

Studying neurodegeneration using mHealth: lessons From Multiple Studies



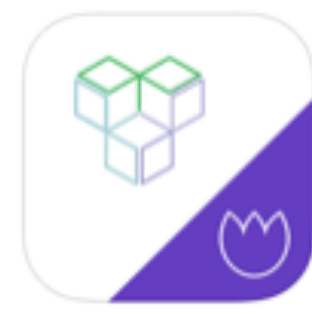
We believe that we can learn more by learning from each other....We advance biomedicine by making science more open, collaborative, and inclusive.

Involved with mHealth/Digital Health research since the inception 2014

> 230,000 study participants



Psoriasis



Parkinsons



Cardiovascular



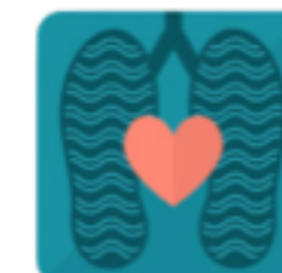
MoleMapper



Asthma



Multiple
Sclerosis



AllofUS
CRF



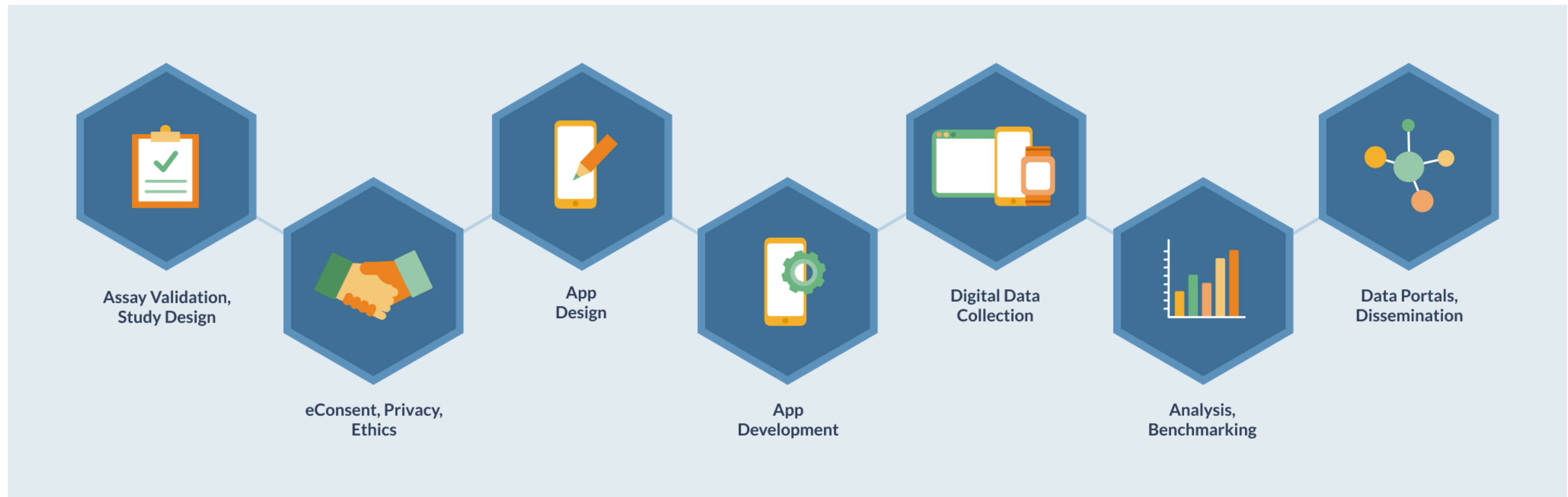
Samsung
my BP lab



Mobile
Toolbox

<https://sagebionetworks.org/digital-health-expertise/>

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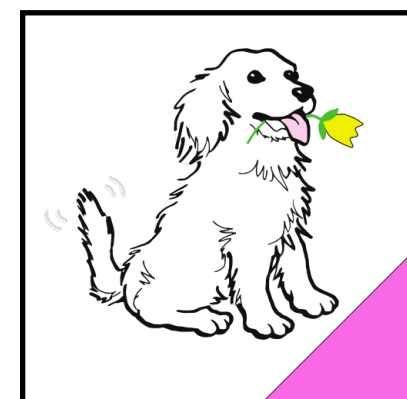


