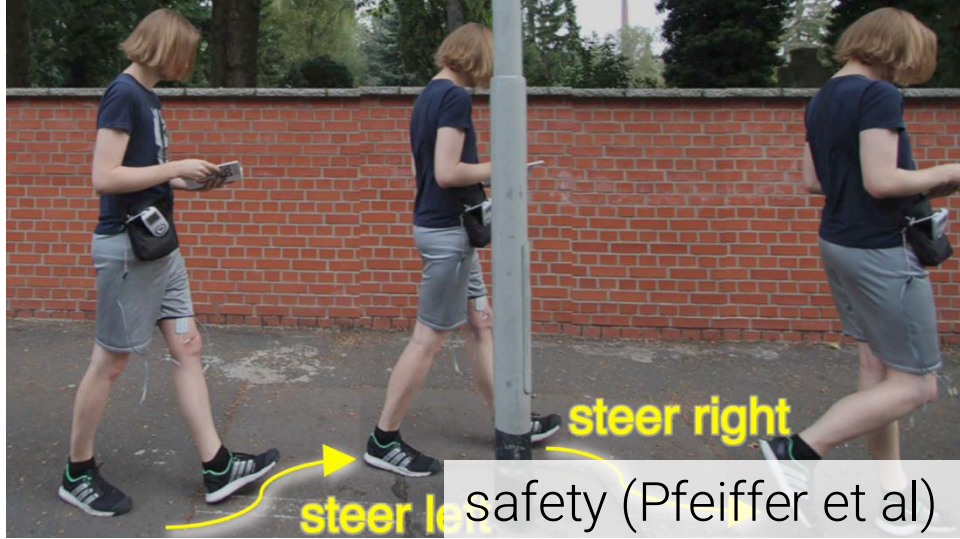
primed action: preserving agency while accelerating
reaction time via *subthreshold* brain stimulation

yudai tanaka, hunter mathews, pedro lopes



THE UNIVERSITY OF
CHICAGO

motivation: reduce intention–action gap





fast decision (Nishida et al.)



safety (Pfeiffer et al)



training (Kasahara et al.)



e-sports (Zhou et al.)



electrical muscle stimulation (**EMS**)



it forces one outcome,
overriding their intention



can we do this without any involuntary actuation?



our approach: **primed action**



voluntary movement: how does it occur?



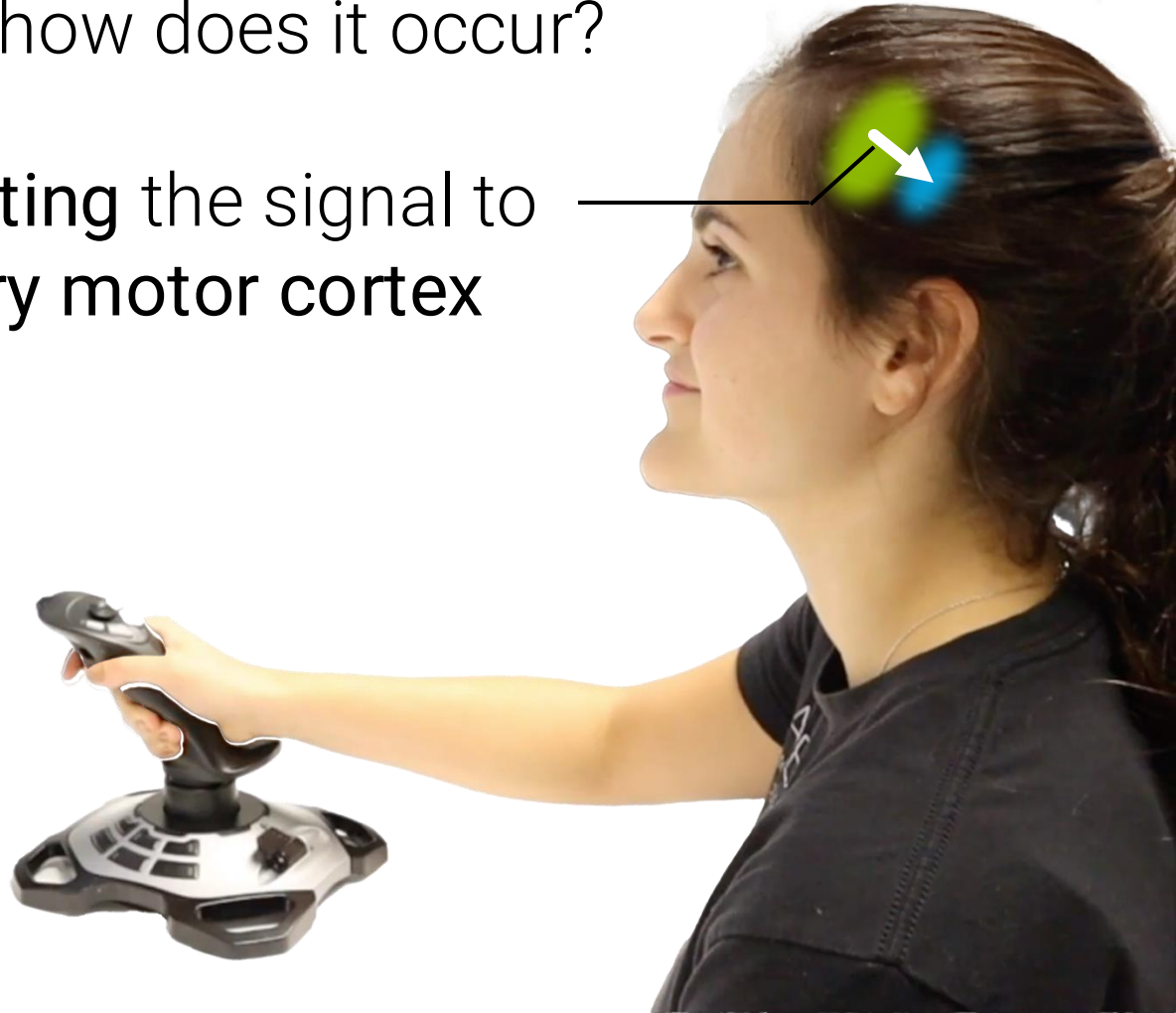
voluntary movement: how does it occur?

neurons in **premotor cortex** excite,
(motor **planning**)



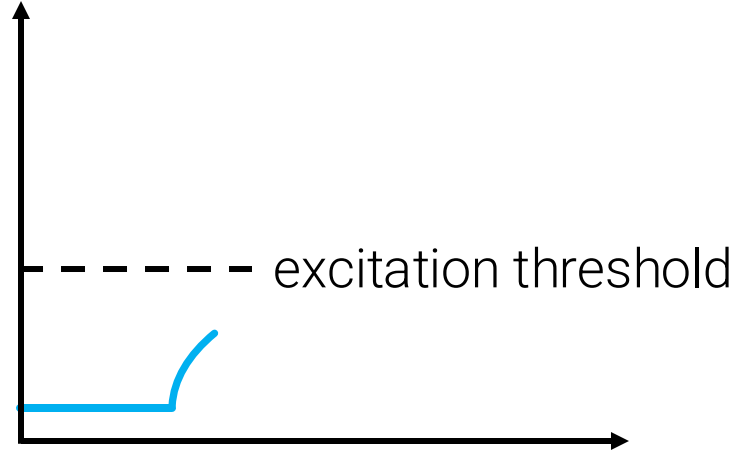
voluntary movement: how does it occur?

projecting the signal to
primary motor cortex

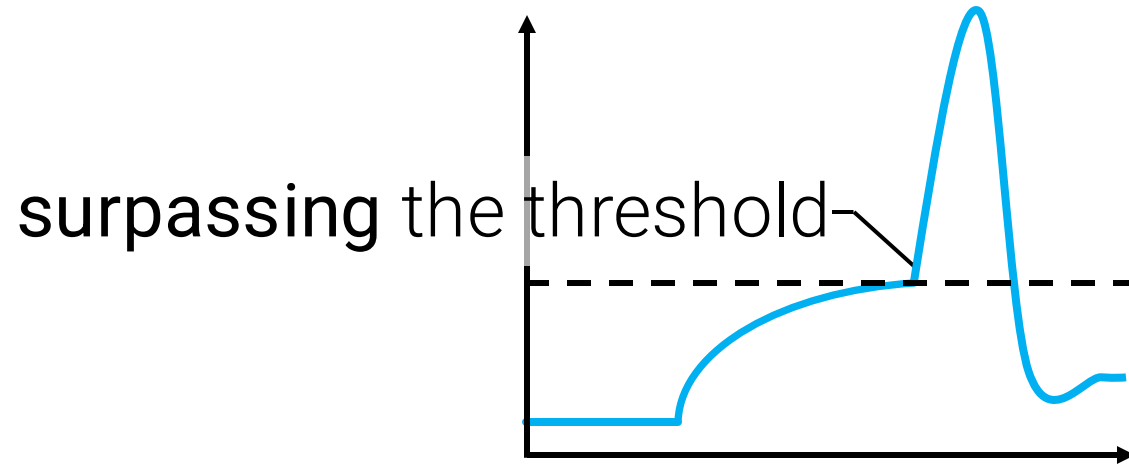


voluntary movement: how does it occur?

action potential

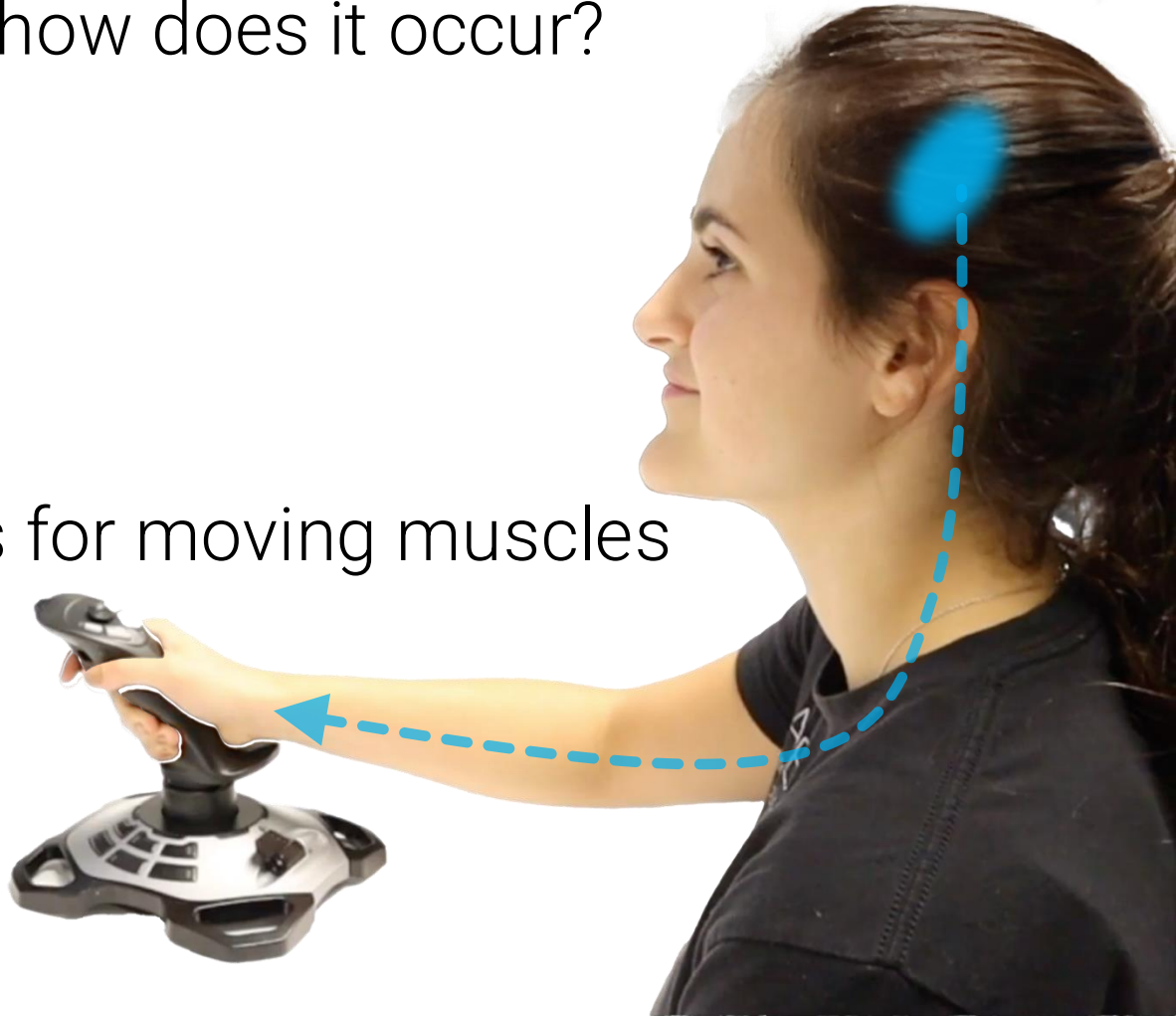


voluntary movement: how does it occur?



