README // about these slides

These are the slides for the talk presented at CHI 2026 by Mithil Guru.
All the links in this PDF are clickable and lead you to YouTube videos, paper, etc.
You can watch the talk here: https://www.youtube.com/watch?v=iBb-K3-Op78
If you need a PPTX/editable version for your class, email us hci@uchicago.edu
More information on this paper (or others of our lab) at: https://lab.plopes.org/#forceEMS

Modeling Perceived Force of Electrical Muscle Stimulation to Improve User's Recall
Mithil Guru, Romain Nith, Pedro Lopes. In Proc. CHI'26 (paper)

Interactive electrical-muscle-stimulation (EMS) supports motor- skills by actuating the user's muscles. However, existing EMS- interfaces have not investigated EMS for skills requiring precise force application (e.g., operating force-sensitive tools). Our user study found that when EMS-interfaces demonstrate a force, participants trying to recall this force, overshoot significantly. This force mismatch renders EMS-interfaces unable to accurately demonstrate forces—drastically limiting the growing potential of EMS for HCI. To significantly improve on this, we modeled users' recall of EMS-demonstrated forces. This model allows to adjust EMS-interfaces to render a target force that, when recalled, matches the intended force best—in our study, this improved their force recall.

CHI'26 paper CHI talk (pre-recorded) CHI talk (live)

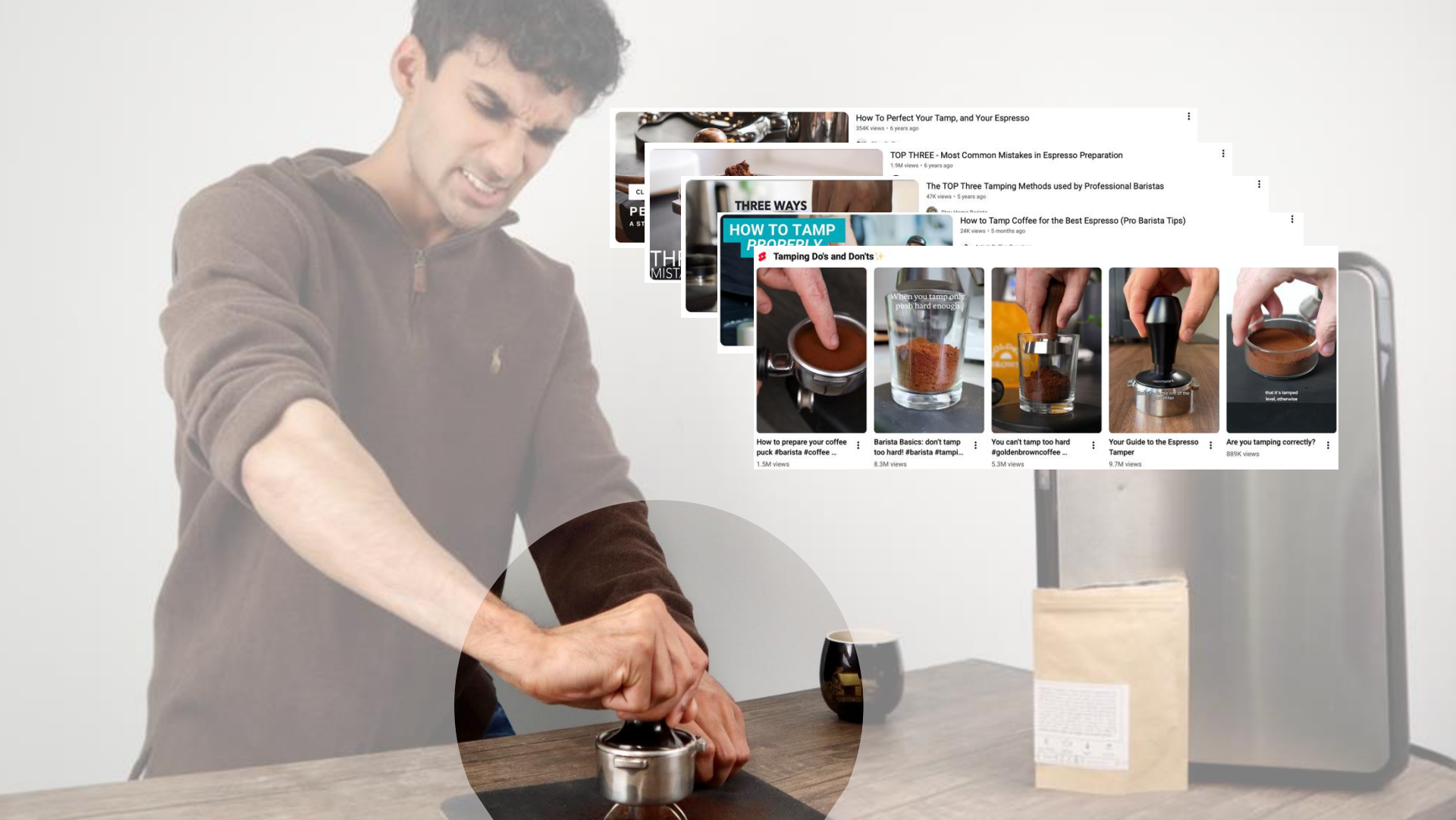
human computer integration lab

THE UNIVERSITY OF CHICAGO

modeling perceived force of muscle stimulation to improve user's recall

mithil guruvugari, romain nith, pedro lopes


motivation: physical skill acquisition


How To Perfect Your Tamp, and Your Espresso
354K views • 6 years ago
TOP THREE - Most Common Mistakes in Espresso Preparation
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The TOP Three Tamping Methods used by Professional Baristas
47K views • 5 years ago
THREE WAYS
How to Tamp Coffee for the Best Espresso (Pro Barista Tips)
24K views • 5 months ago
HOW TO TAMP
Tamping Do's and Don'ts
When you tamp only push hard enough
How to prepare your coffee puck #barista #coffee ...
1.5M views
Barista Basics: don't tamp too hard! #barista #tampi...
8.3M views
You can't tamp too hard #goldenbrowncoffee ...
5.3M views
Your Guide to the Espresso Tamper
9.7M views
Are you tamping correctly?
889K views


how can we learn an **exact force?**

electrical muscle stimulation **(EMS)**

EMS interactive potential = download
interactive assistance to our body


steer left
EMS actuates user's head orientation
I did it!
EEG
haptic prediction error