Parkinson's and other motor disease studies

mPower 1.0



Smart4Sure
and other clinical
trials



Digital Biomarker
Challenge



elevateMS

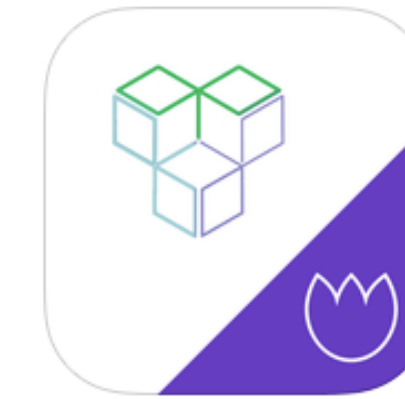
objectivePD
validation



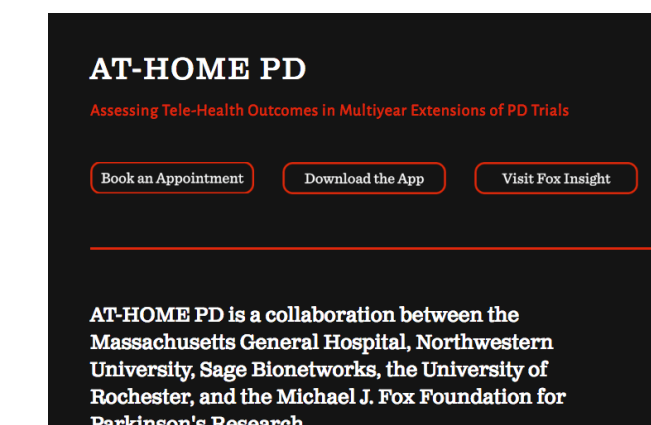
validation of Tremor
Penn



mPower
progression



At Home PD



mobile
Toolbox

DxA

Super Users

UR-UDALL

2015

2016

2017

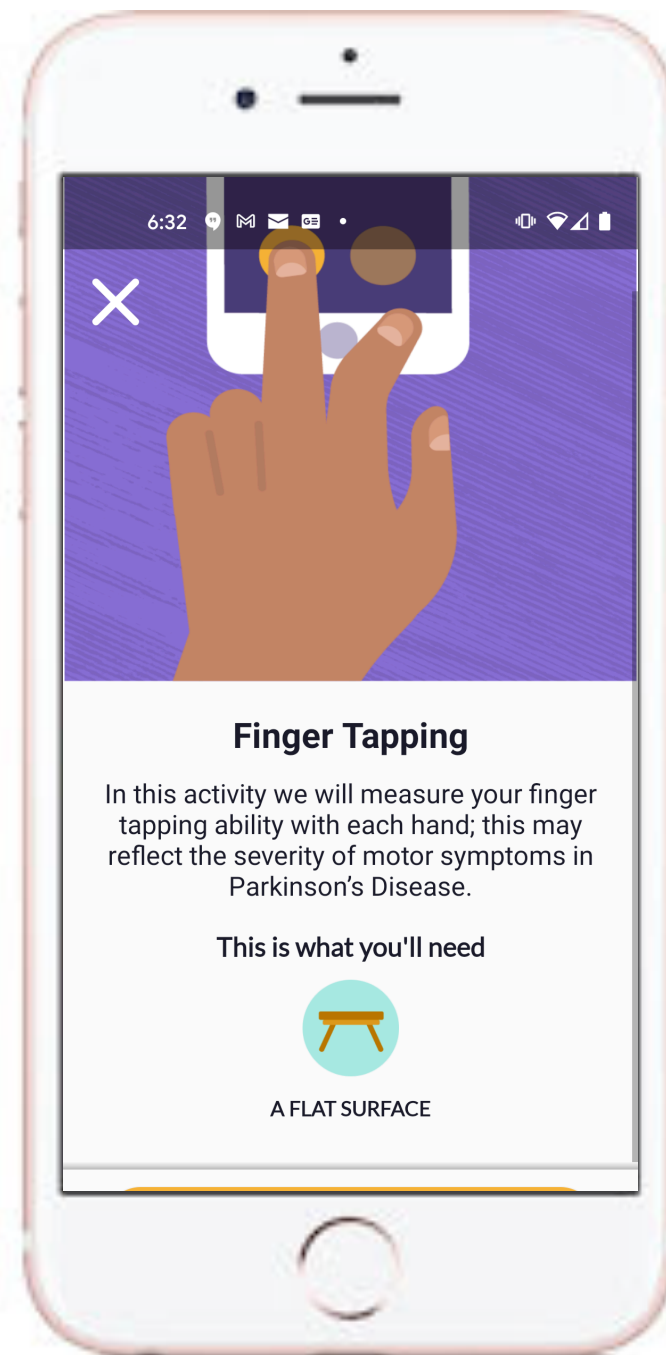
2018

2019

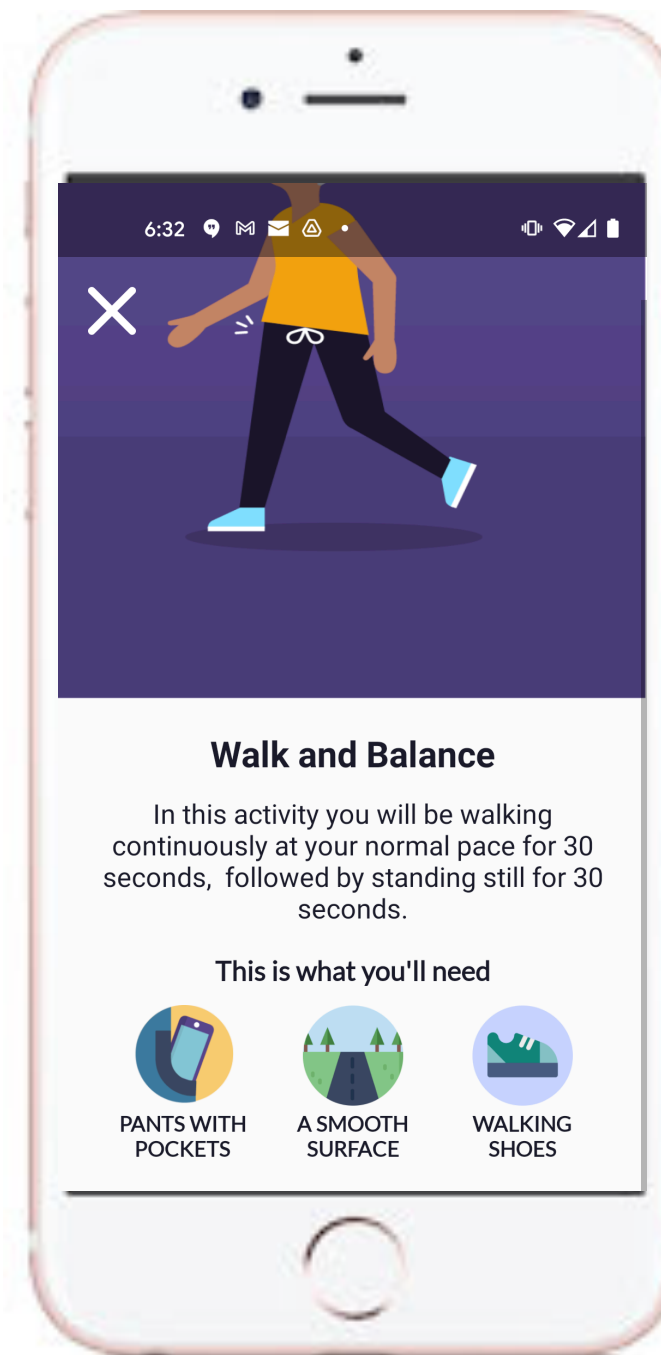
2020

Collection of real world data

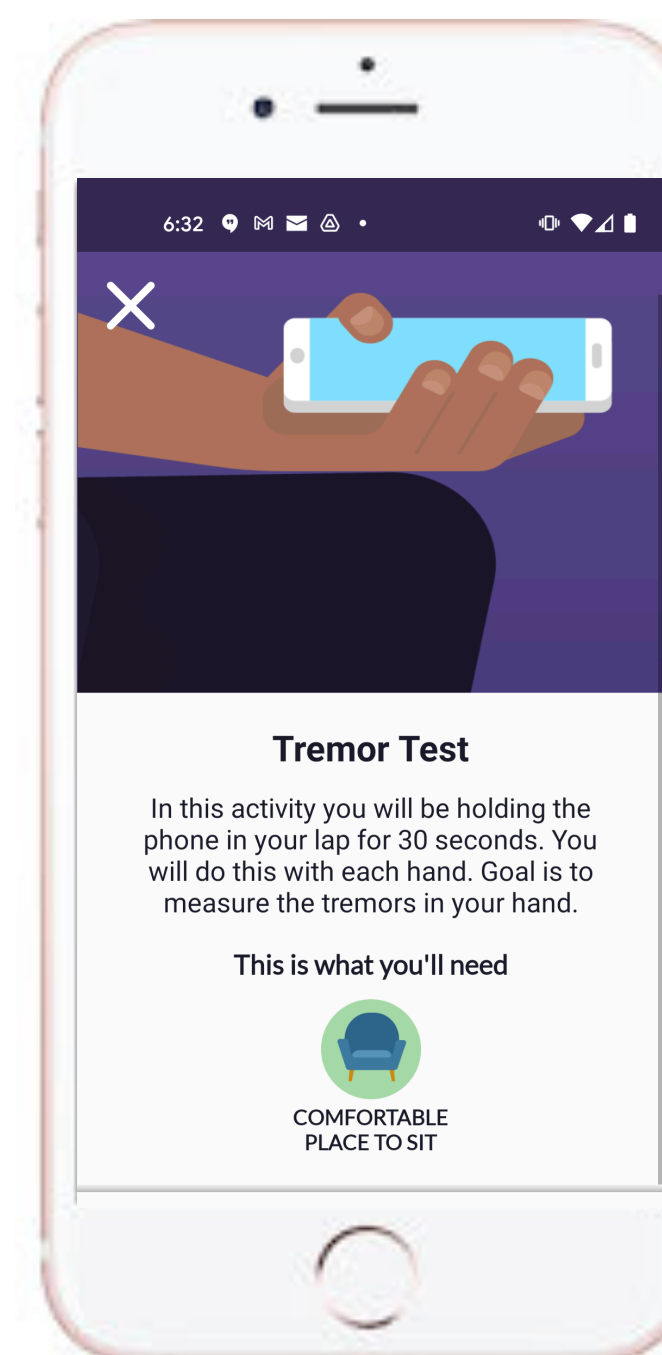
timed tapping



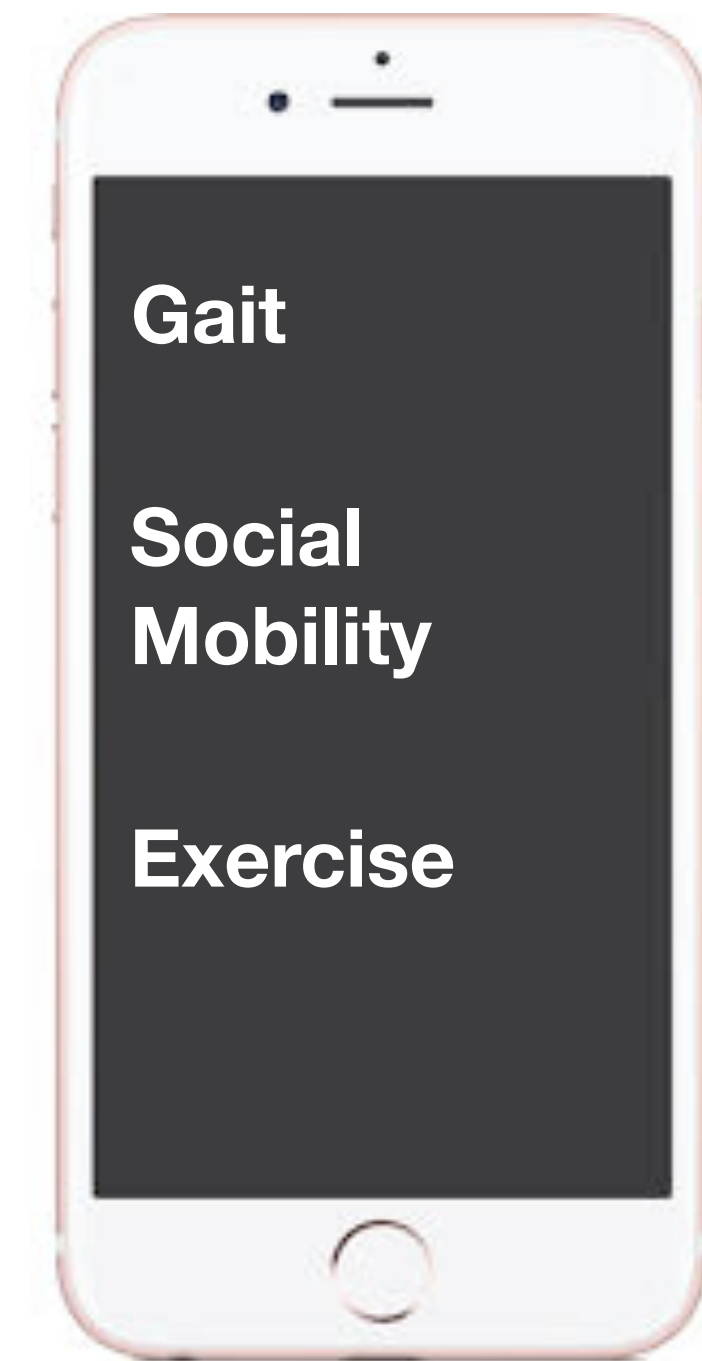
walk/balance



tremor



passive tracking

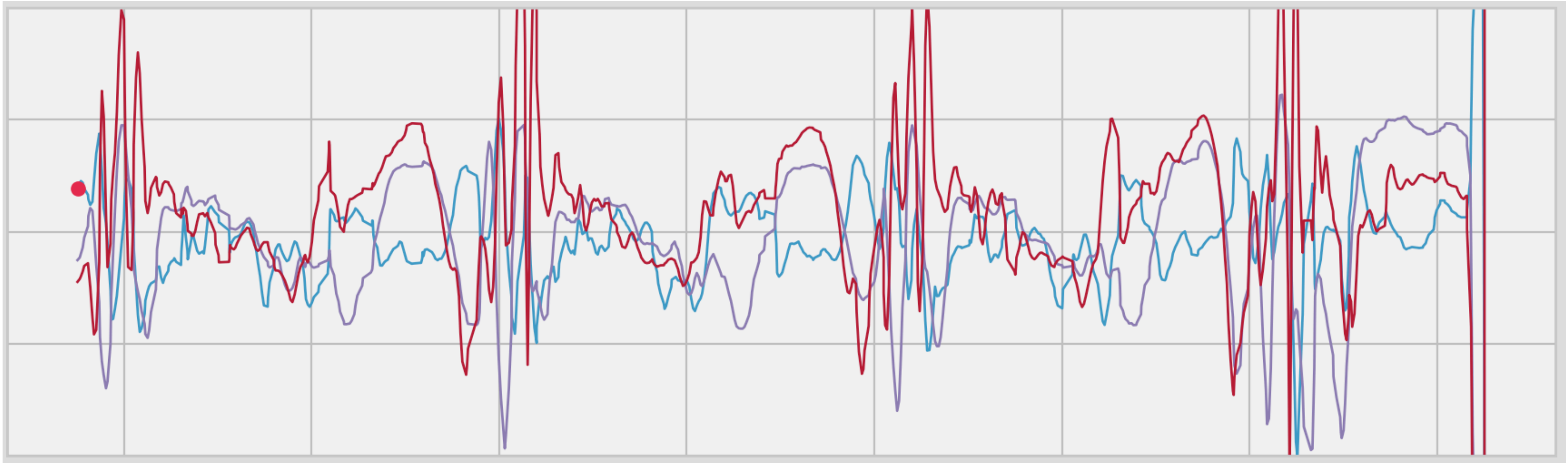
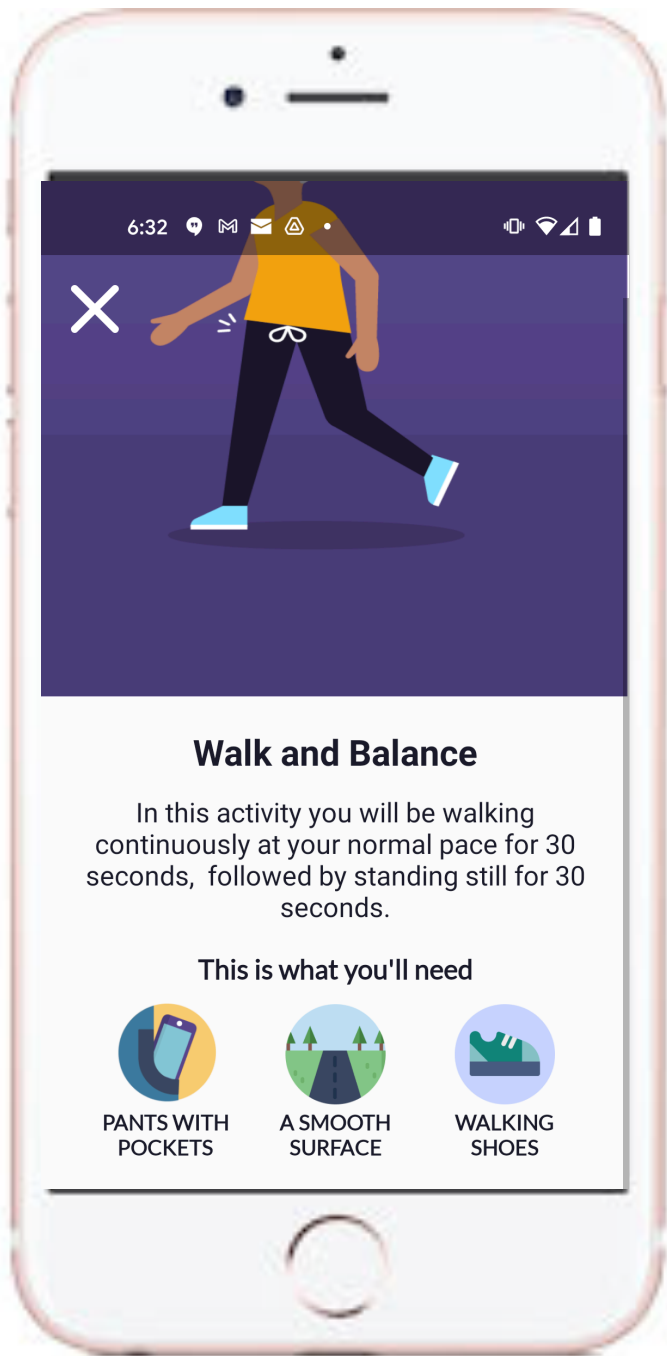