voluntary movement: how does it occur?

generating signals for moving muscles

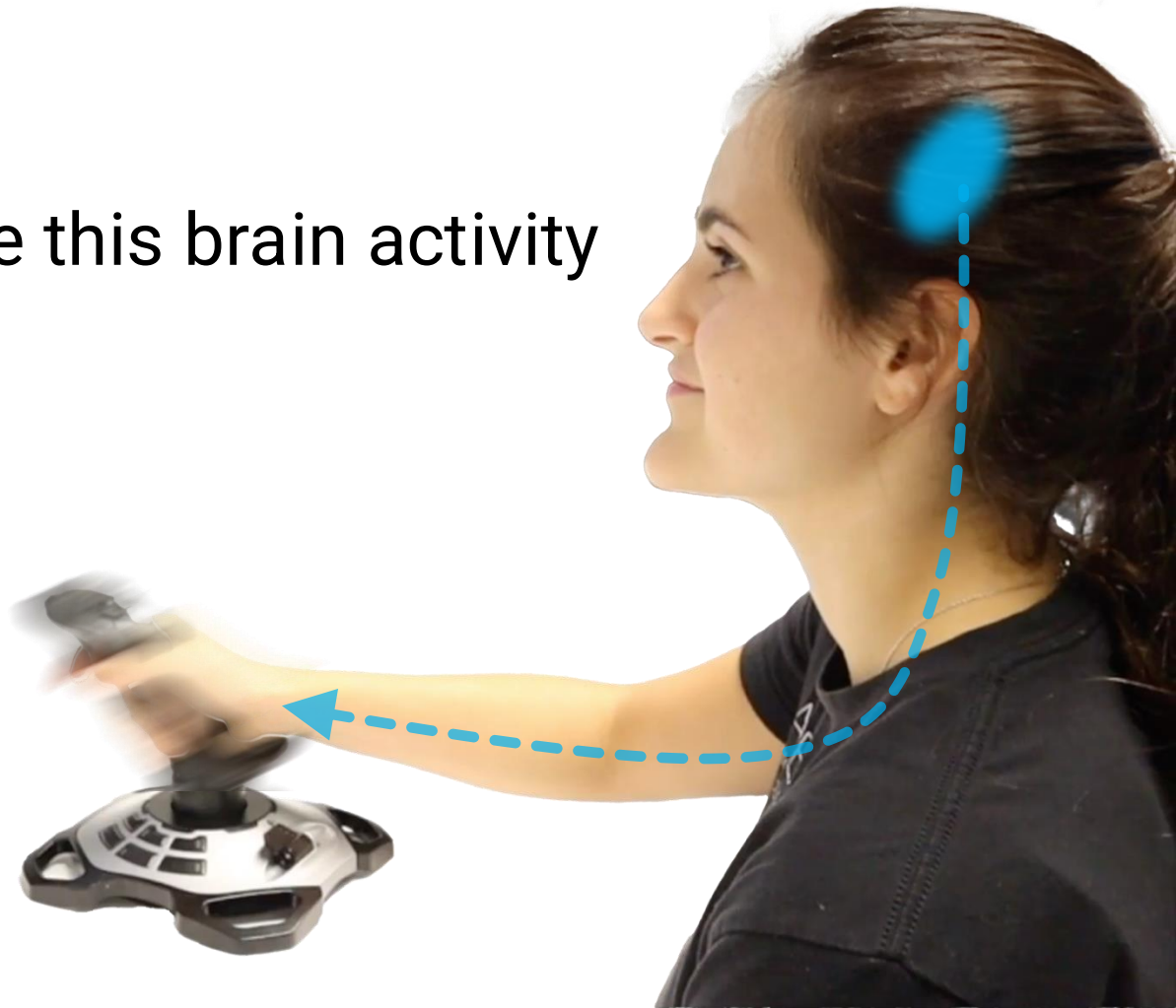


voluntary movement: how does it occur?

voluntary movement



my proposal: modulate this brain activity

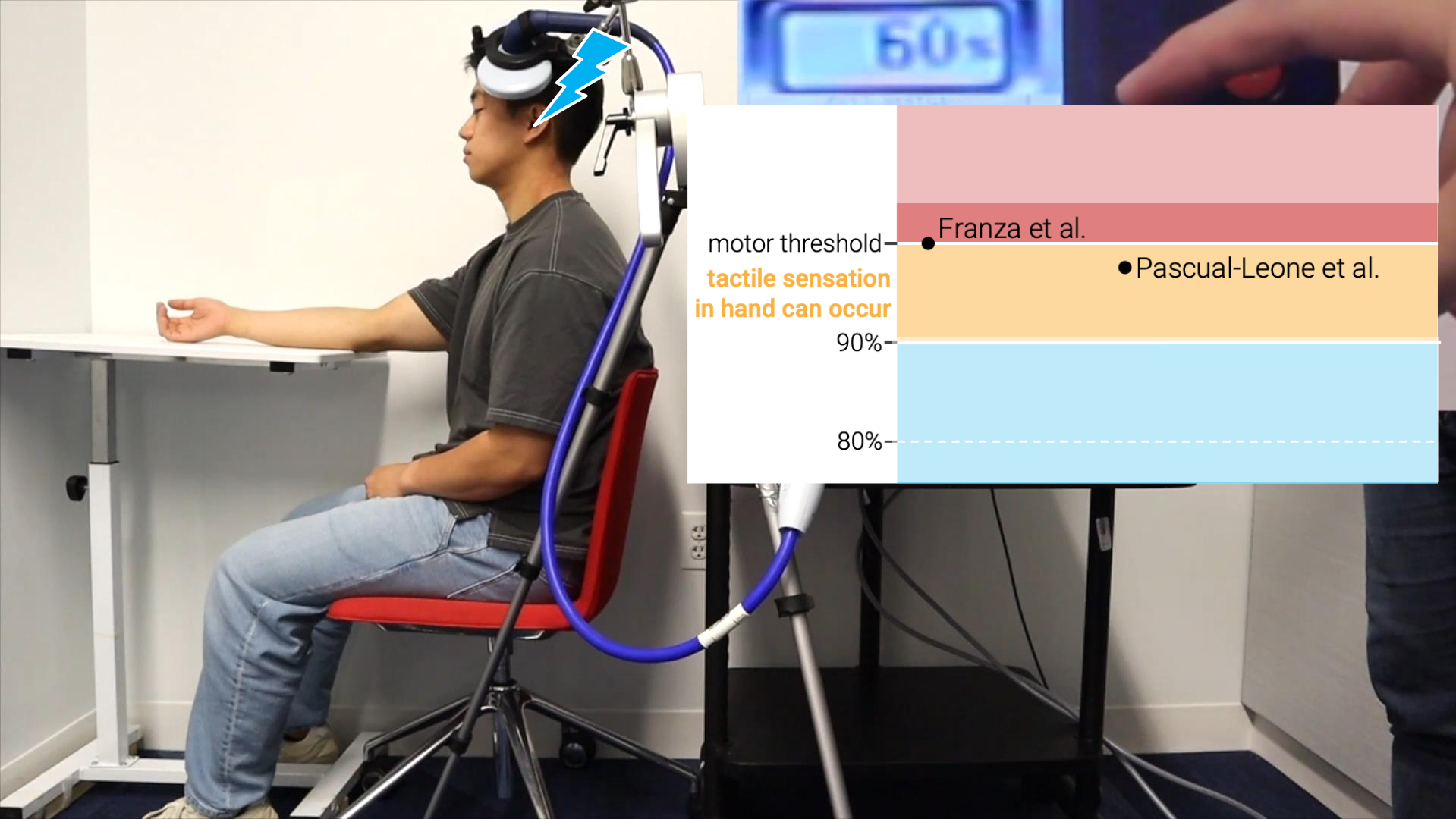


my proposal: modulate this brain activity
via *subthreshold* brain stimulation



transcranial magnetic stimulation (TMS)





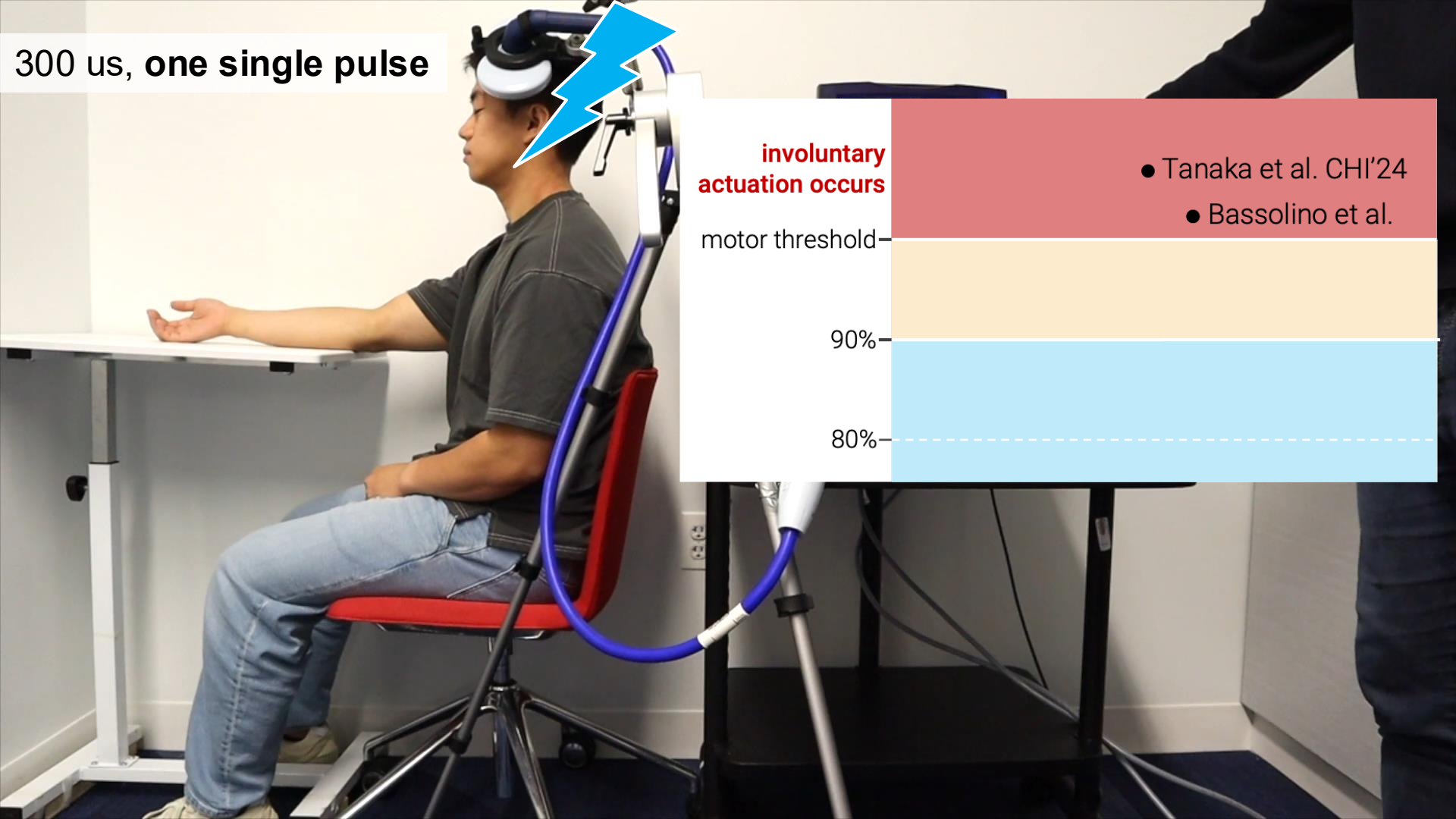
motor threshold—
tactile sensation
in hand can occur