151 papers (as of 2022)
Faltaous et al., MUM'22

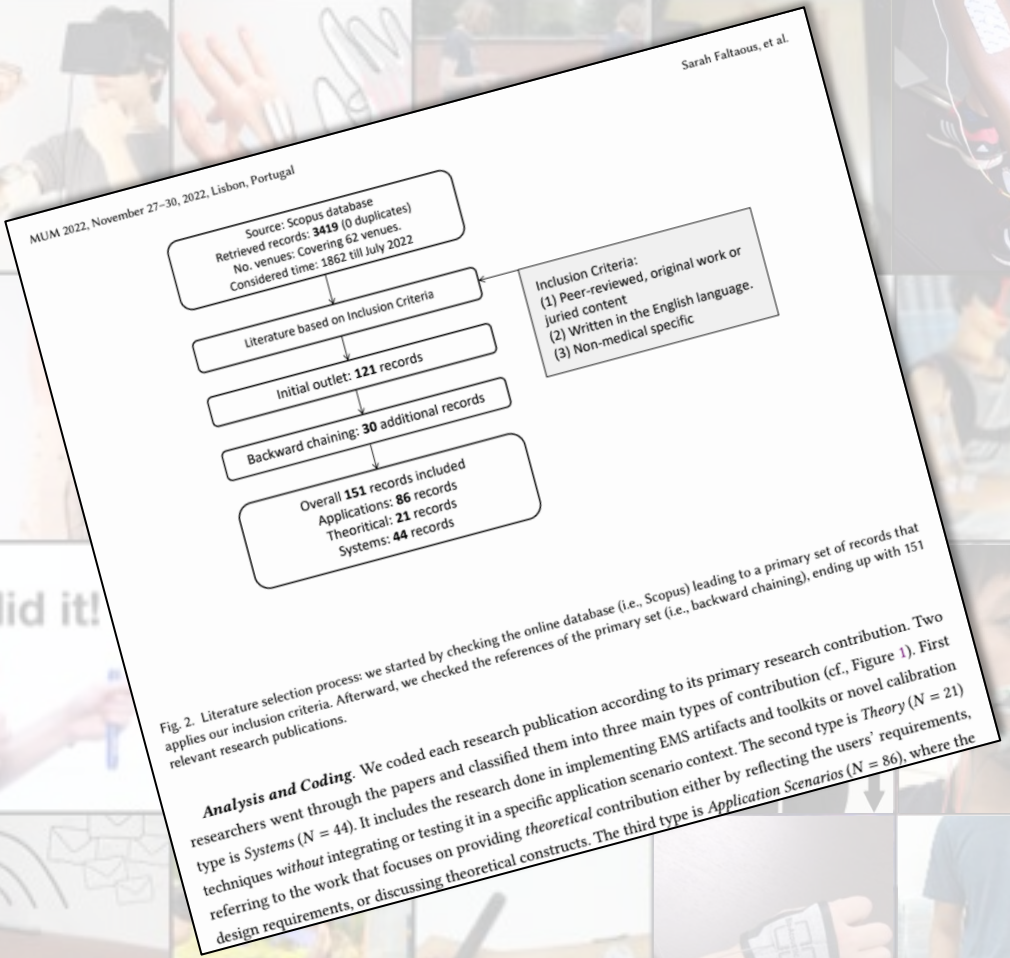
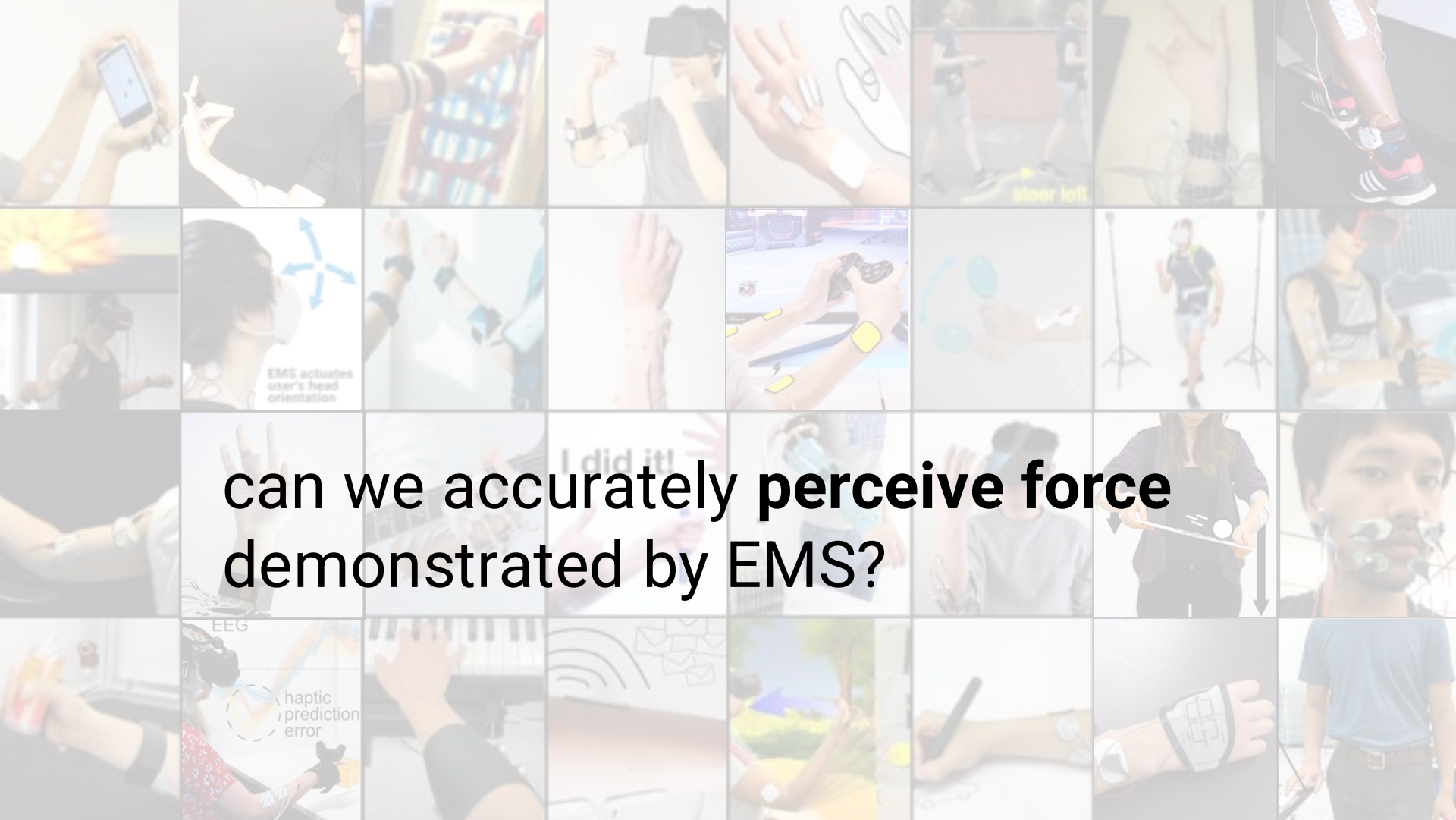


Fig. 2. Literature selection process: we started by checking the online database (i.e., Scopus) leading to a primary set of records that applies our inclusion criteria. Afterward, we checked the references of the primary set (i.e., backward chaining), ending up with 151 relevant research publications.

Analysis and Coding. We coded each research publication according to its primary research contribution. Two researchers went through the papers and classified them into three main types of contribution (cf., Figure 1). First type is *Systems* ($N = 44$). It includes the research done in implementing EMS artifacts and toolkits or novel calibration techniques *without* integrating or testing it in a specific application scenario context. The second type is *Theory* ($N = 21$) referring to the work that focuses on providing *theoretical* contribution either by reflecting the users' requirements, design requirements, or discussing theoretical constructs. The third type is *Application Scenarios* ($N = 86$), where the

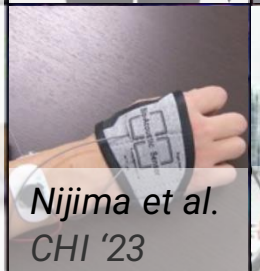


can we accurately **perceive force** demonstrated by EMS?