Patient Reported Outcomes:

PDQ-8, PHQ-8, Medication Tracking, Motor self assessment

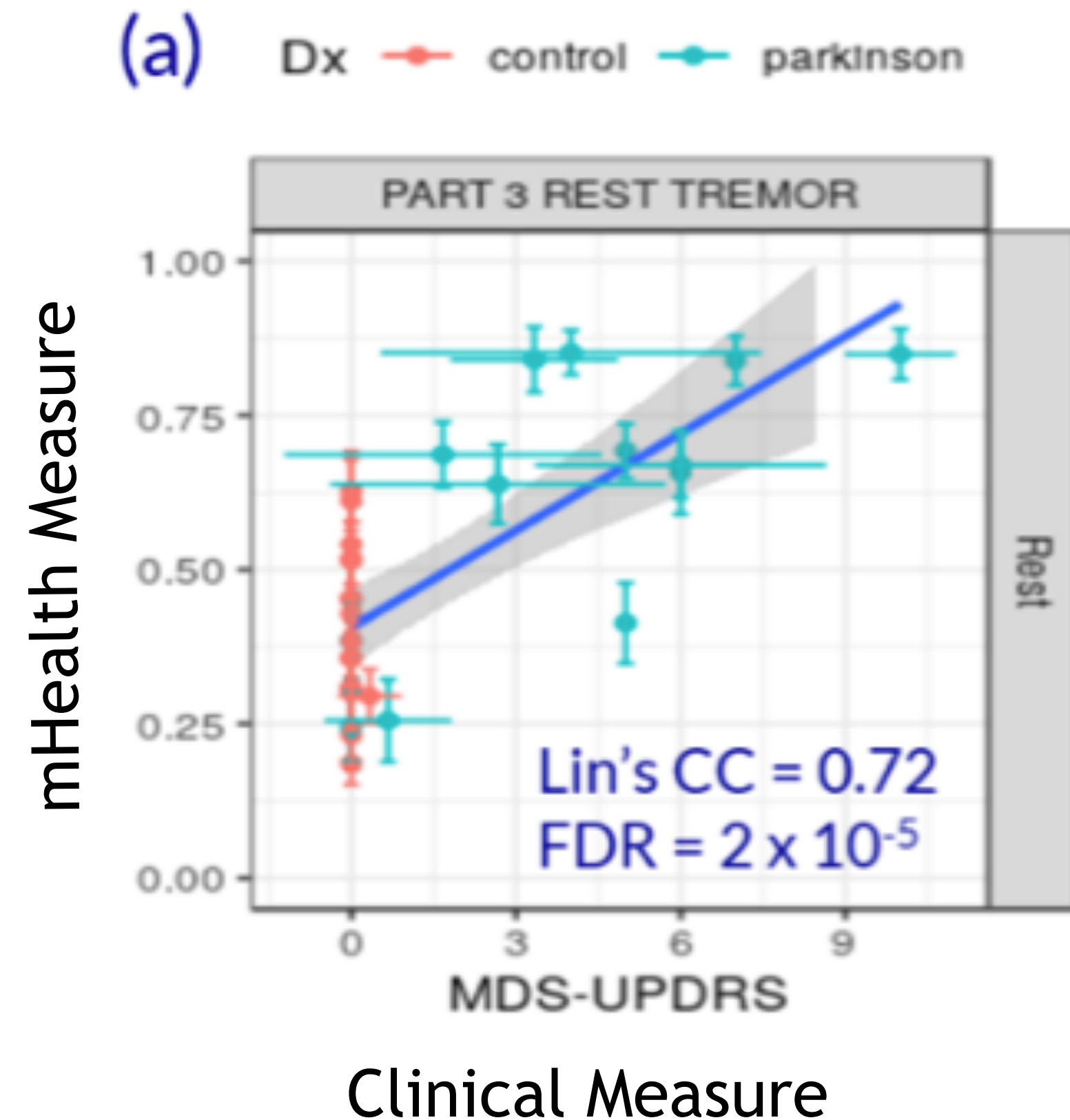


walk/balance

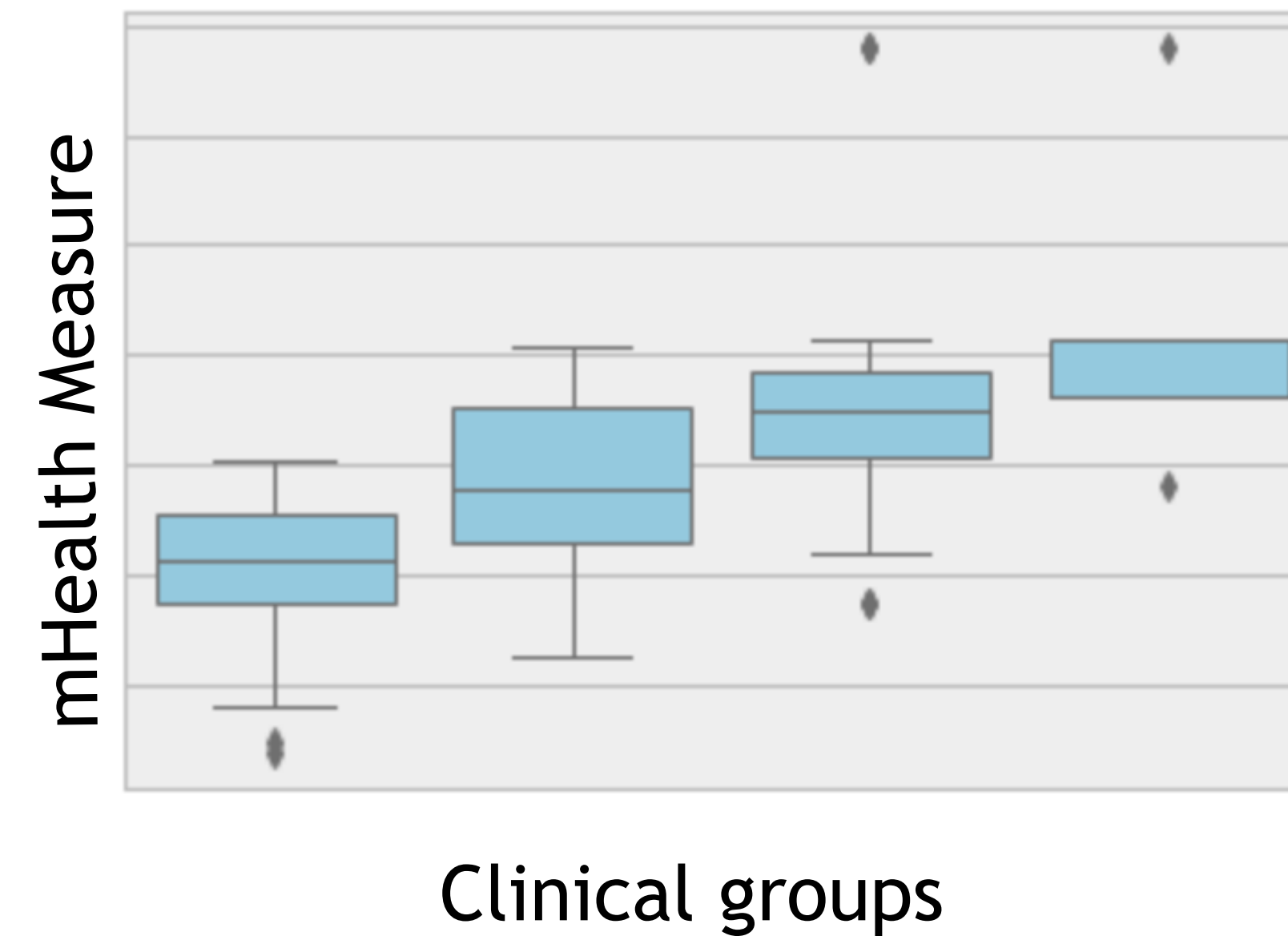


We want validated, robust, and trusted measures and biomarkers