90%—

80%—

• Franza et al.

• Pascual-Leone et al.



300 us, **one single pulse**

**involuntary
actuation occurs**

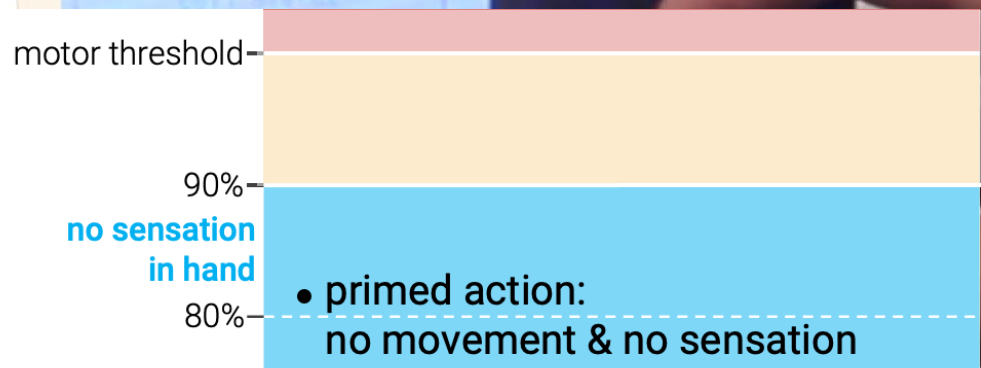
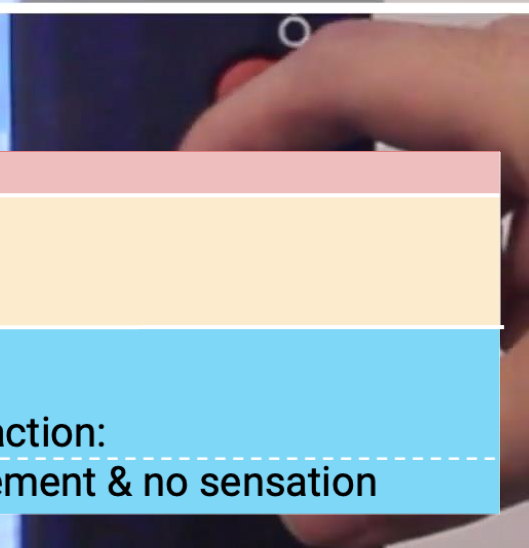
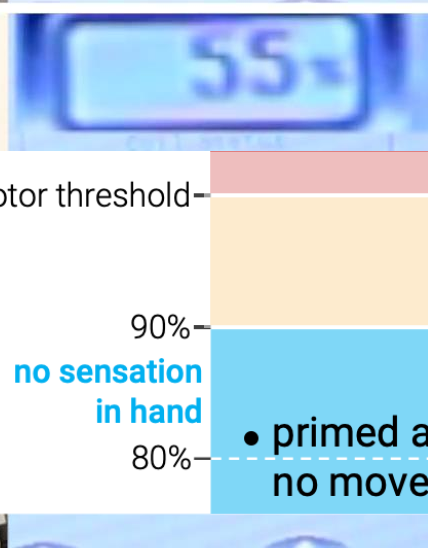
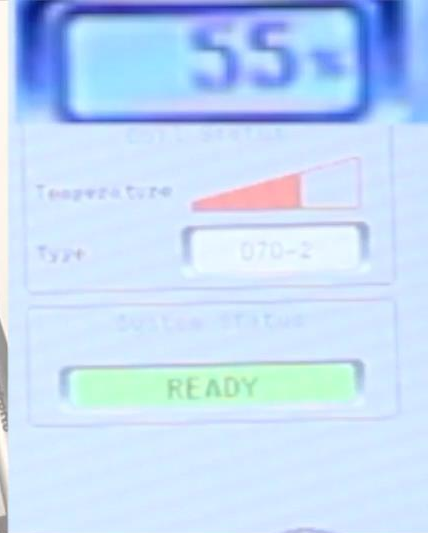
motor threshold

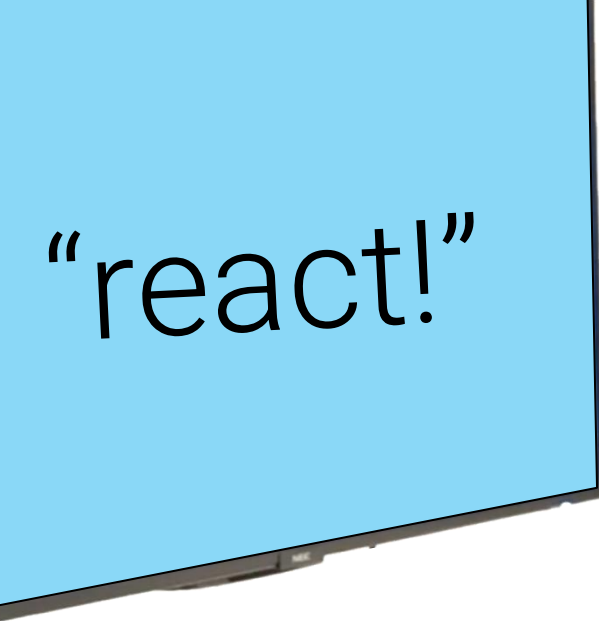
90%

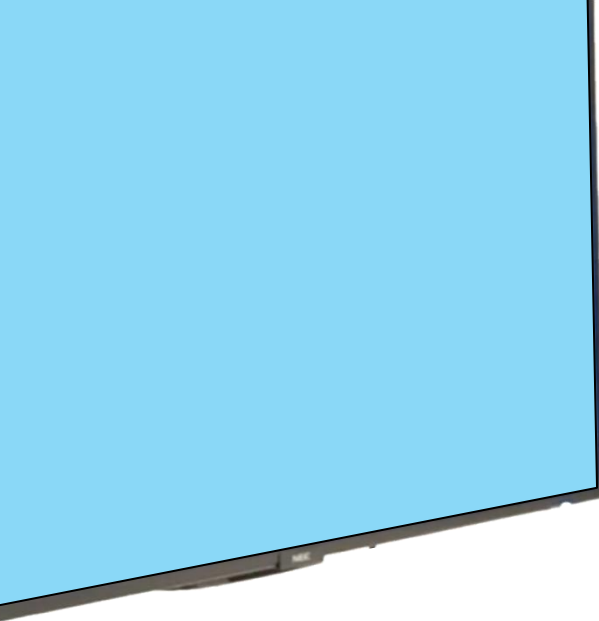
80%

• Tanaka et al. CHI'24

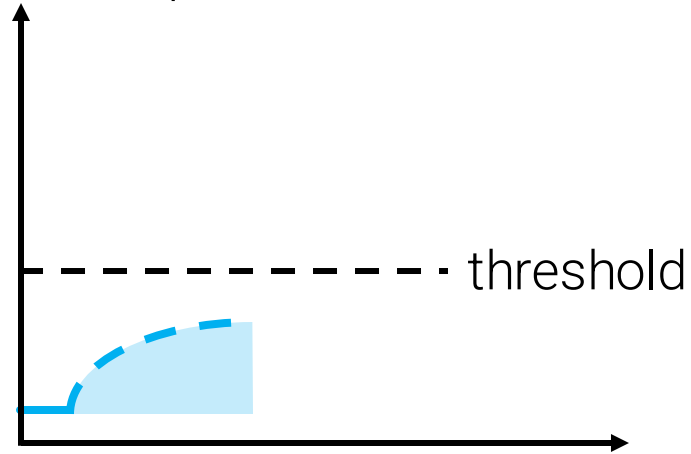
• Bassolino et al.

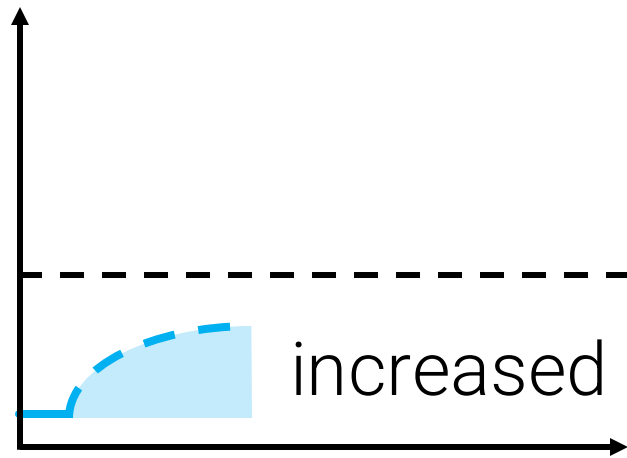
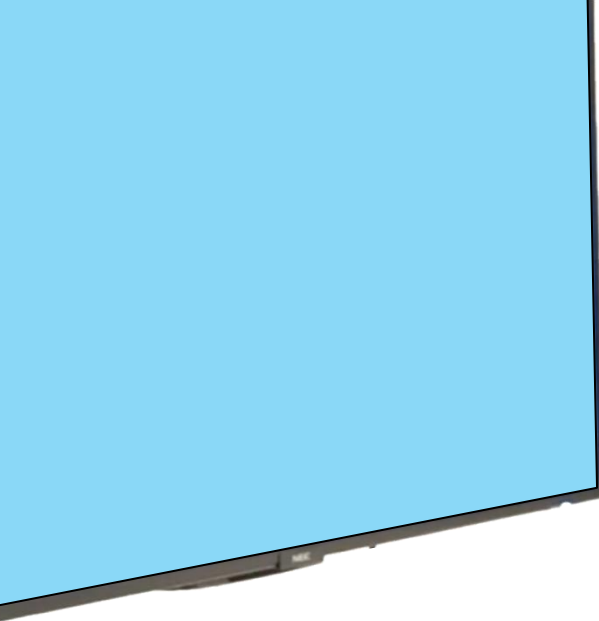