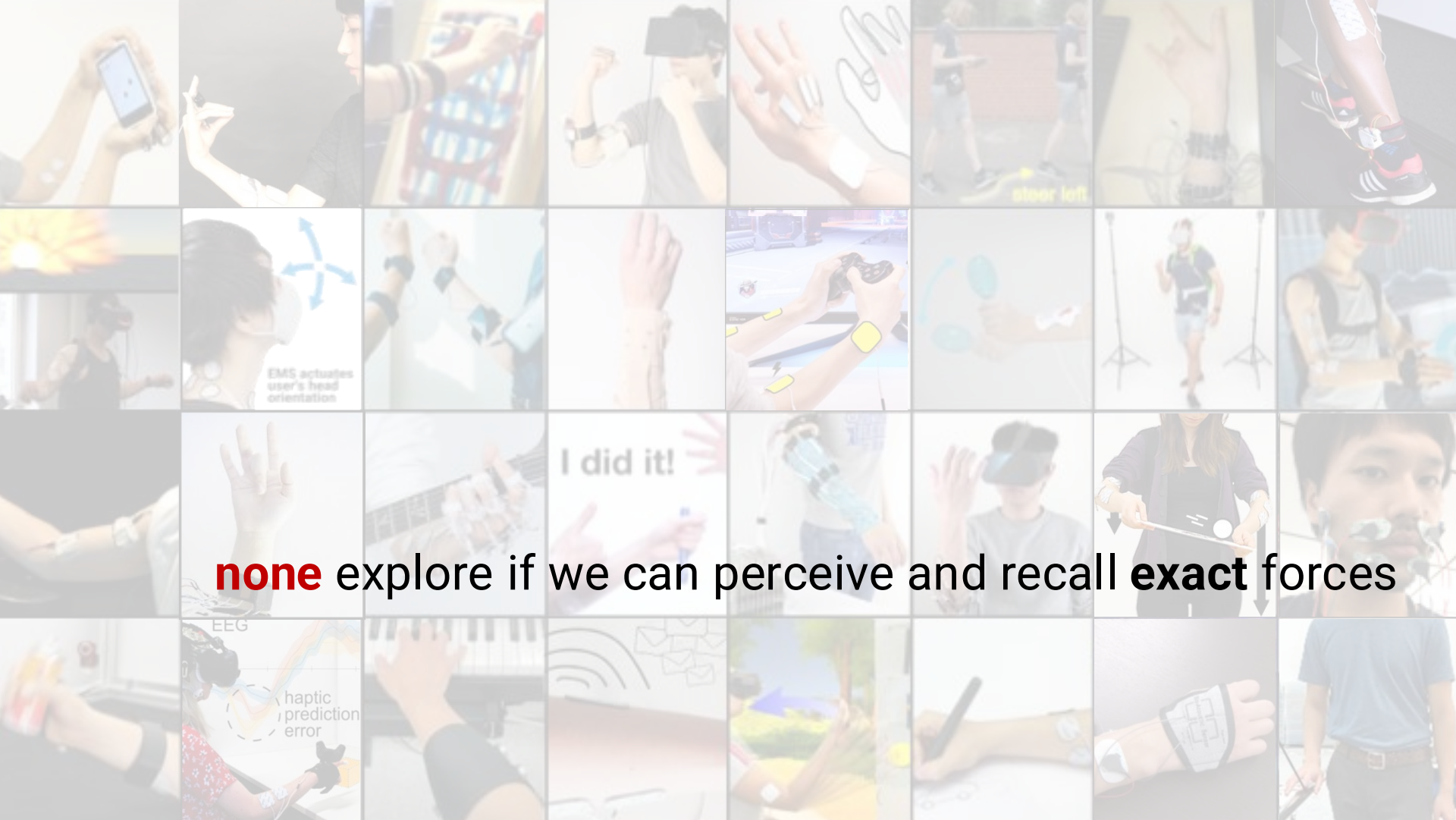
only **some** works have explored forces


Lopes et al.
CHI '18


Nijima et al.
CHI '18


Nijima et al.
CHI '23


Shindo et al.
EMBC '21



none explore if we can perceive and recall **exact** forces

why is replicating EMS force difficult?

why is replicating EMS force difficult?

limitation: **rapid** force build-up

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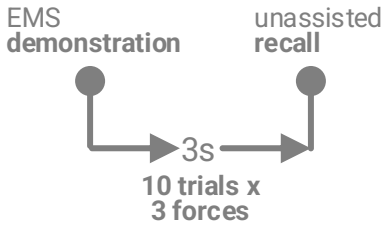
limitation: **rapid** force build-up

involuntary contraction with **unnatural** muscle fiber recruitment

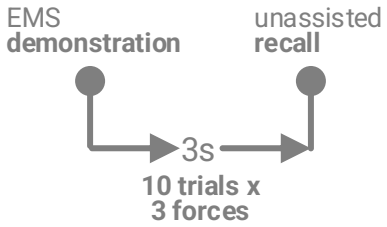
user study: can users **accurately** replicate force demonstrated by EMS?

study design

10 trials x
3 forces



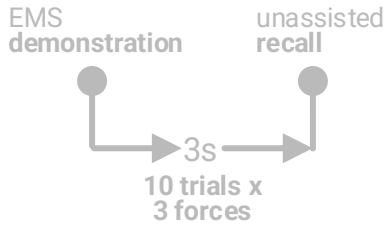
users tend to overshoot, recalling a significantly **higher** force



users tend to overshoot, recalling a significantly **higher** force.

median user recall error = +19%

the greatest overshoots are seen with **low** forces



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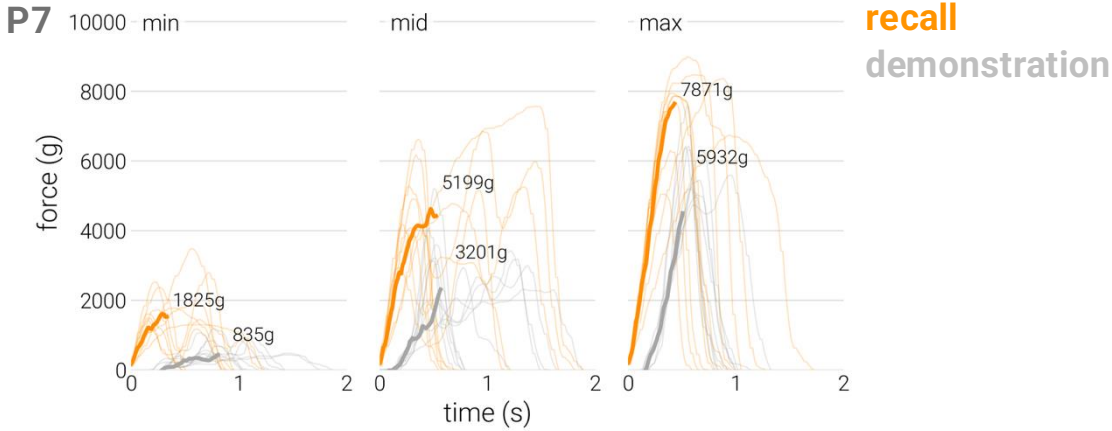
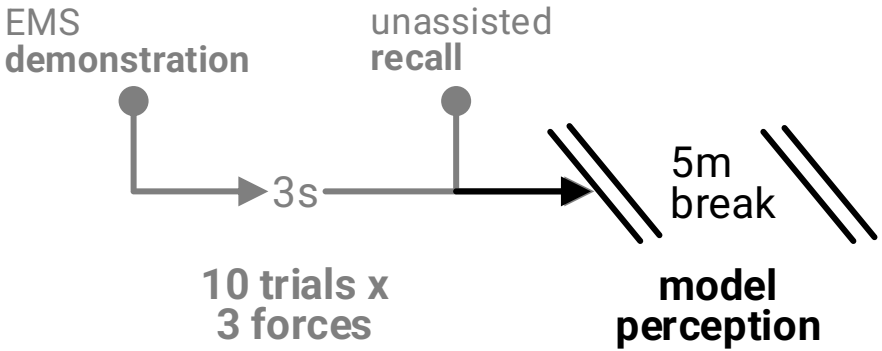
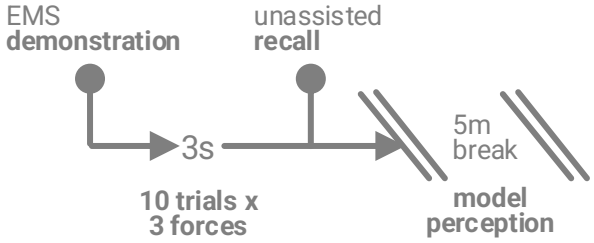
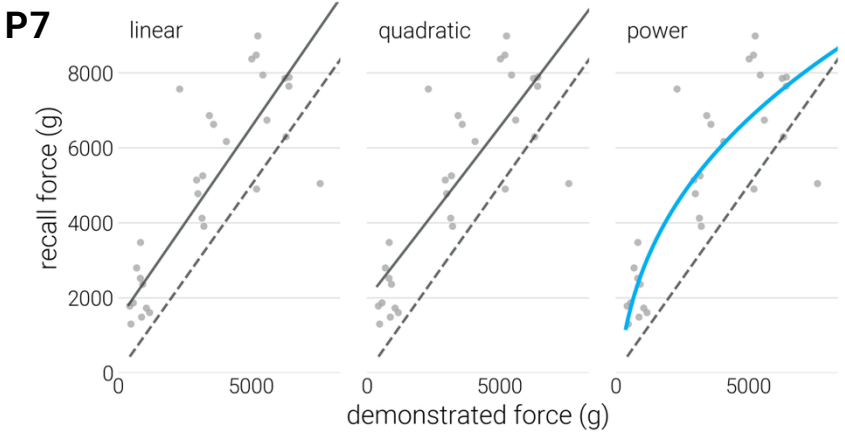