validated



sensitive

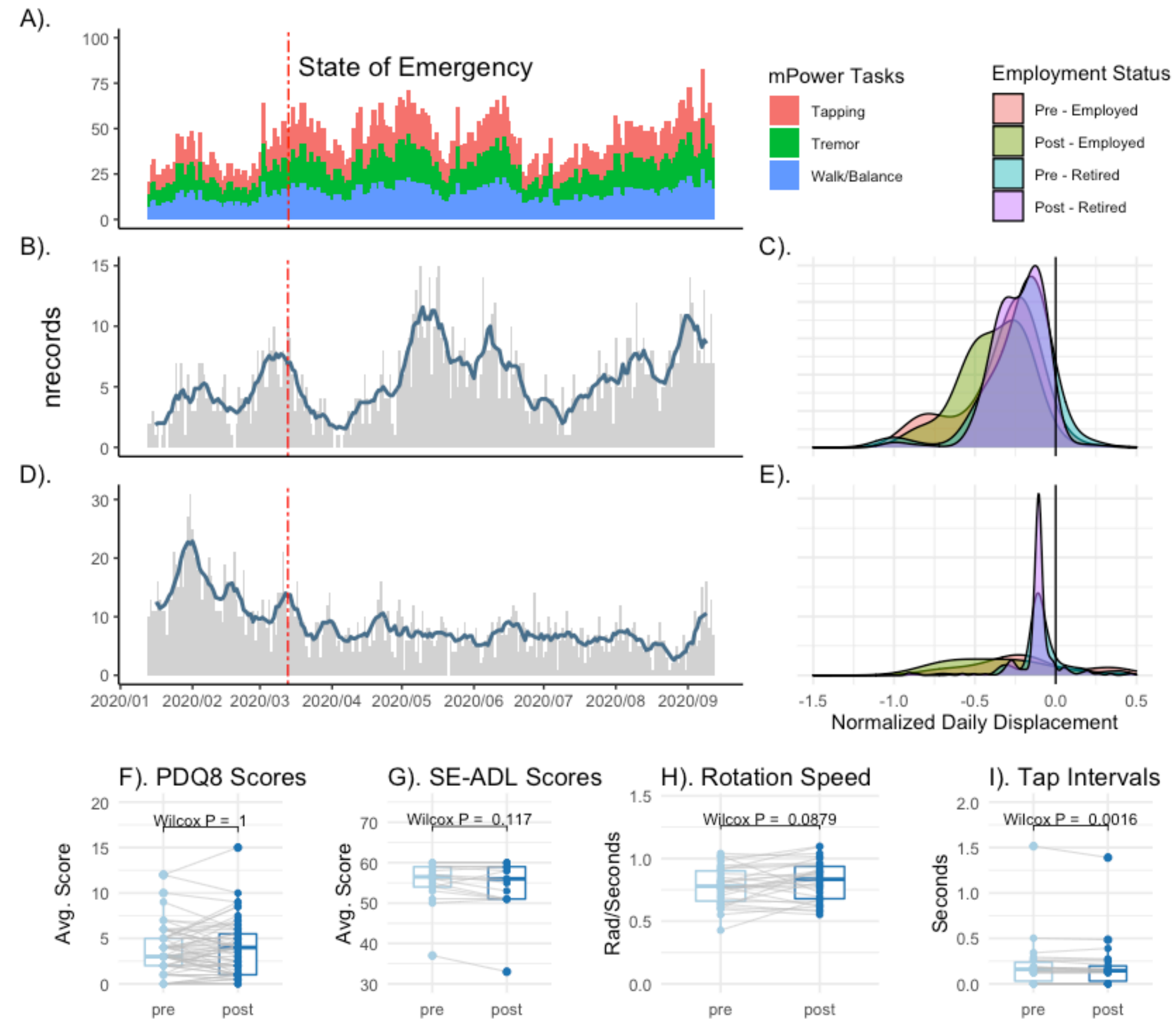


and the study designs that support them

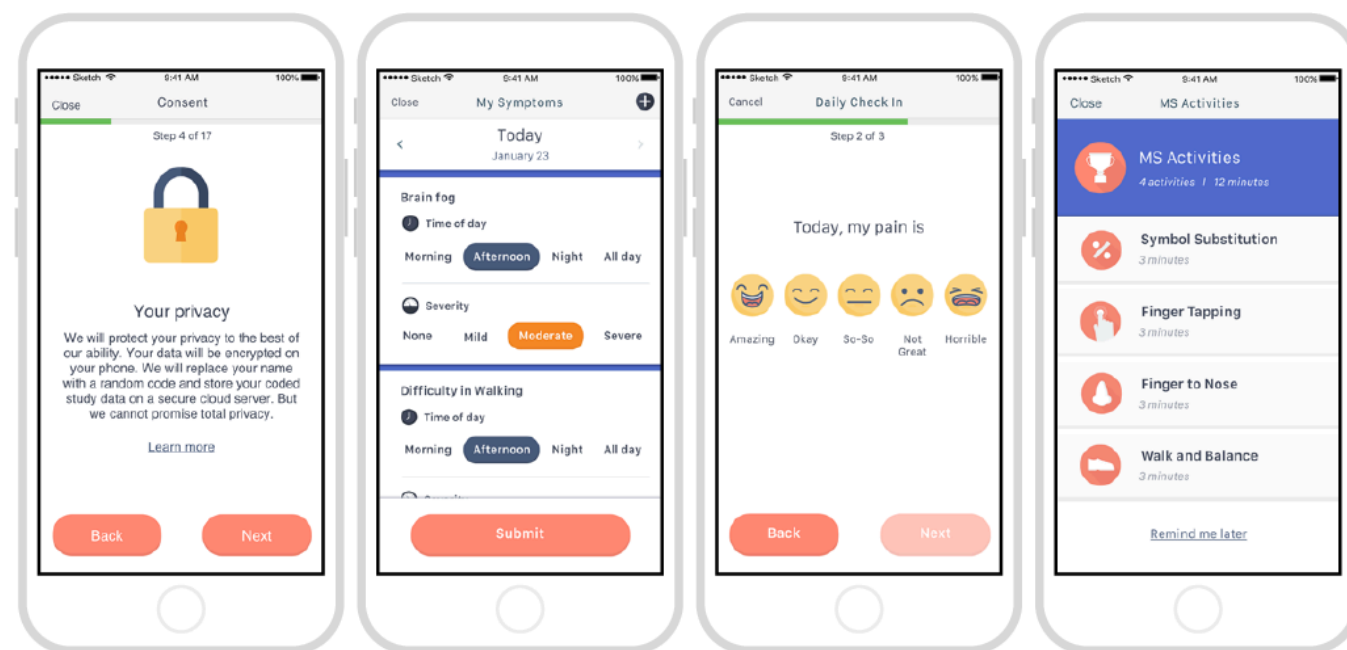
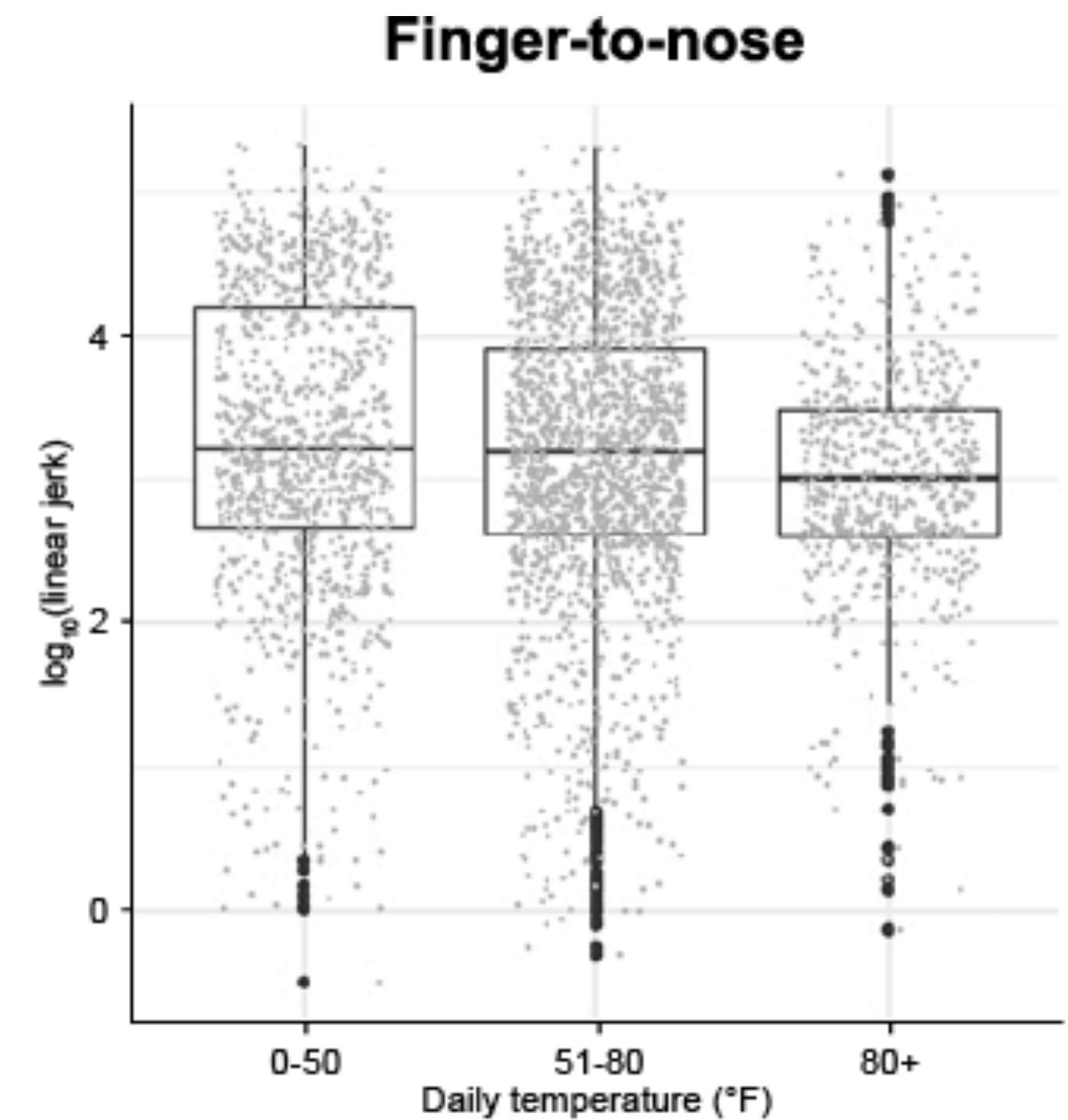
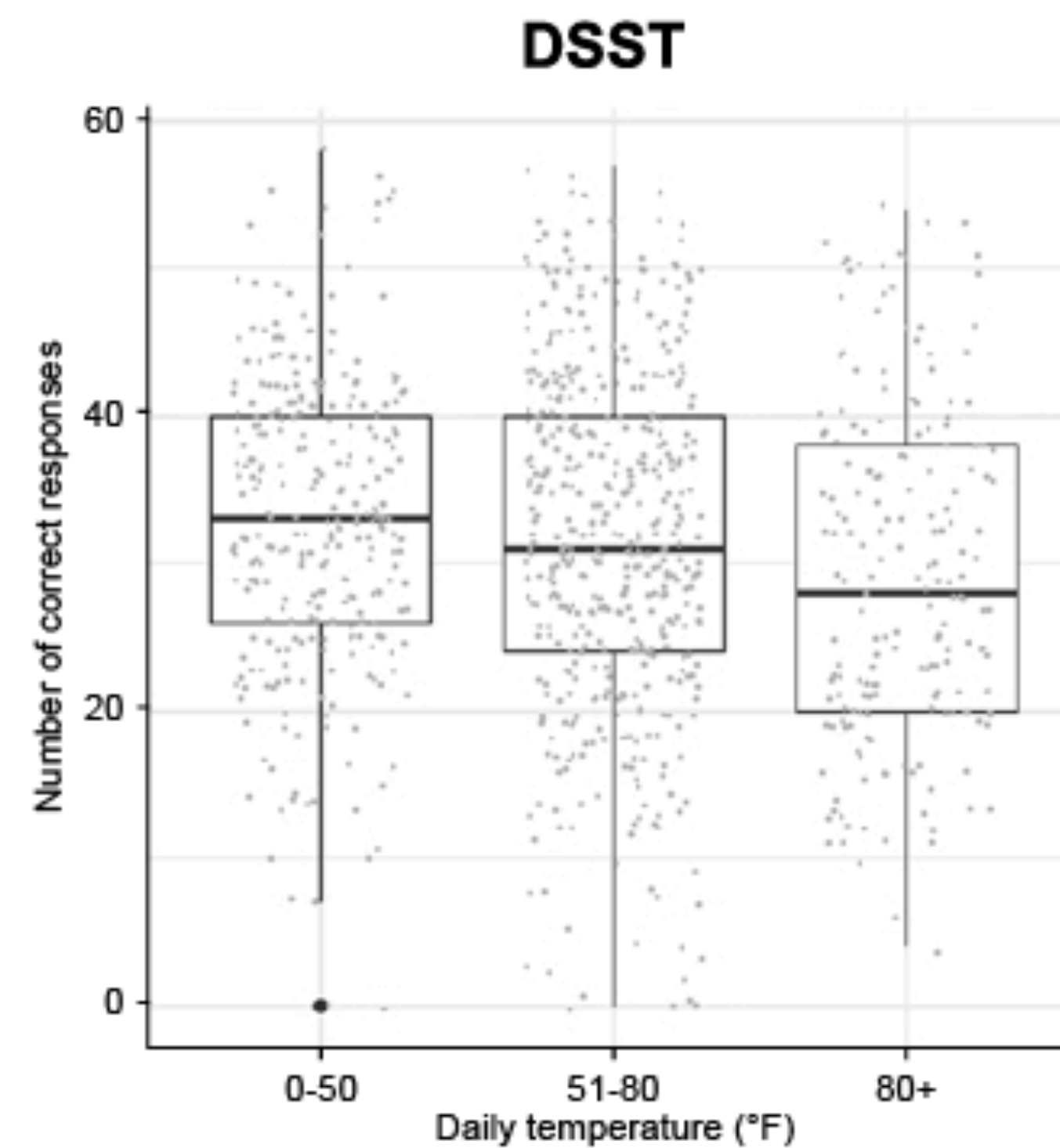