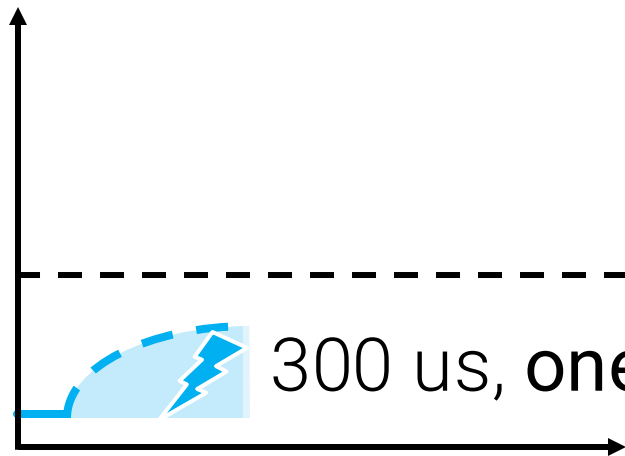
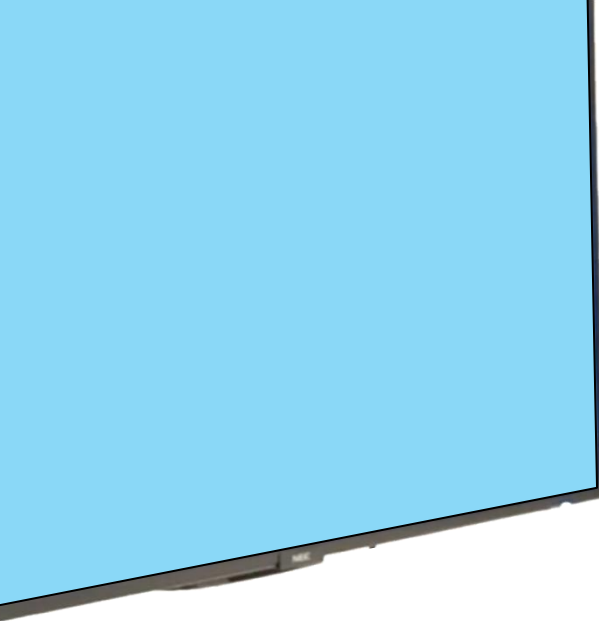




action potential

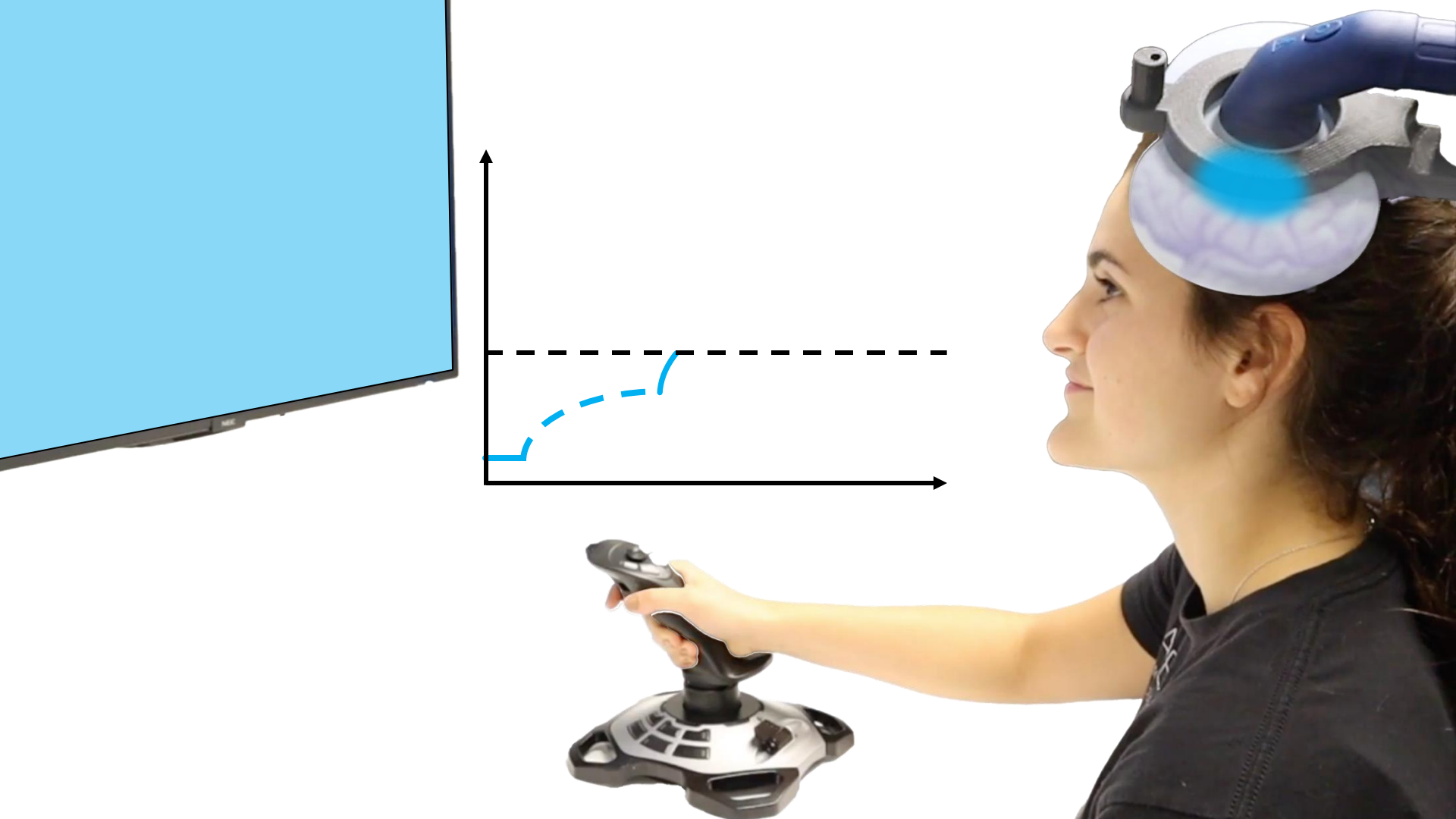


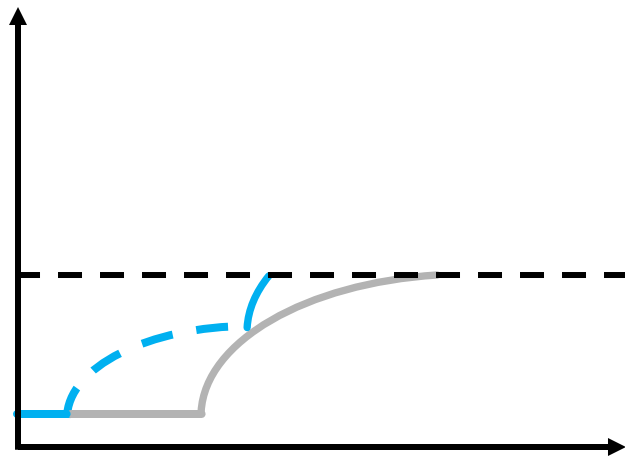
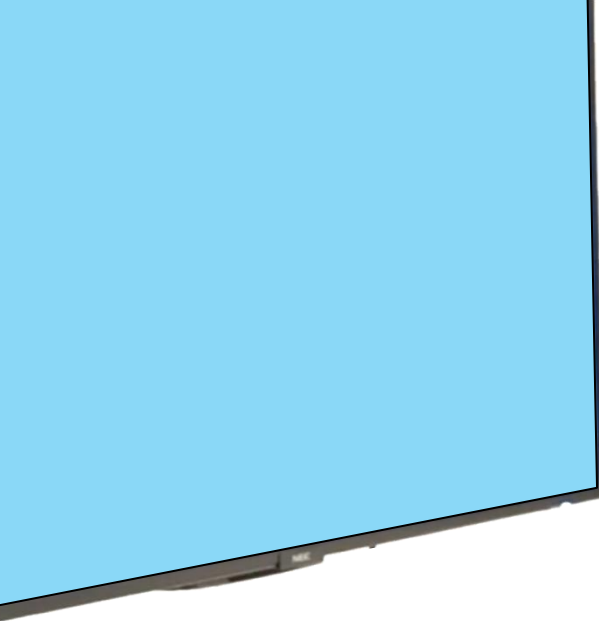


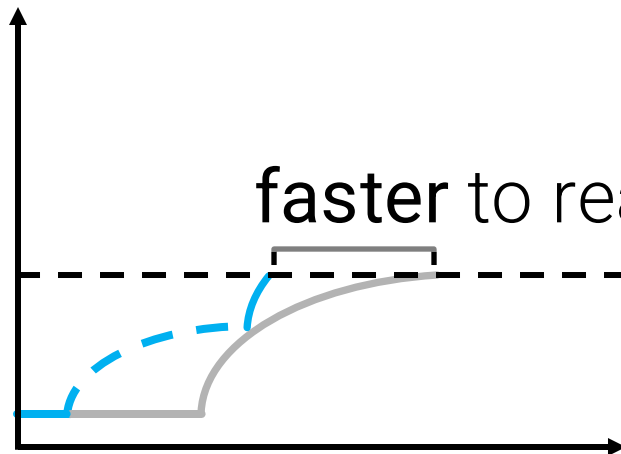
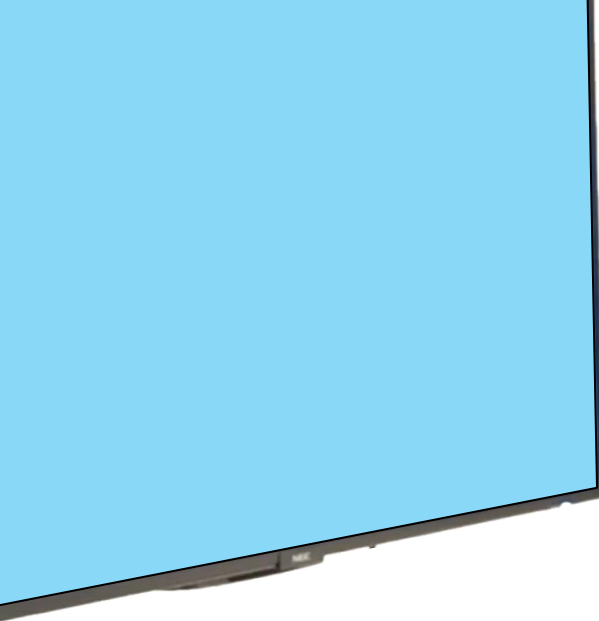