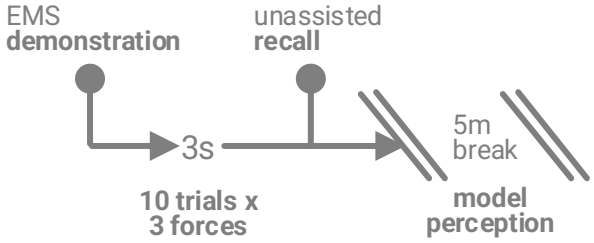
our proposal: can we **model** user perception of force from EMS and compensate for the offset?

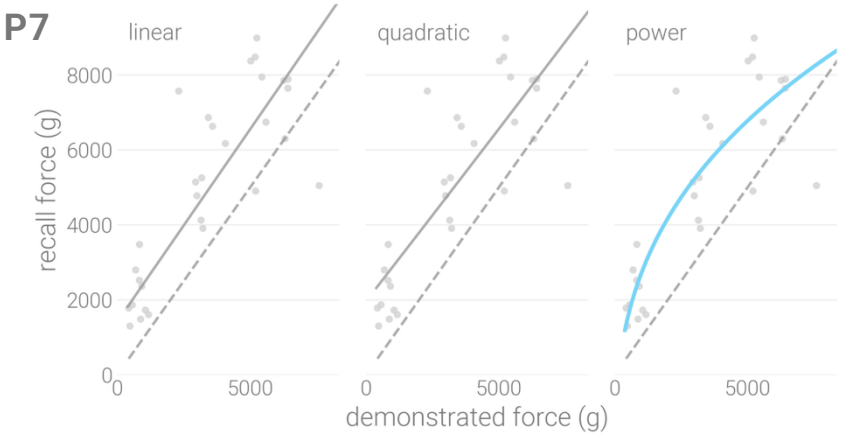
study design




EMS
demonstration
unassisted
recall
3s
5m
break
10 trials x
3 forces
model
perception


P7
linear
quadratic
power
recall force (g)
8000
6000
4000
2000
0
0
5000
demonstrated force (g)

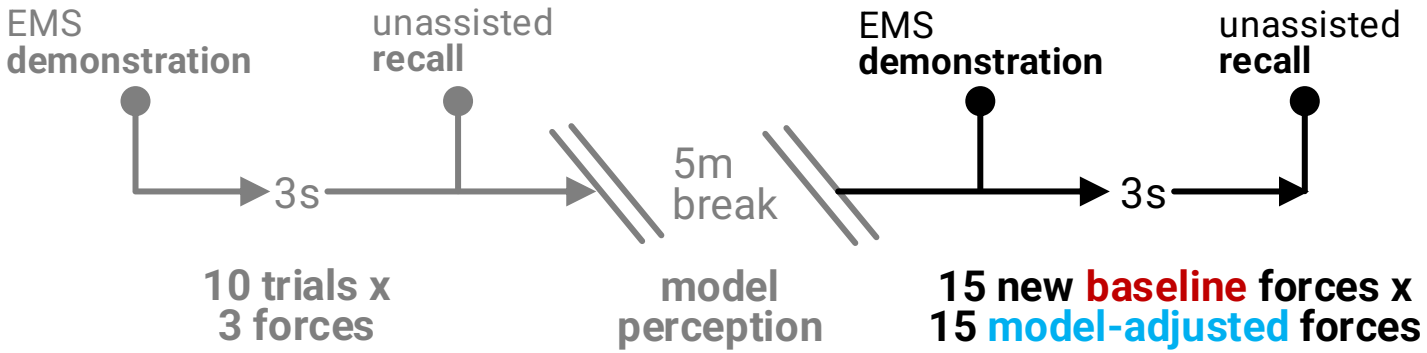




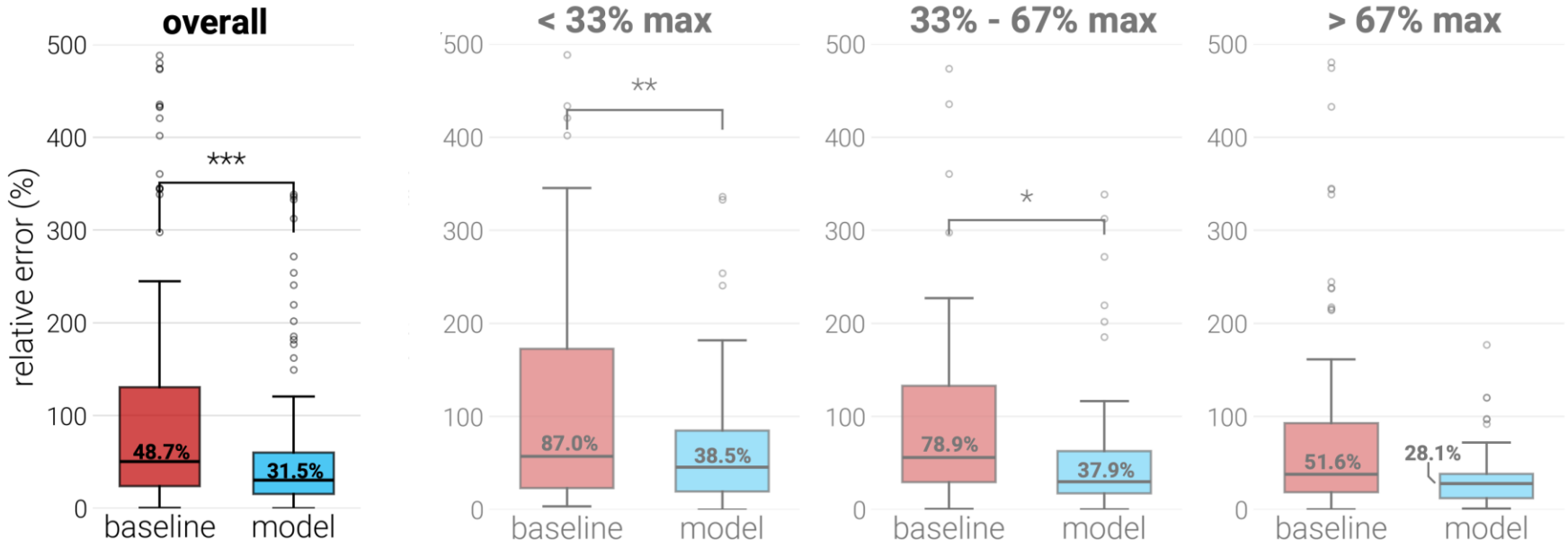
all

participant	personalized-linear	personalized-quadratic	personalized-power
P1	624.6	**603.2**	819.4
P2	4219.2	**3067.3**	5356.5
P3	**3293.5**	3811.2	3989.3
P4	**996.1**	1219.9	1585.9
P5	**729.5**	1521.2	1705.2
P6	1000.4	**962.1**	972.7
P7	1780.9	2316.3	**1294.6**
P8	**794.5**	2564.7	1097.8
P9	1246.4	**1149.2**	1262.7
P10	950.9	904.9	**742.1**
P11	**1284.5**	1318.3	2366.5
P12	**4777.9**	4805	4841.2