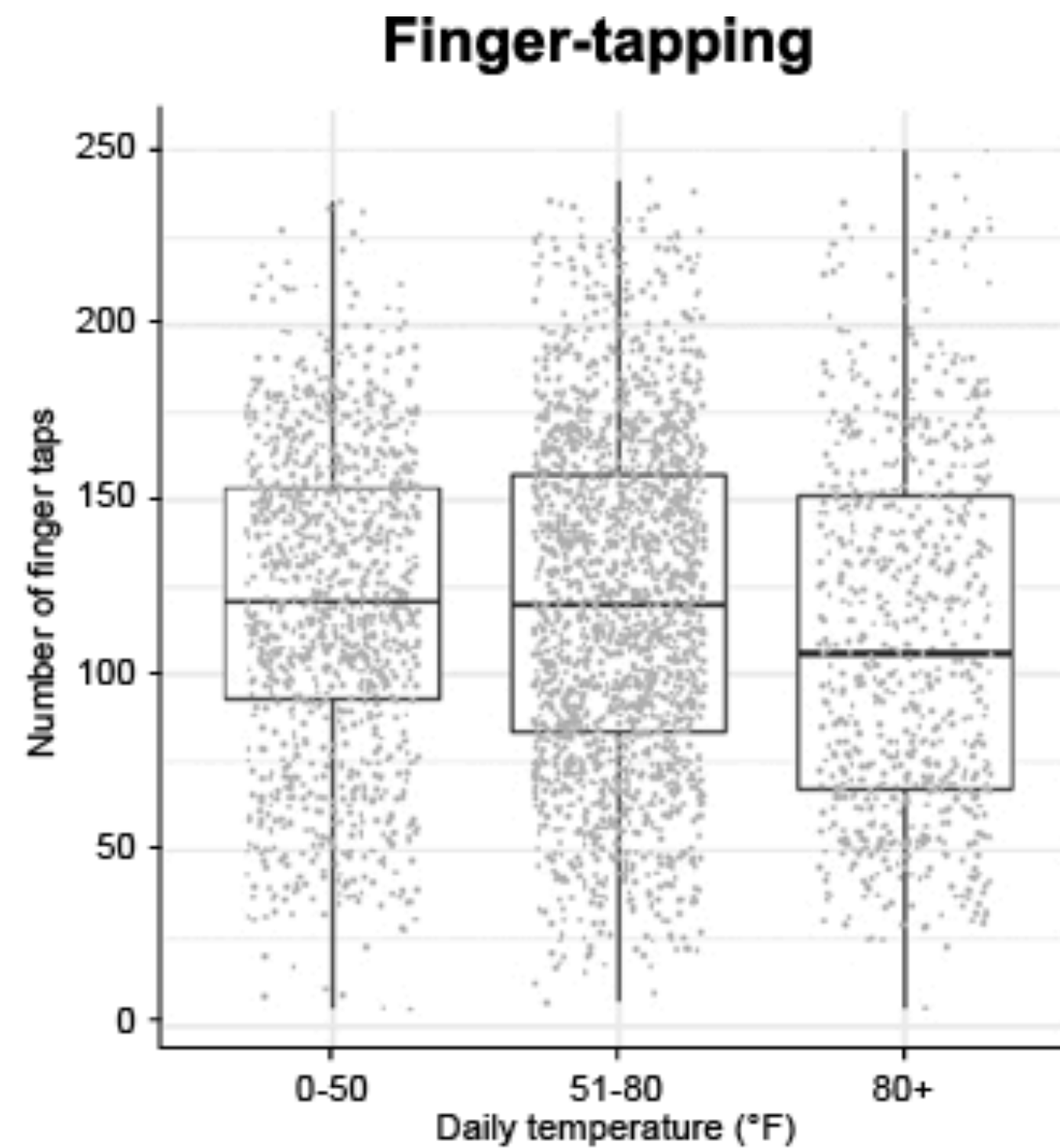


Context Matters: A Recent Example

Effect of COVID-19 on Mobility patterns and Severity



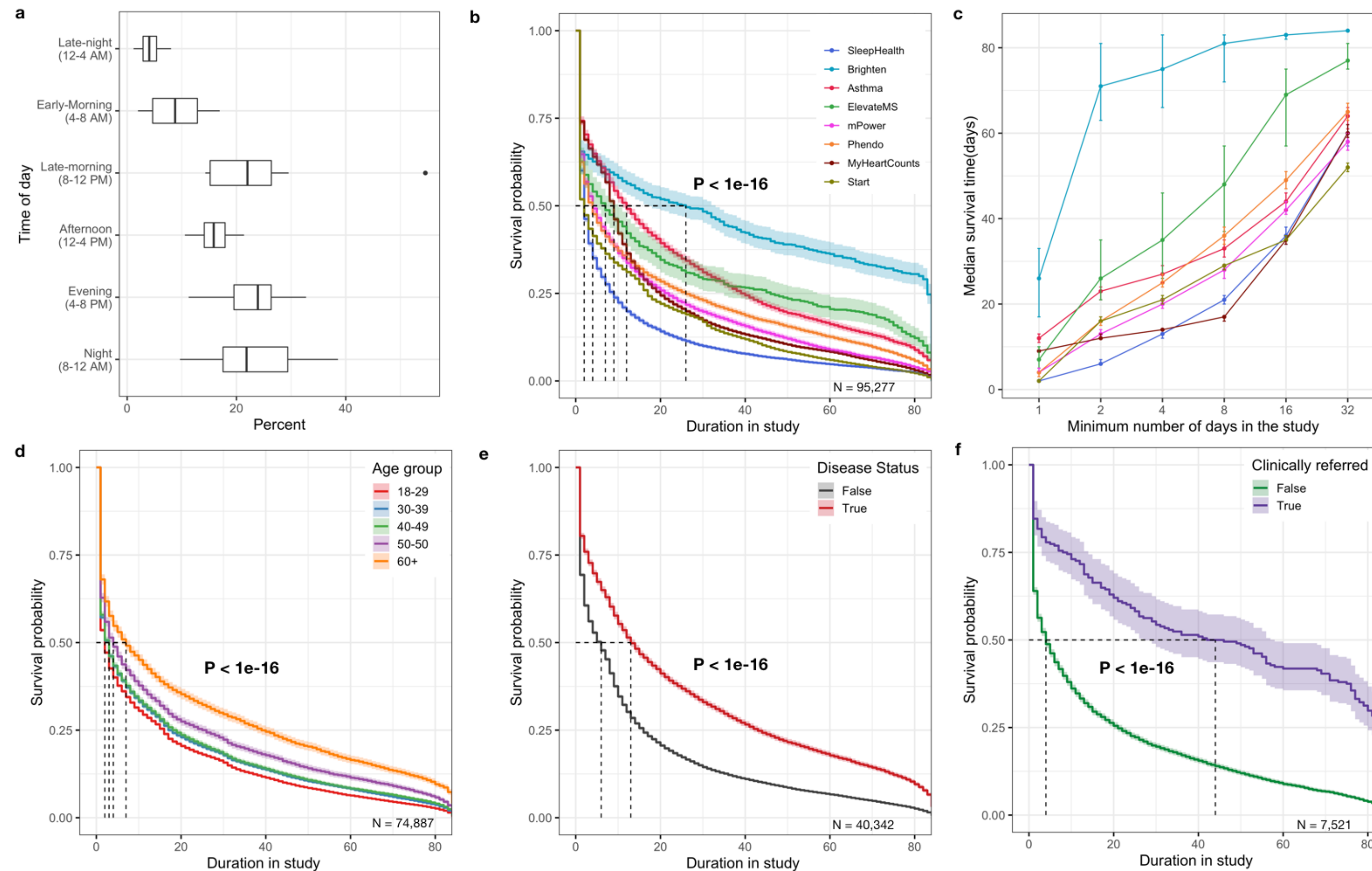
Context Matters: A Disease specific example Example