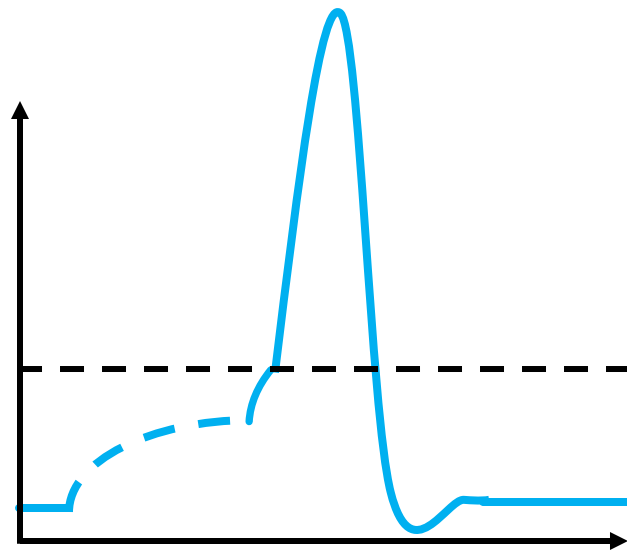
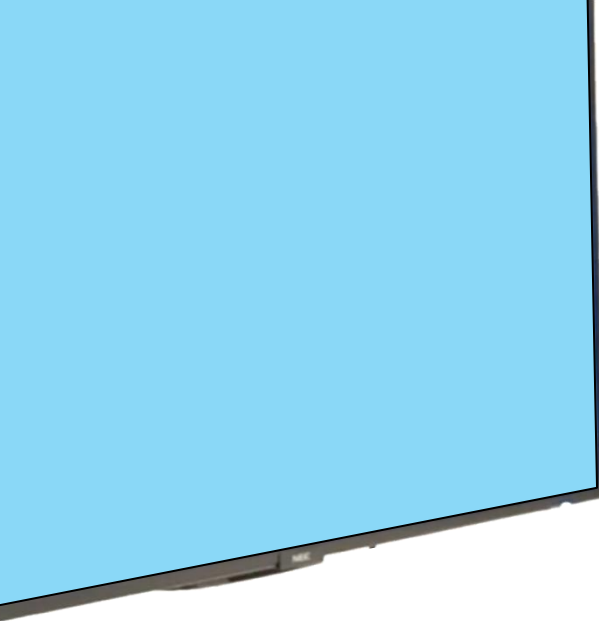
300 us, one single pulse