study design



model-adjusted EMS **significantly reduced** recall error



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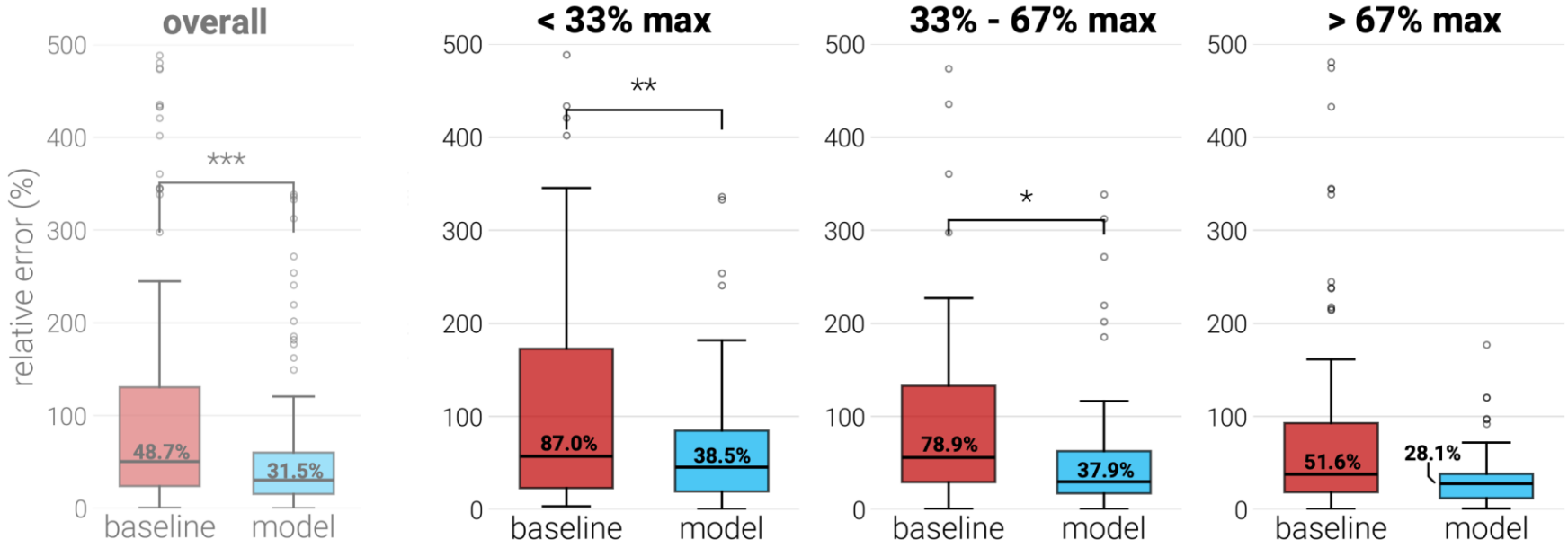


steer left
EMS actuates user's head orientation
I did it!
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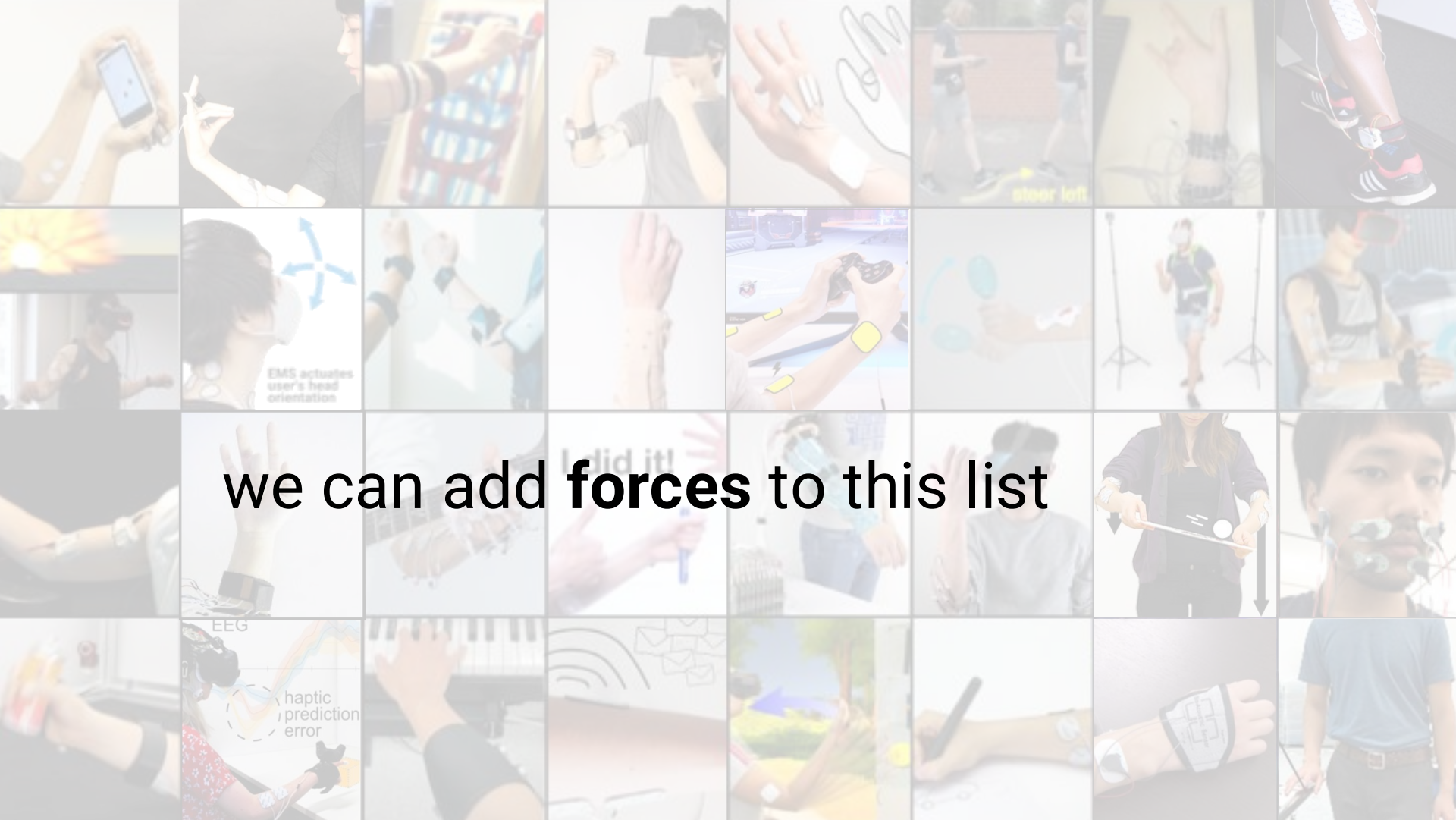