Pratap, A. *et al.* (2020) Evaluating the Utility of Smartphone-Based Sensor Assessments in Persons With Multiple Sclerosis in the Real-World Using an App (elevateMS): Observational, Prospective Pilot Digital Health Study. *JMIR mHealth*. Vol 8, No 10 (2020): October

Even if validated - your population might still be confounded

A meta study: Retention across 8 studies and 109,000 participants



Pratap, A. *et al.* (2020) Indicators of retention in remote digital health studies: a cross-study evaluation of 100,000 participants. *npj Digit. Med.* **3**, 21.

How to slay a Dragon

Issue 1: in wild recruitment can lead imbalanced population


Issue 2: dimensional reduction is hard

Issue 3: noisy data

Issue 4: there can be strong confounders

Issue 5: Interactions between confounders

Issue 6: strong autocorrelation due to frequent sampling

Issue 7: 

Omberg et al Clinical Pharmacology (2020)
Dorsey et al Journal of Parkinson's Disease (2020)
Pratap et al Nature Digital Medicine (2020)
Sieberts et al BioArxiv (2020)
Neto et al arXiv:1911.05139 (2020)
Neto et al Nature Digital Medicine (2019)
Neto et al SIGKDD (2019)

A person is seen from behind, rappelling down a rope from the edge of a dark cave opening. They are looking out over a vast, dramatic landscape. In the foreground, the dark, silty interior of the cave frames the view. Outside, a rugged coastline features steep, light-colored cliffs partially covered in green vegetation. At the base of the cliffs is a sandy beach and the ocean. The sky is filled with soft, grey clouds. The overall mood is one of adventure and the realization of needing help for such a task.

We can't do this alone

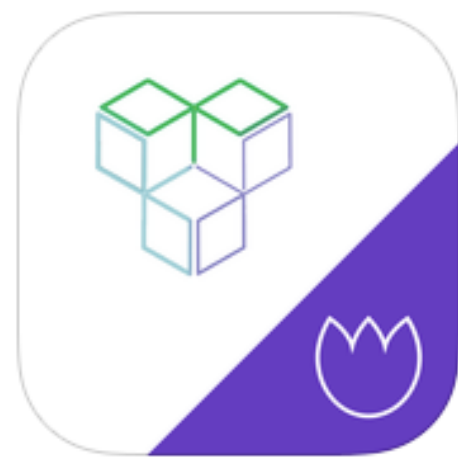
What do participants want?

83% of 219,000 research participants chose to share their data with *any* qualified researcher

Yet vast majority of mHealth data collected is in
closed ecosystems



data and **analysis** deemed to have commercial value



mPower - Researcher Community

 mPower Public Researcher Portal 



Larsson Omberg (larssono)