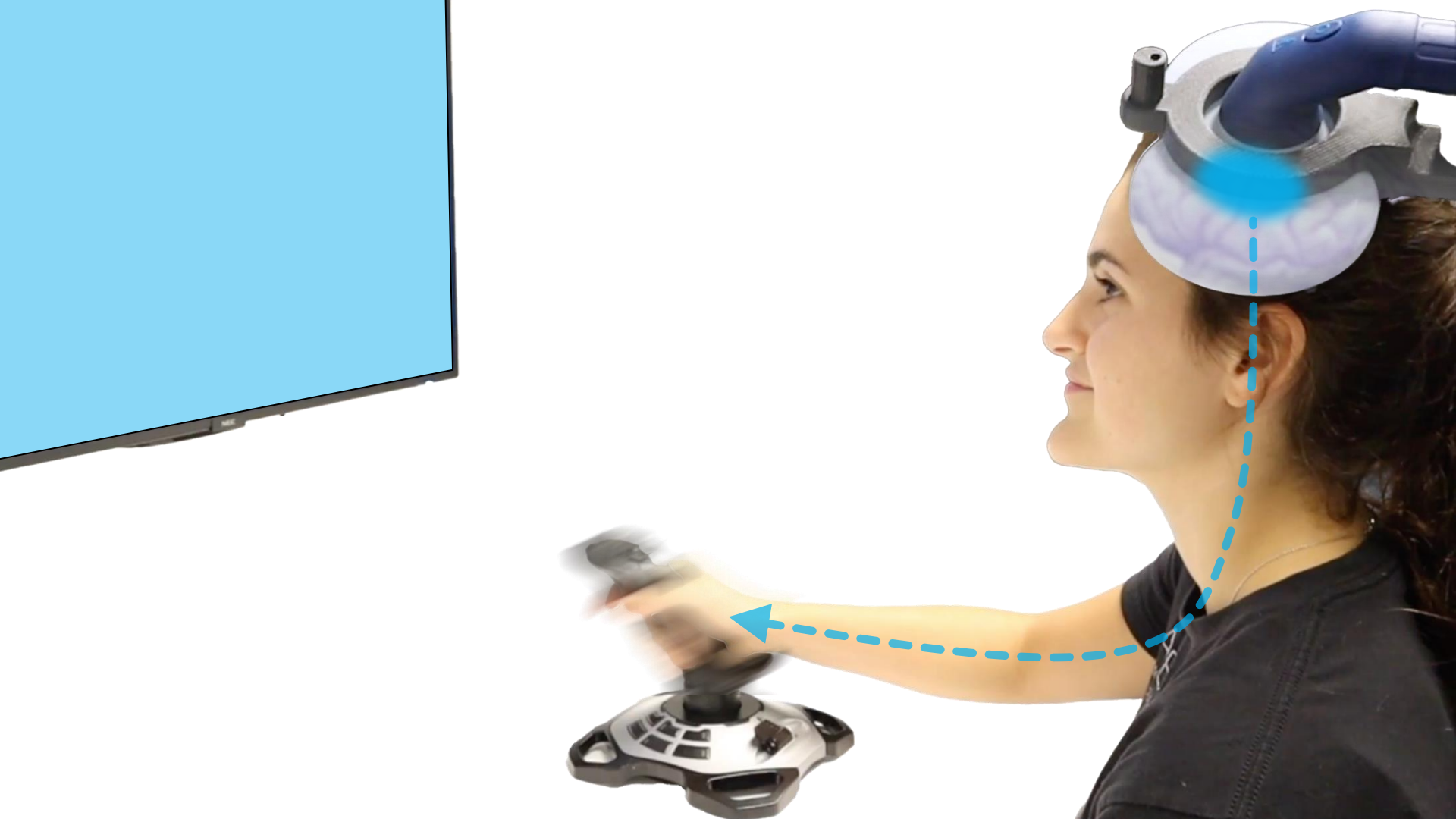






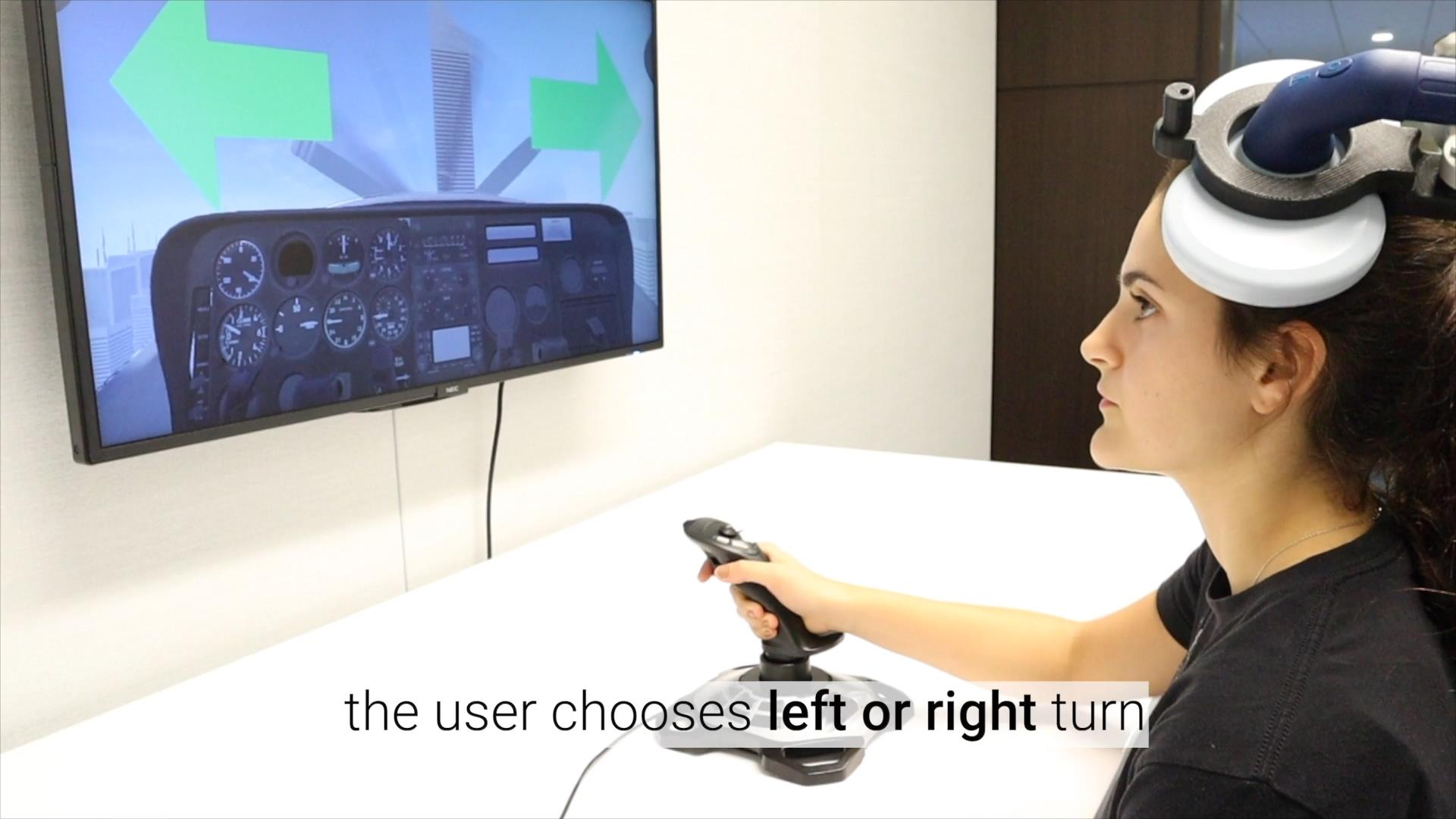






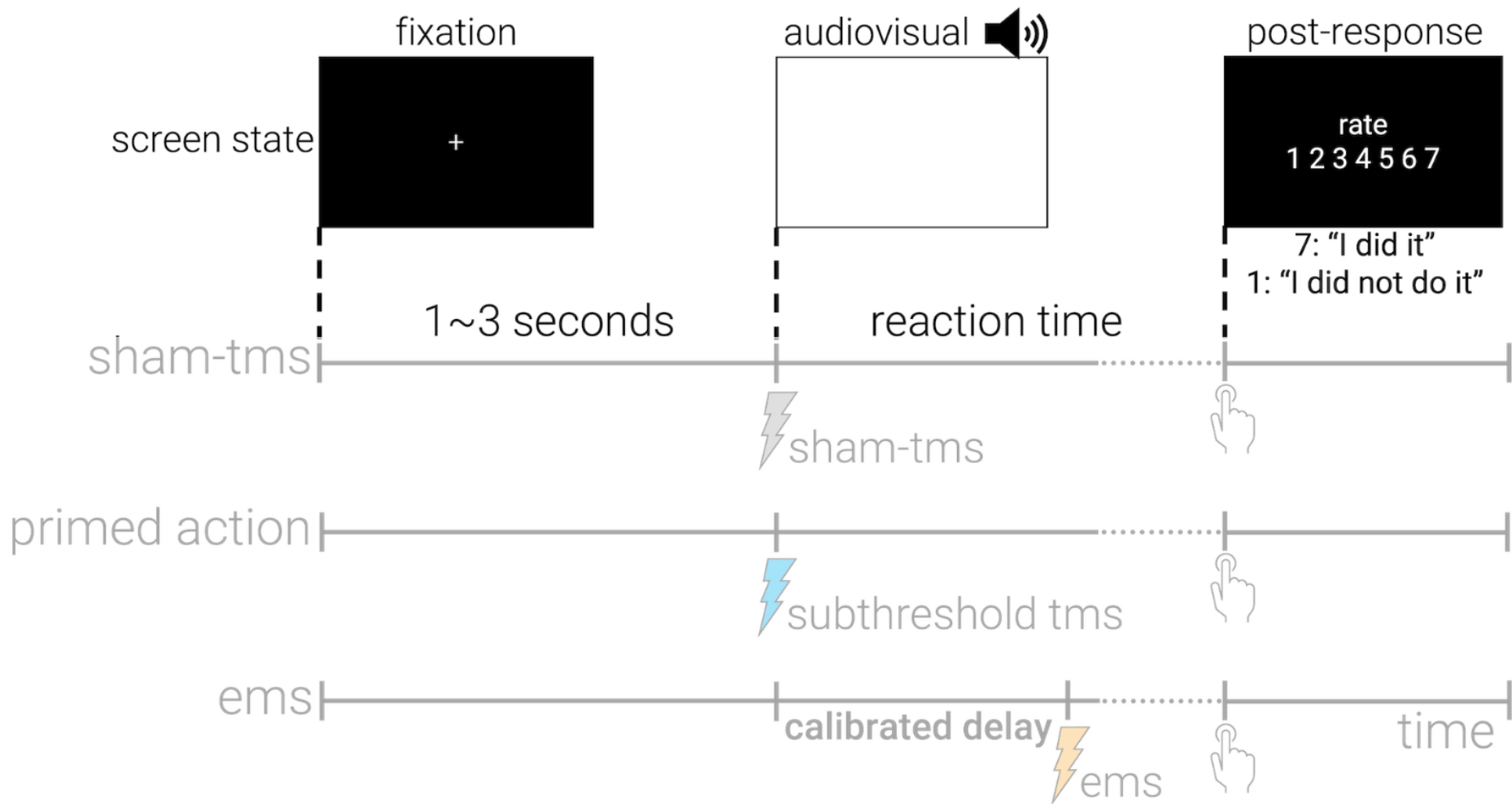


this is truly **voluntary action**



the user chooses **left or right** turn

user study: understanding **agency** & **reaction time**



conditions: order counter-balanced

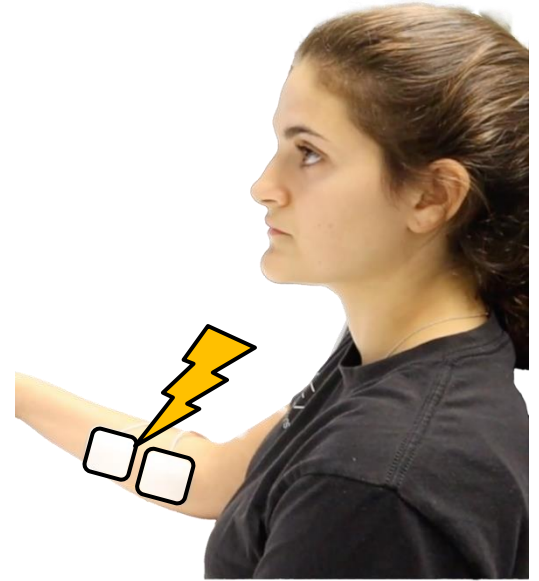


sham TMS



primed action

single pulse, subthreshold



EMS

(prior work for agency)

conditions: order counter-balanced

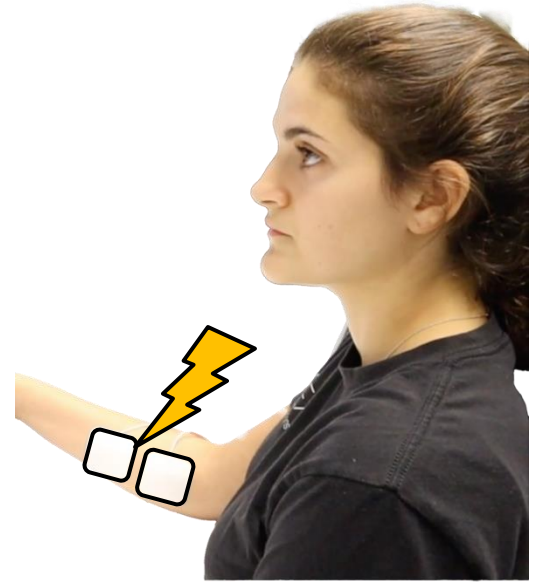


sham TMS



primed action

single pulse, subthreshold



EMS

(preemptive action)

conditions: order counter-balanced



sham TMS



primed action

single pulse, subthreshold



EMS

(prior work for agency)

conditions: order counter-balanced

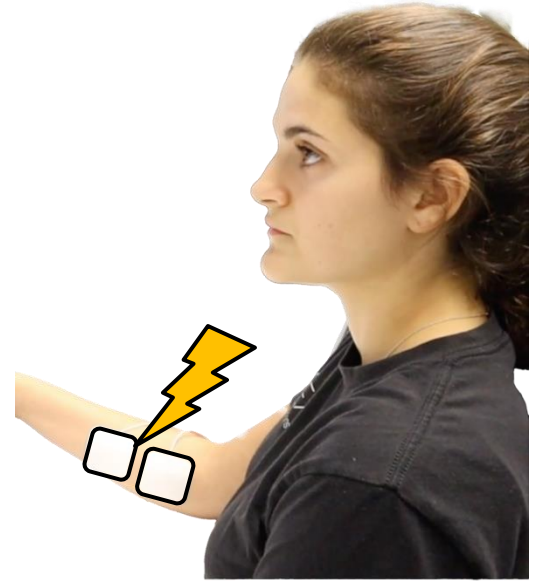


sham TMS



primed action

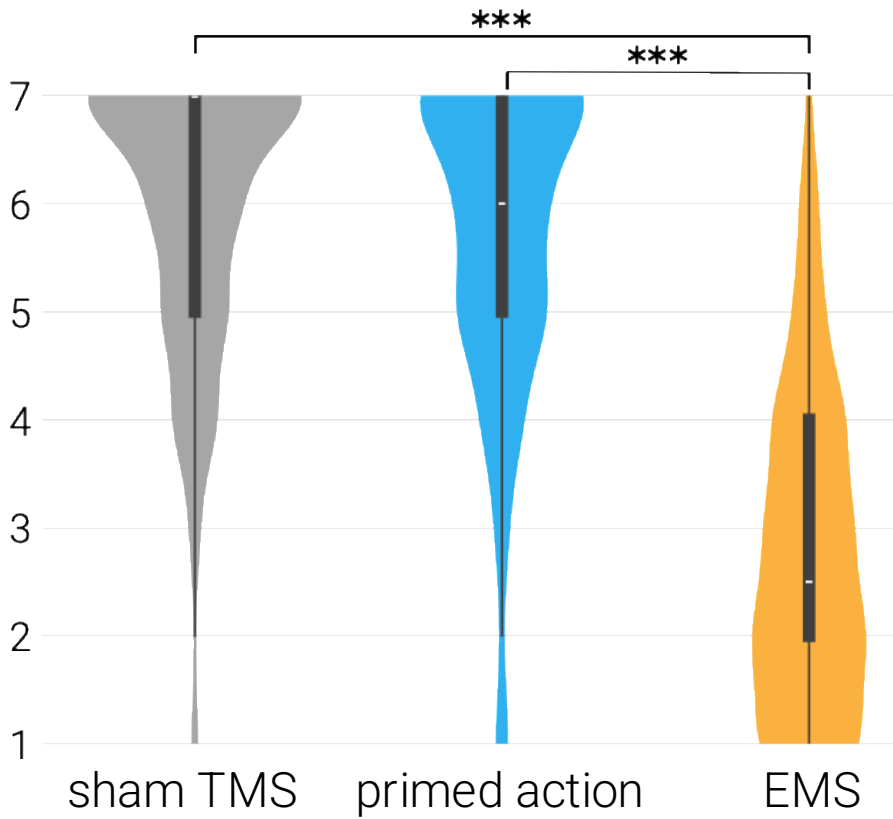
single pulse, subthreshold



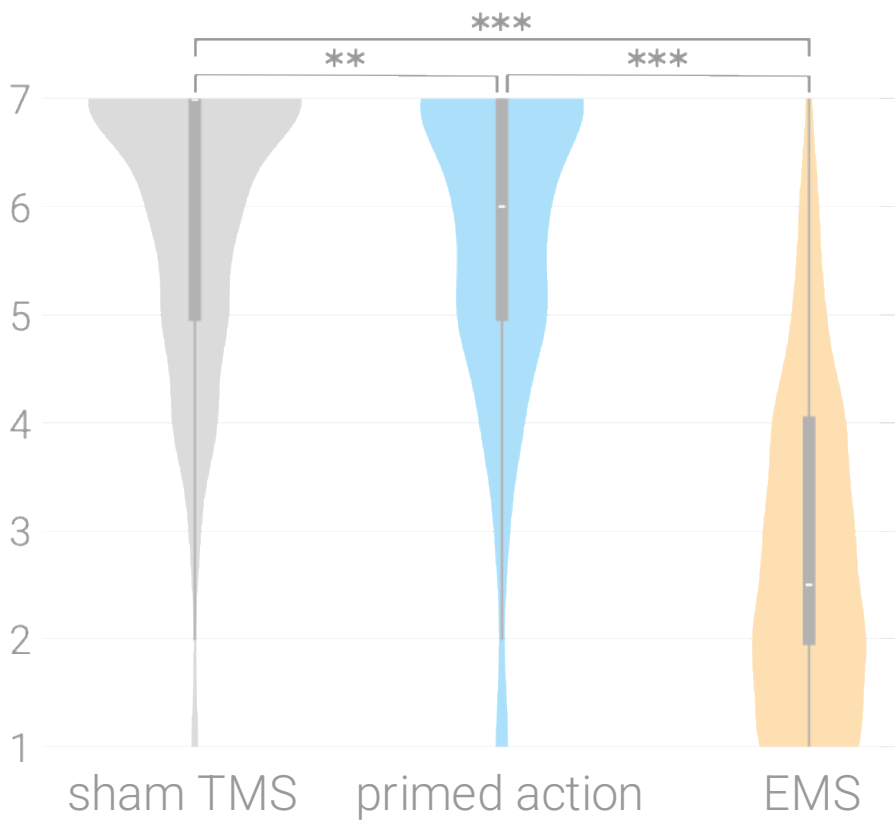
EMS

(prior work for agency)