we can add **forces** to this list

demonstrate
adjusted-EMS
chord force


recall **intended**
force to play
chord

demonstrate
adjusted-EMS
chisel force


recall **intended**
force to chisel

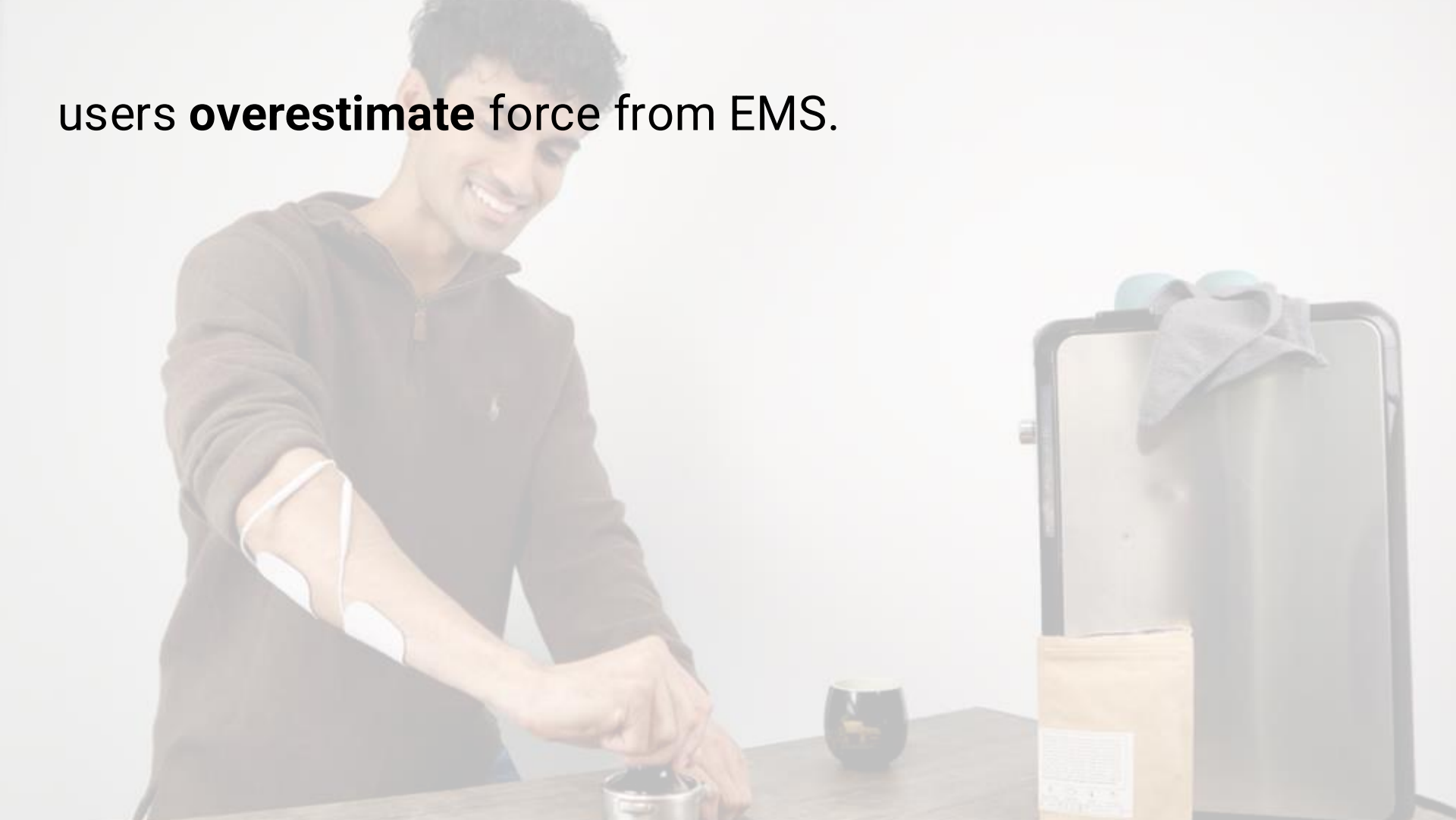
demonstrate
adjusted-EMS
grip force

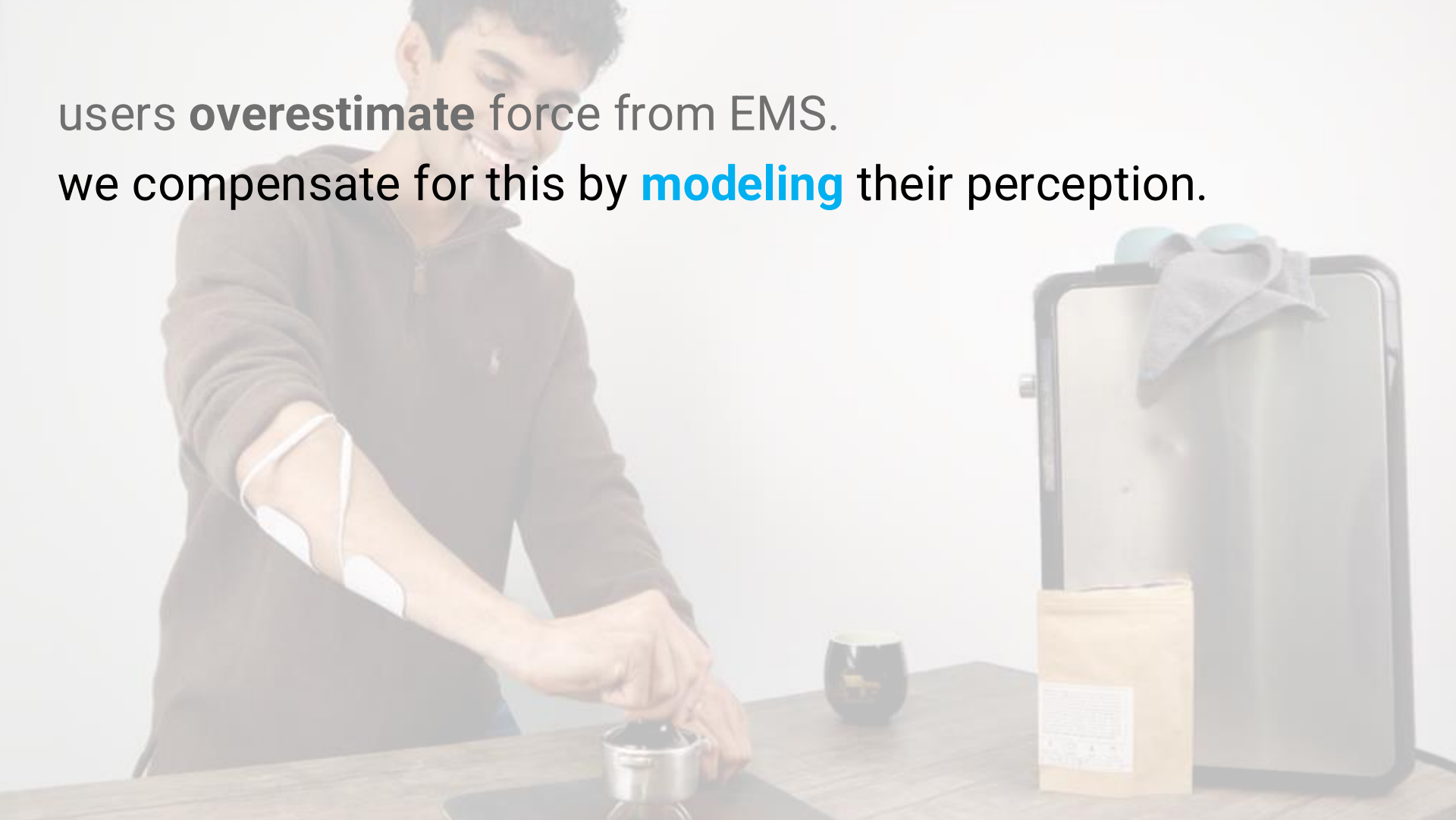

demonstration
continues
throughout putt


recall **intended**