Help



Synapse ID: syn4993293

DOI: doi:10.7303/syn4993293

Storage Location: Synapse Storage 

 Share

 Annotations


 Tools 

Wiki 

Files 

Tables 

Discussion 

mPower Public Researcher Portal 

1 - Accessing the mPower data

2 - Data description 

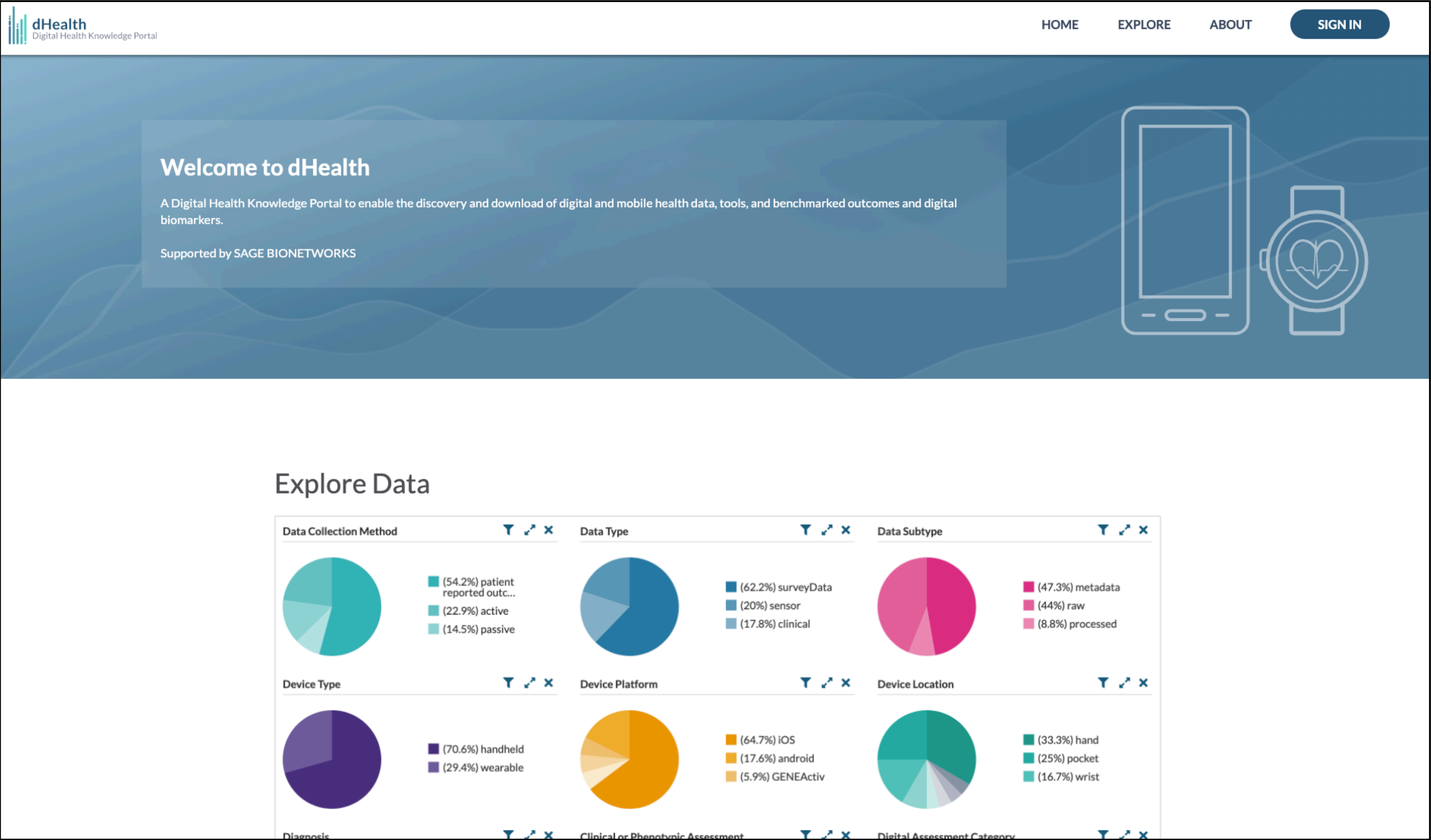
3 - mPower research community

4 - Publications

5 - FAQs

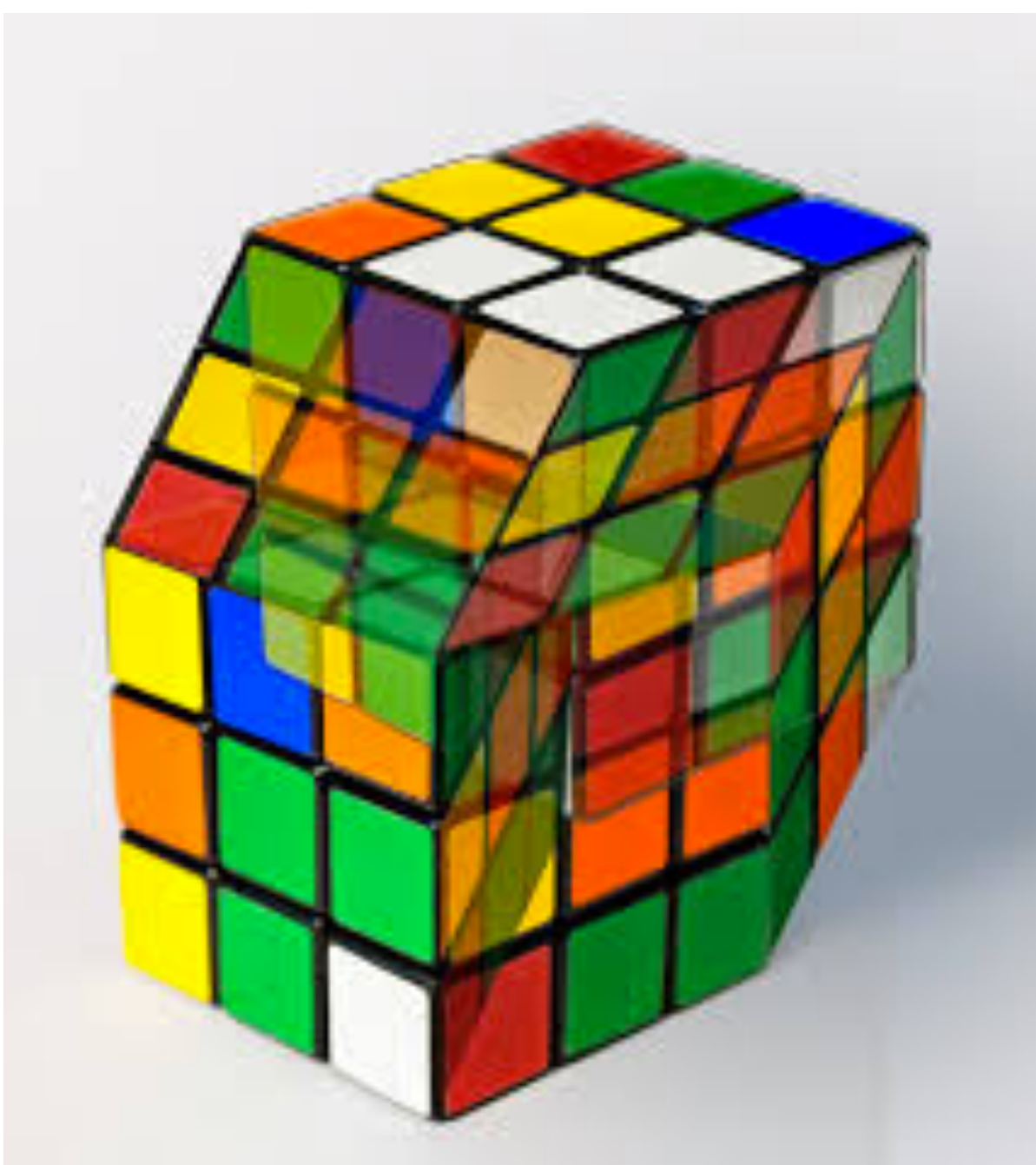
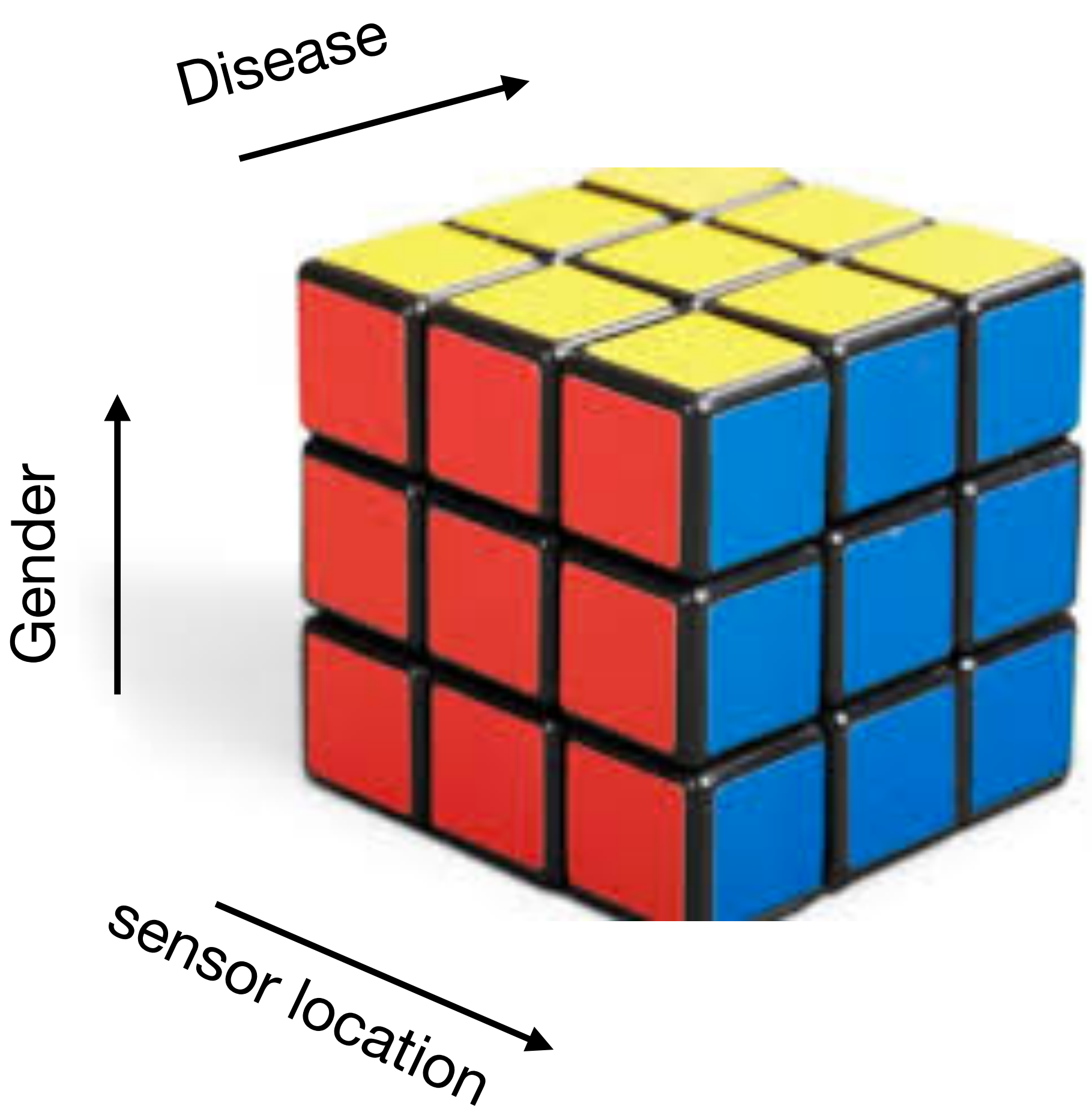
6 - Contact us

Digital Health Knowledge Portal



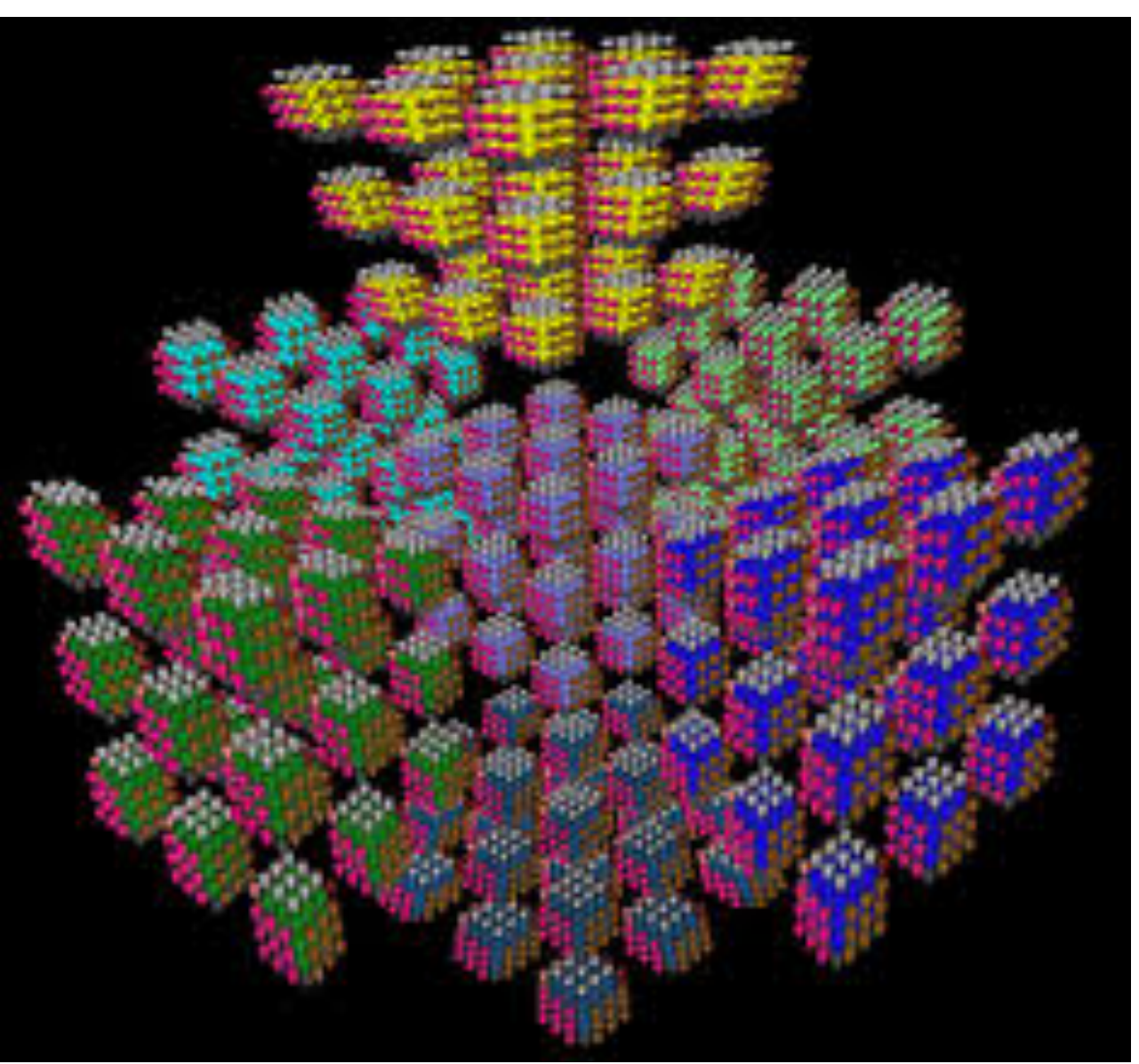
Even with hundreds of users and dozens of papers....