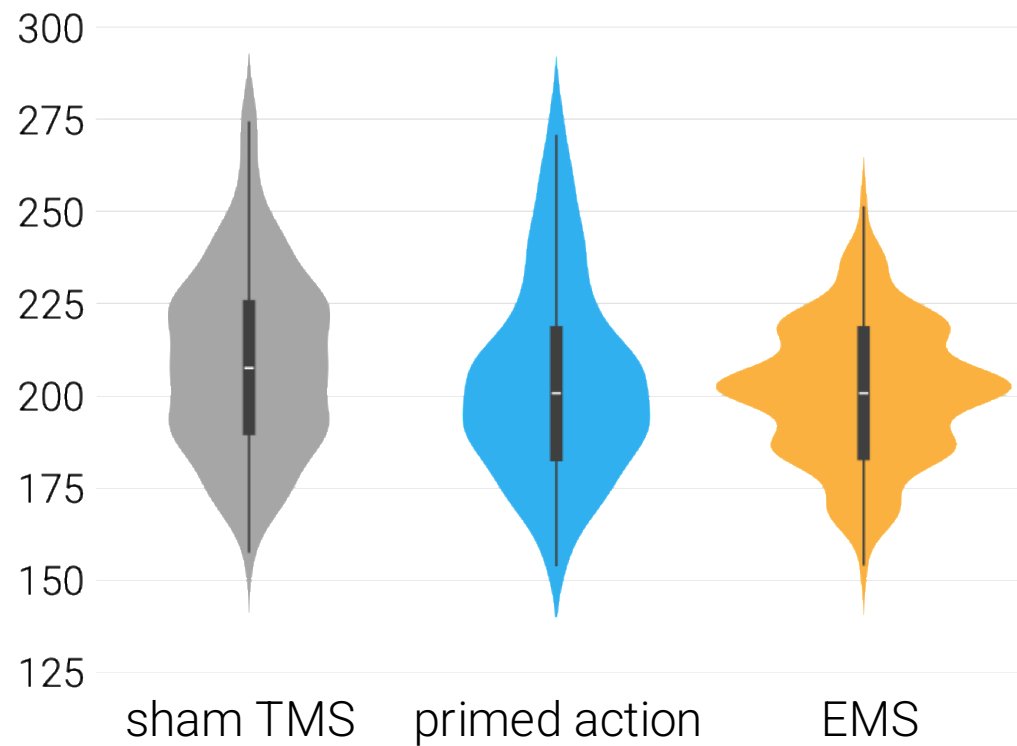
agency score



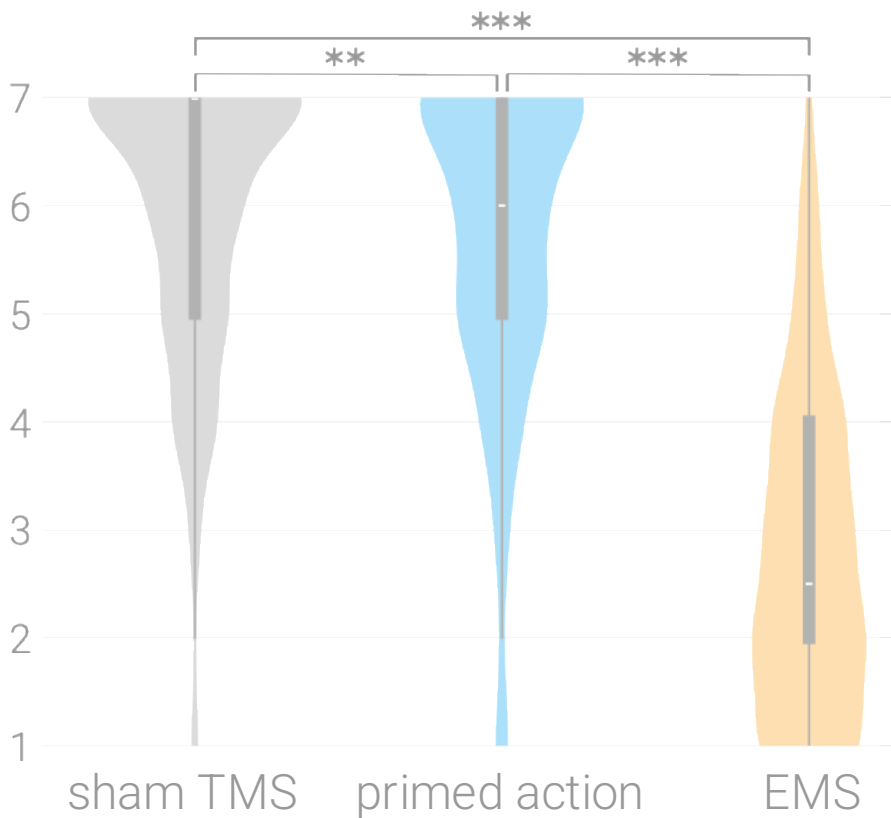
agency score



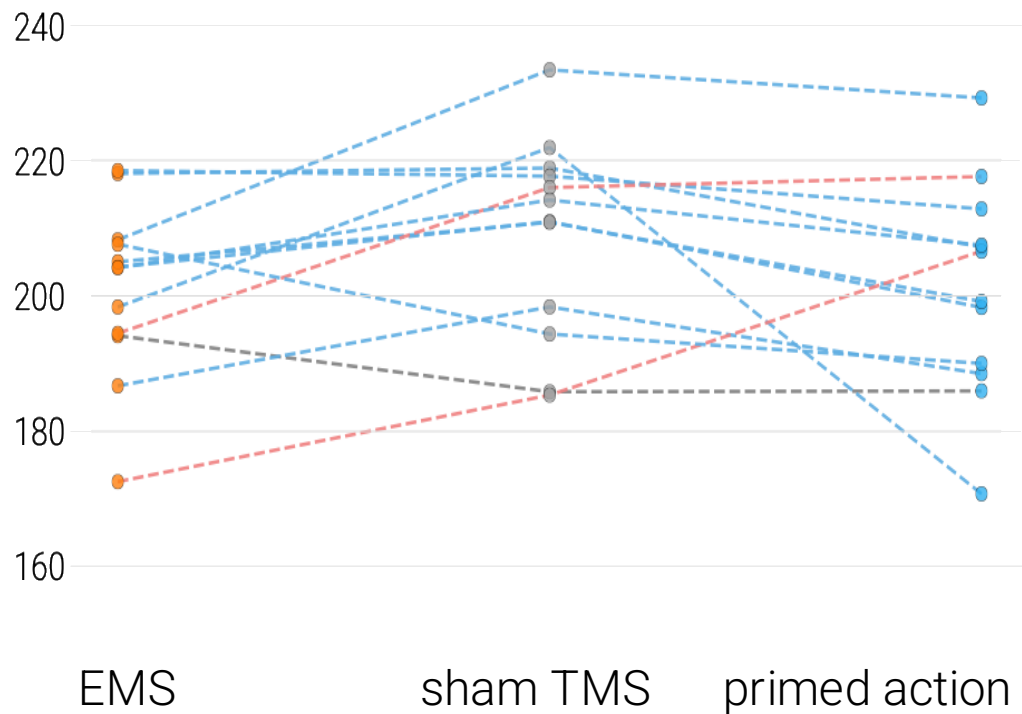
reaction time (ms)



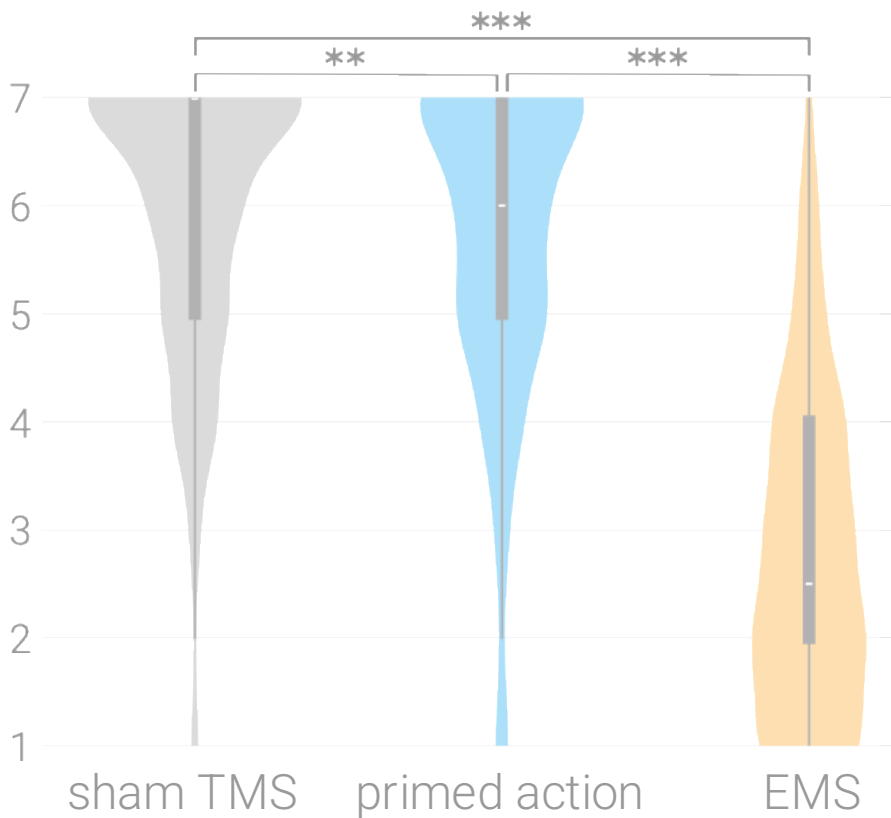
agency score



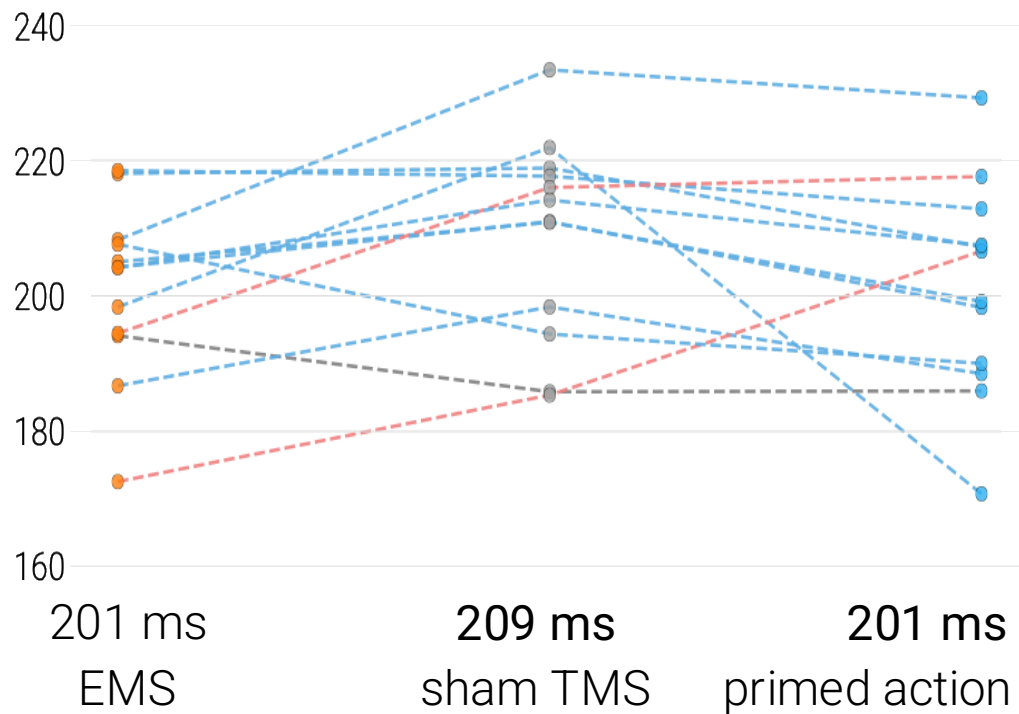
reaction time (ms)



agency score



reaction time (ms)