grip force

conclusion & takeaways

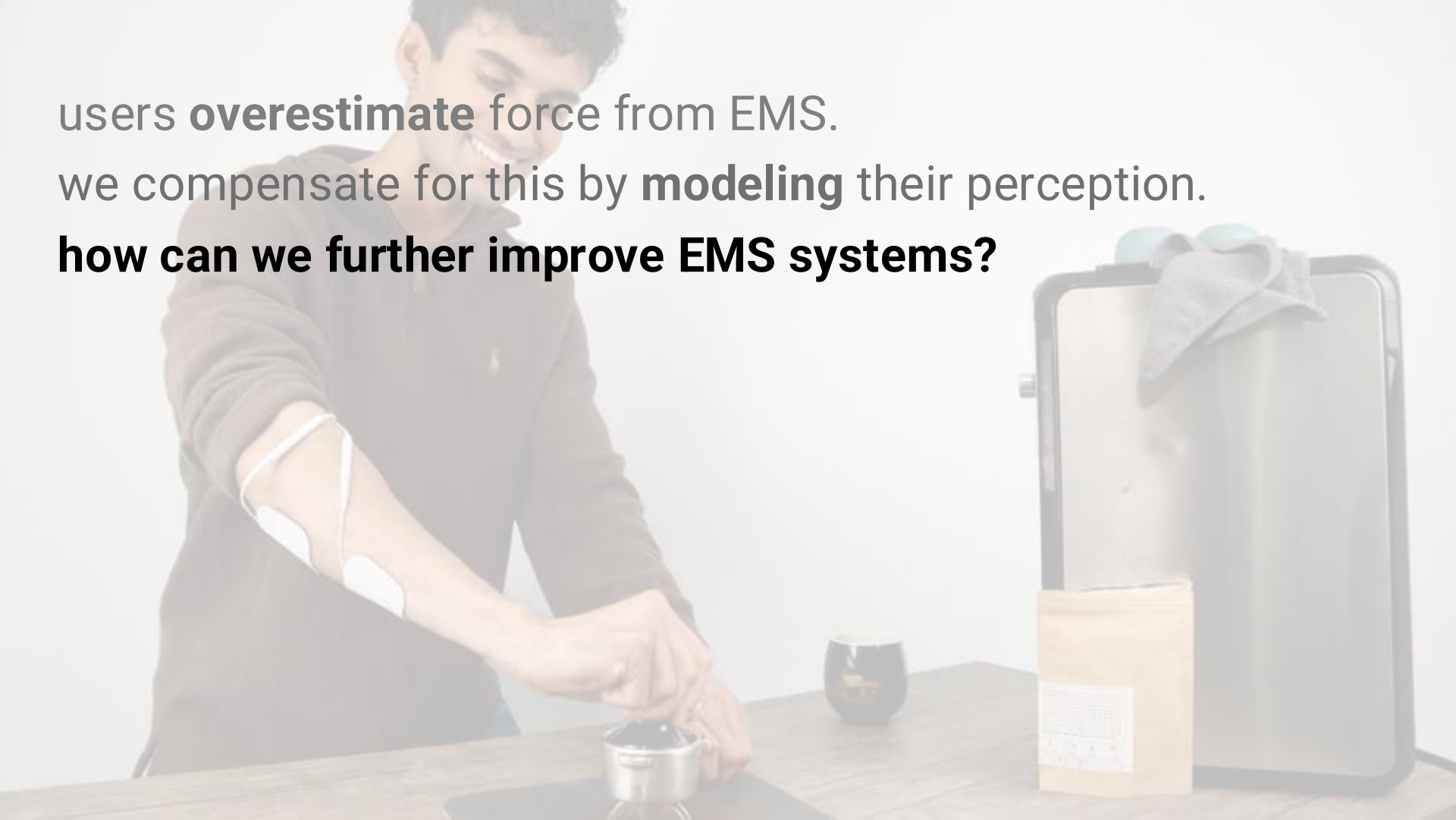
users **overestimate** force from EMS.





users **overestimate** force from EMS.

we compensate for this by **modeling** their perception.



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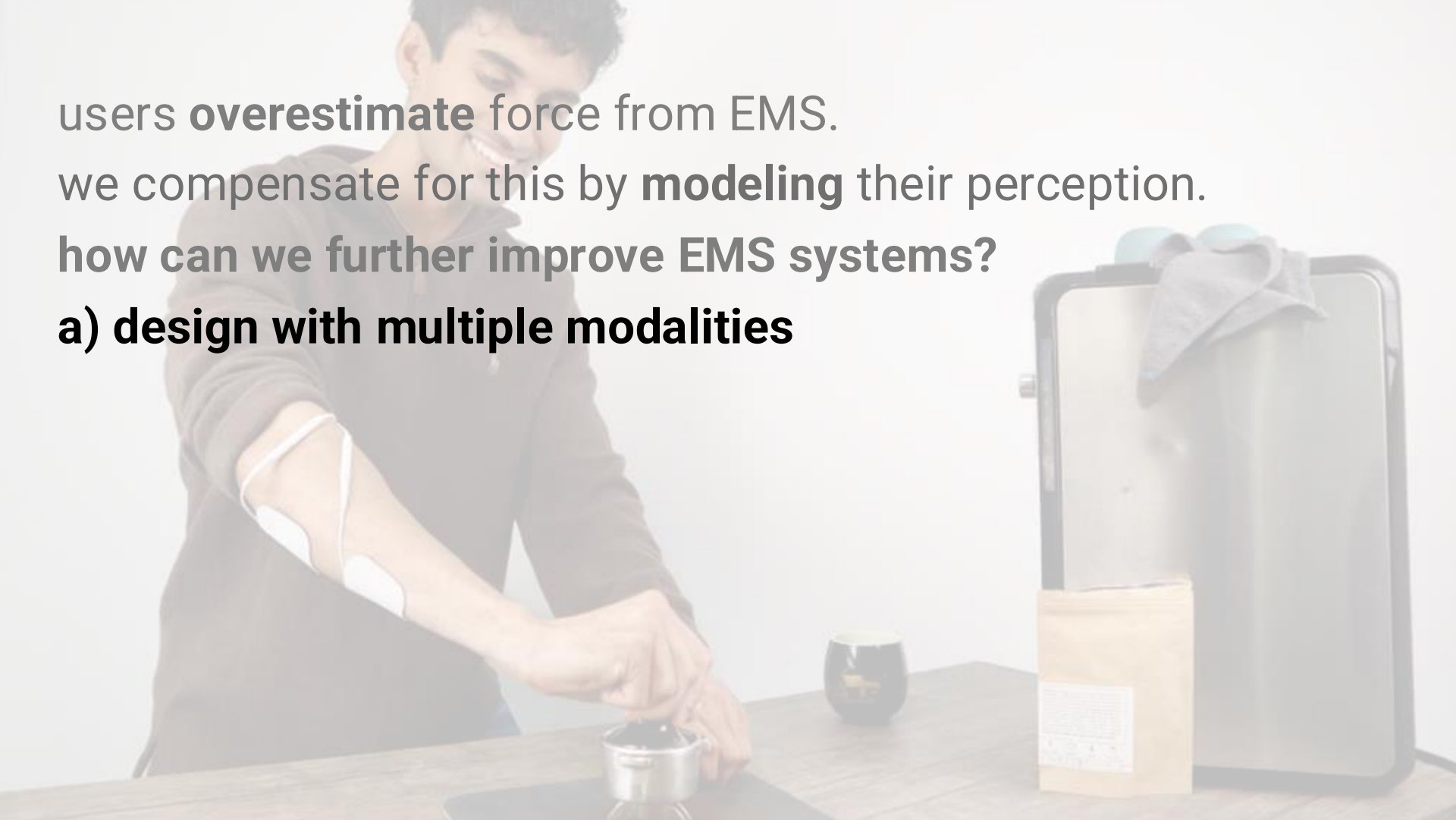
how can we further improve EMS systems?