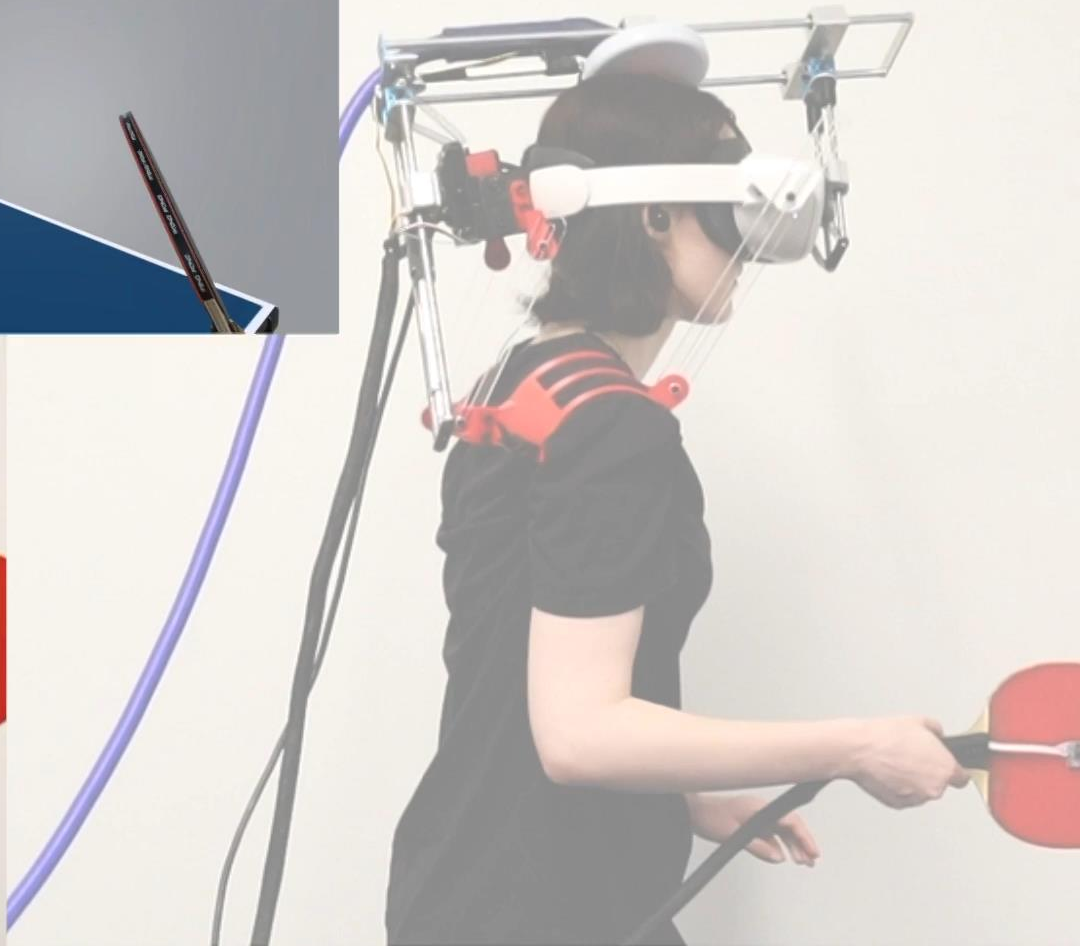
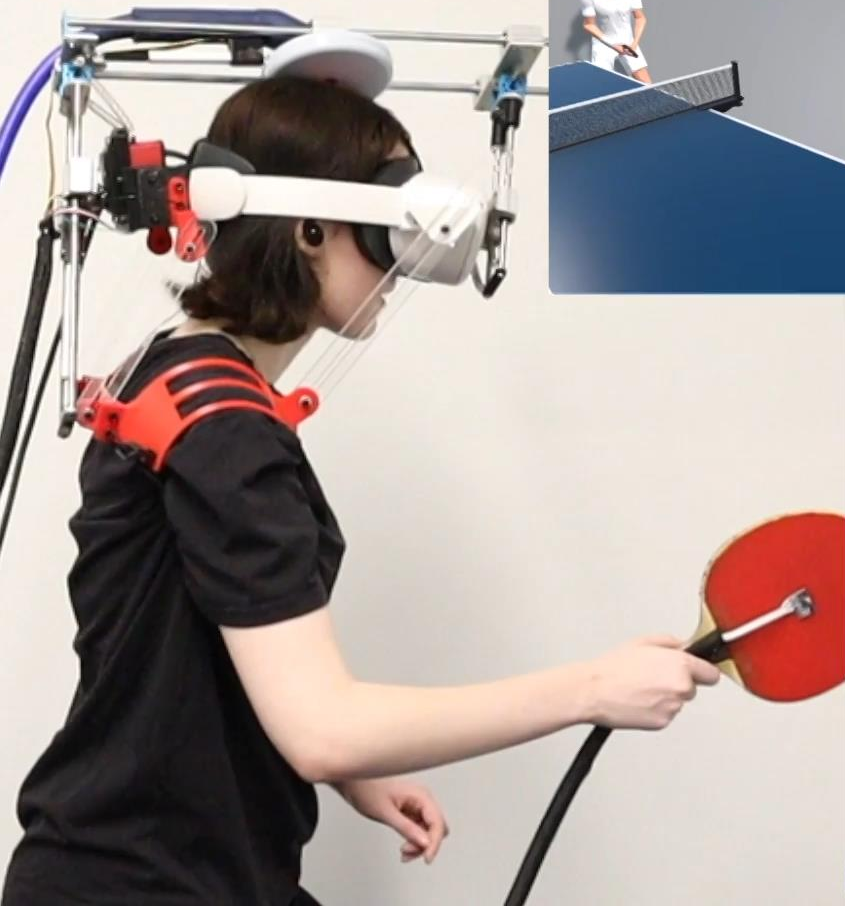




envisioned applications



primed action: **OFF**



conclusion

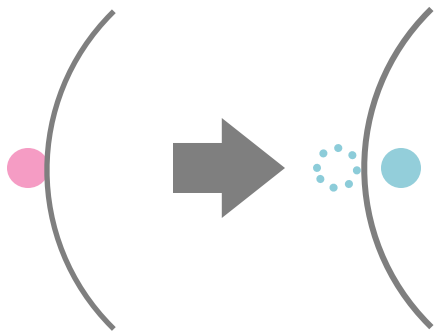
subthreshold
brain stimulation



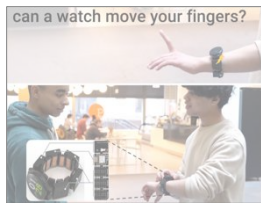


nervous system **interception**

1. **freeing up** the endpoint

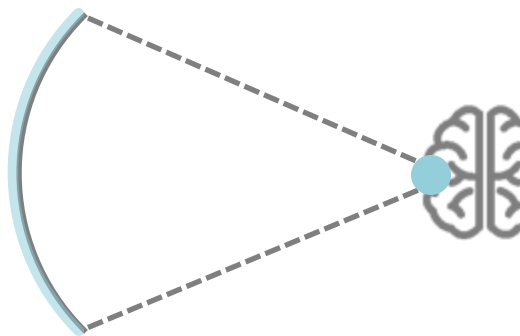


CHI '23 **best paper**



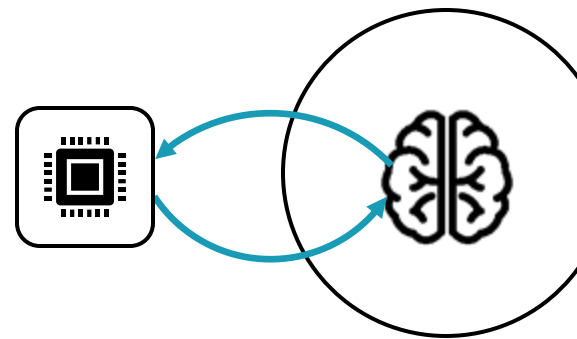
UIST '24 **honorable mention**

2. **generalizing** via the brain



CHI '24 **honorable mention**

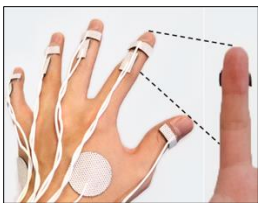
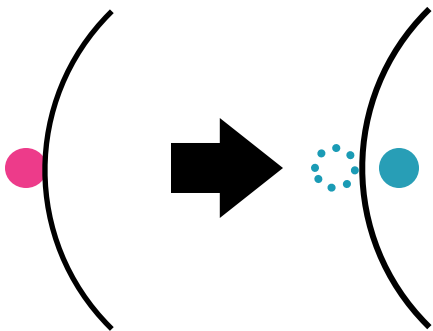
3. **agency dynamics**



UIST '25 **primed action**

nervous system **interception**

1. **freeing up** the endpoint

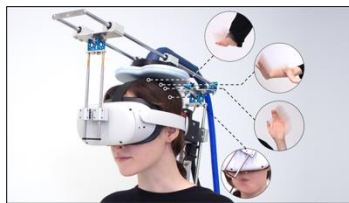
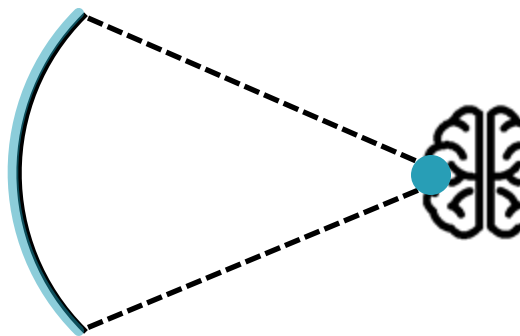


CHI '23 **best paper**



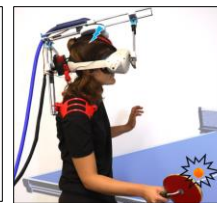
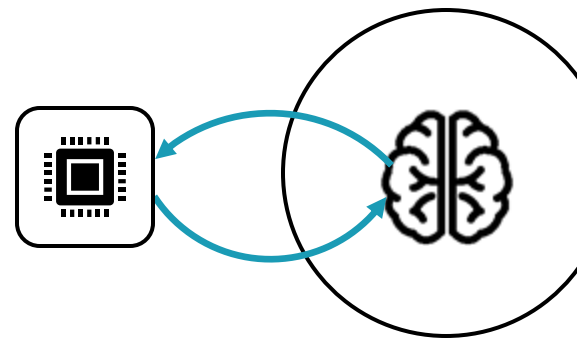
UIST '24 **honorable mention**

2. **generalizing** via the brain



CHI '24 **honorable mention**

3. **dynamics** in interaction



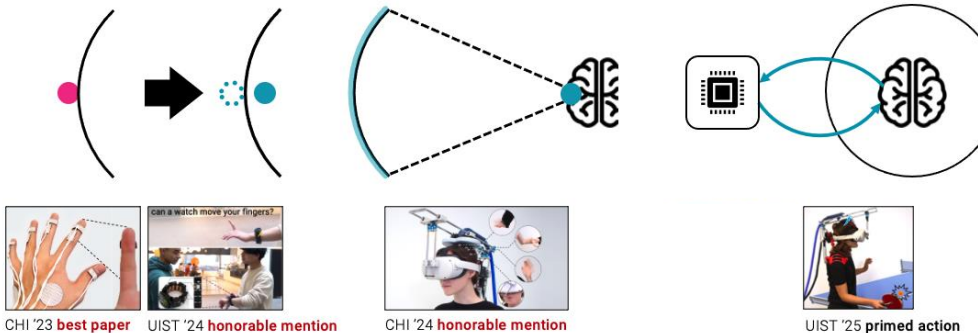
UIST '25 **primed action**

I'm on the *faculty* job market!



nervous system **interception**

1. **freeing up** the endpoint
2. **generalizing** via the brain
3. **dynamics** in interaction



yudai tanaka PhD candidate at UChicago with Pedro Lopes

| Google PhD fellow | Siebel scholar

| 11 CHI/UIST/+ papers (7 first-author, 🏆 x1, 🏅 x2)

| yudai-tanaka.com | yudaitanaka@uchicago.edu





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More on this paper (or others of our lab) at: <https://lab.plopes.org/#primed-action>



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