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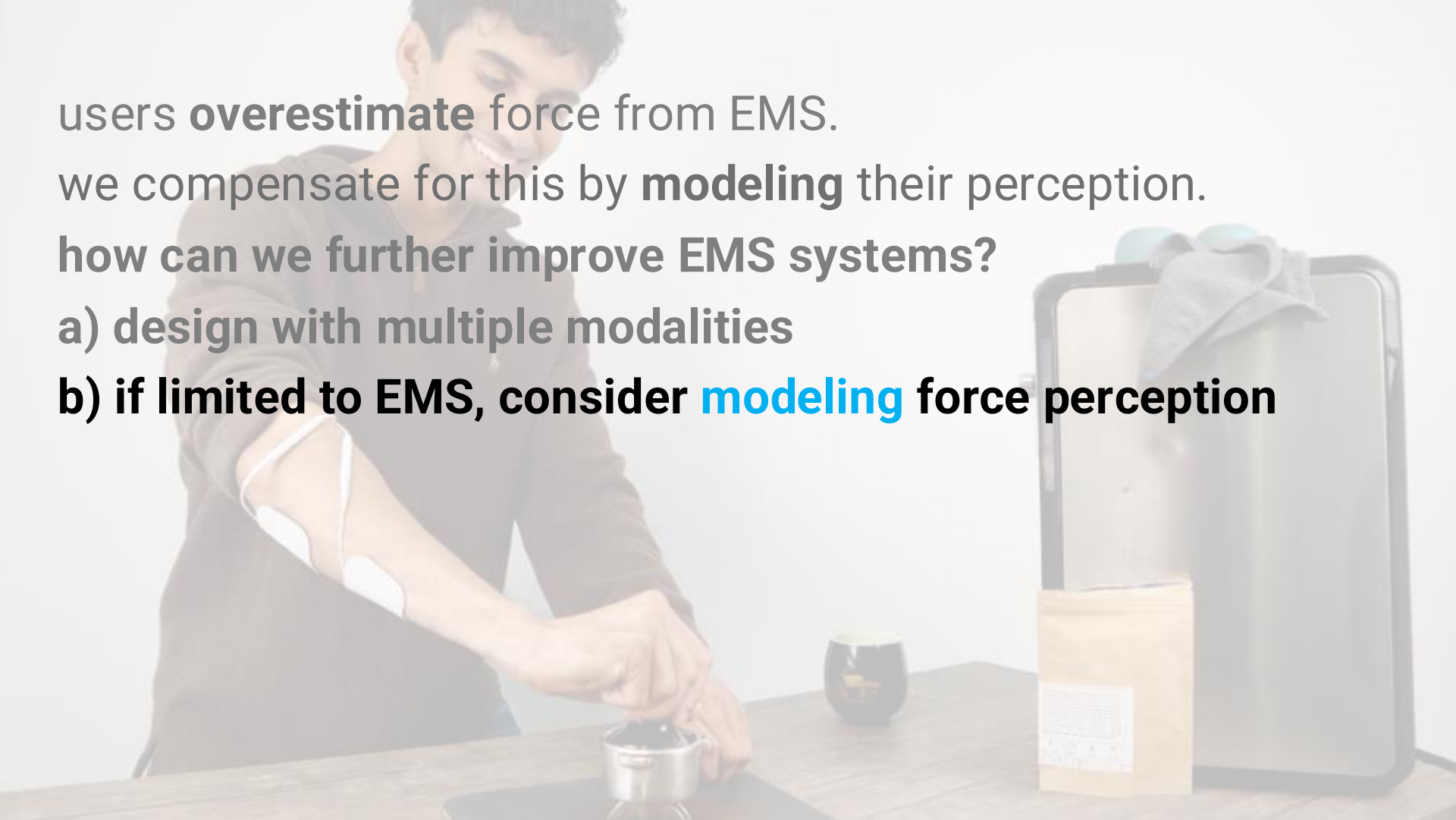
a) design with multiple modalities



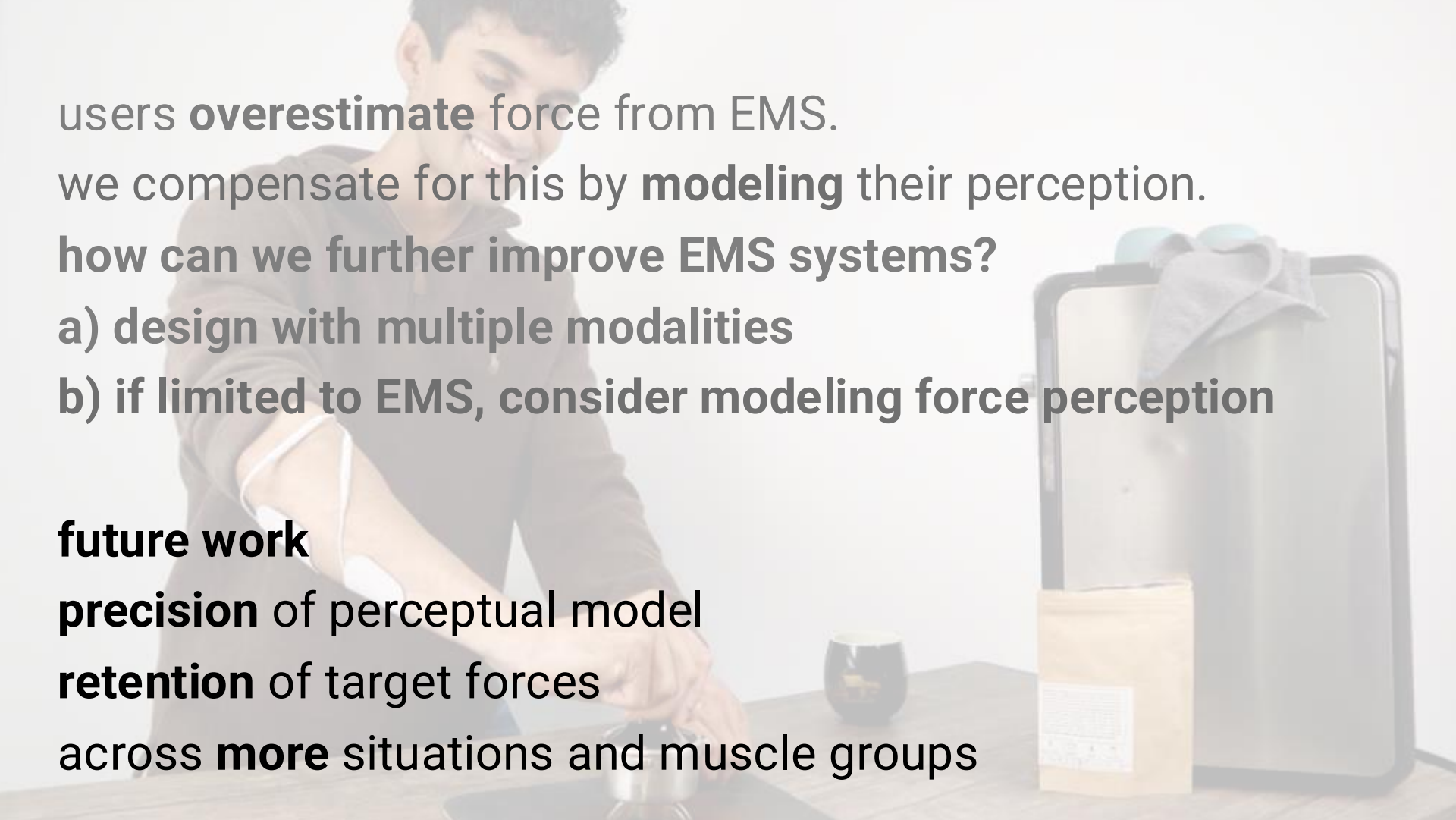
users **overestimate** force from EMS.

we compensate for this by **modeling** their perception.

how can we further improve EMS systems?

a) design with multiple modalities

b) if limited to EMS, consider modeling force perception



users **overestimate** force from EMS.

we compensate for this by **modeling** their perception.

how can we further improve EMS systems?

a) design with multiple modalities

b) if limited to EMS, consider modeling force perception

future work

precision of perceptual model

retention of target forces

across **more** situations and muscle groups


better morning
espresso


human computer
integration lab
THE UNIVERSITY OF CHICAGO
thanks for listening, **questions?**

human computer integration lab

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modeling perceived force of muscle stimulation to improve user's recall

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