The space of exploration is too large and results were not comparable



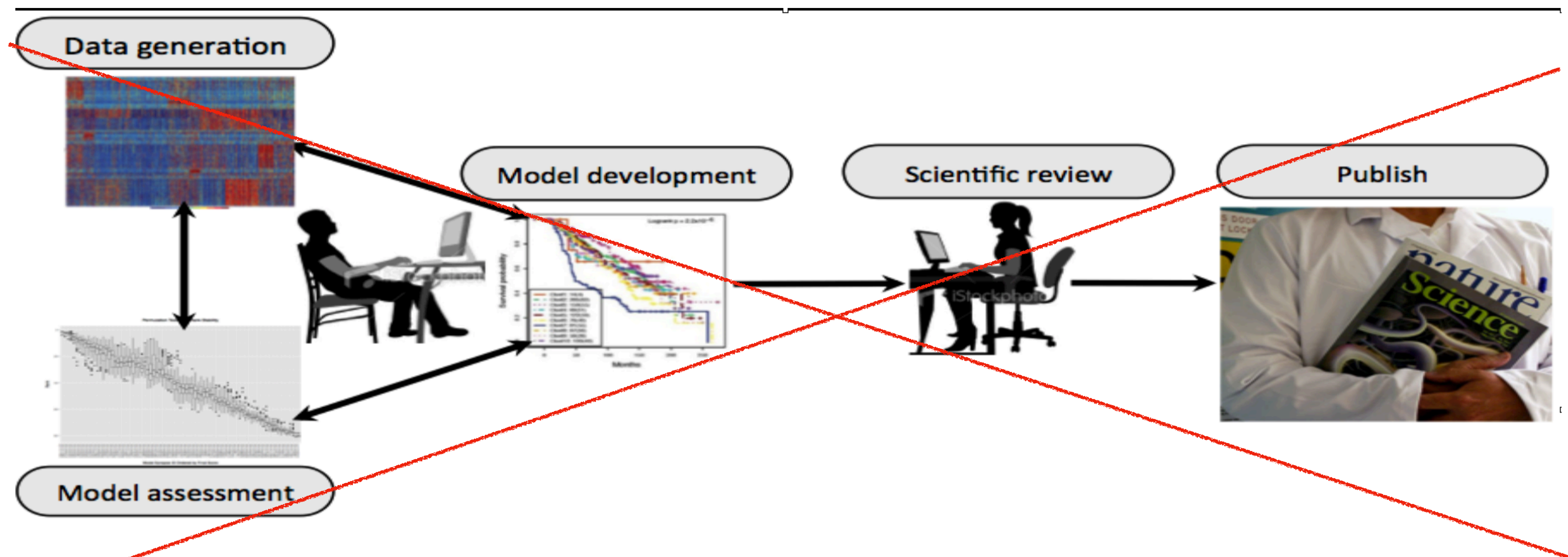
4D

Age, Gender, Location, Device, Noise, ...

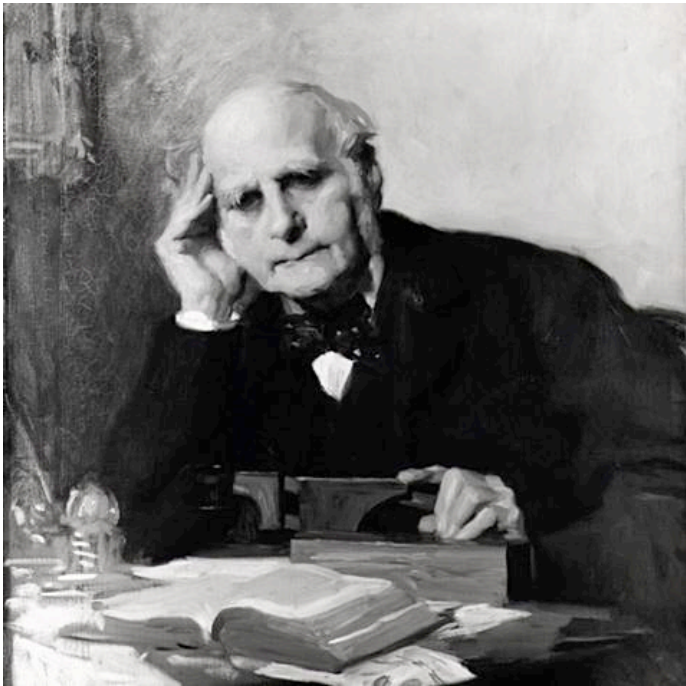
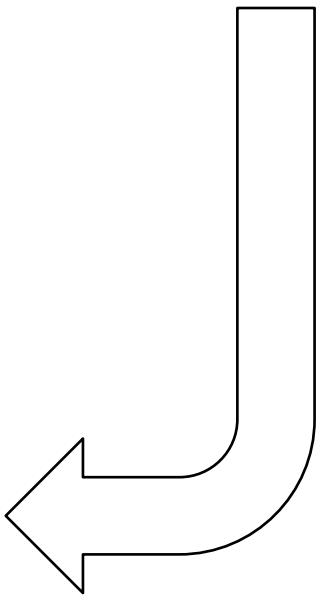
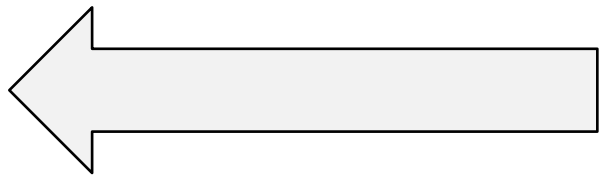
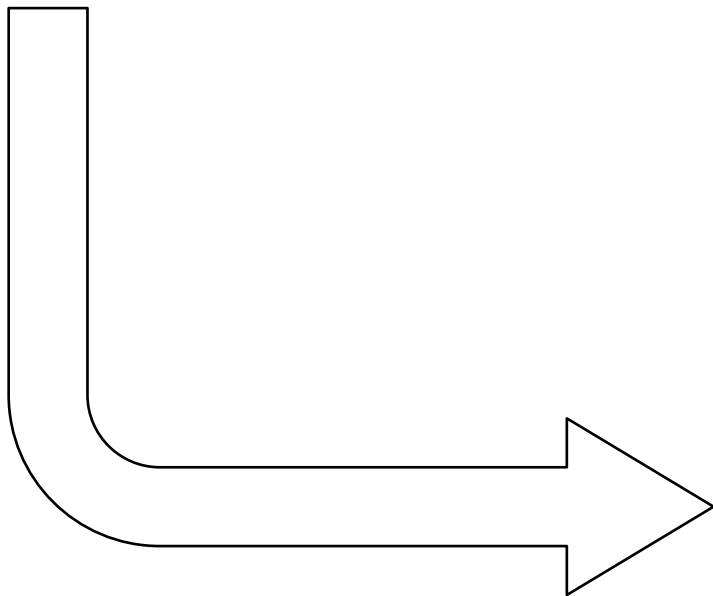
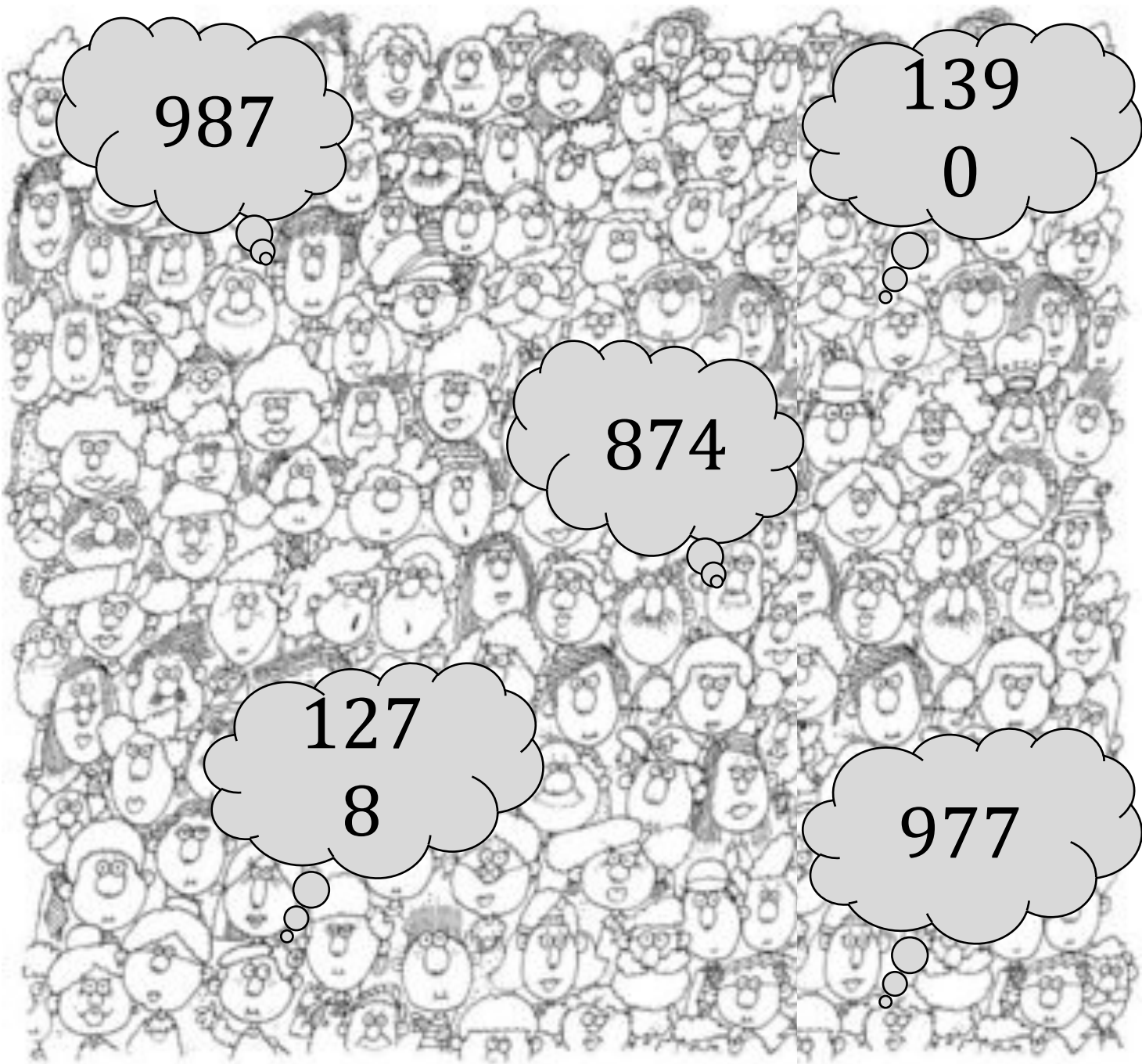
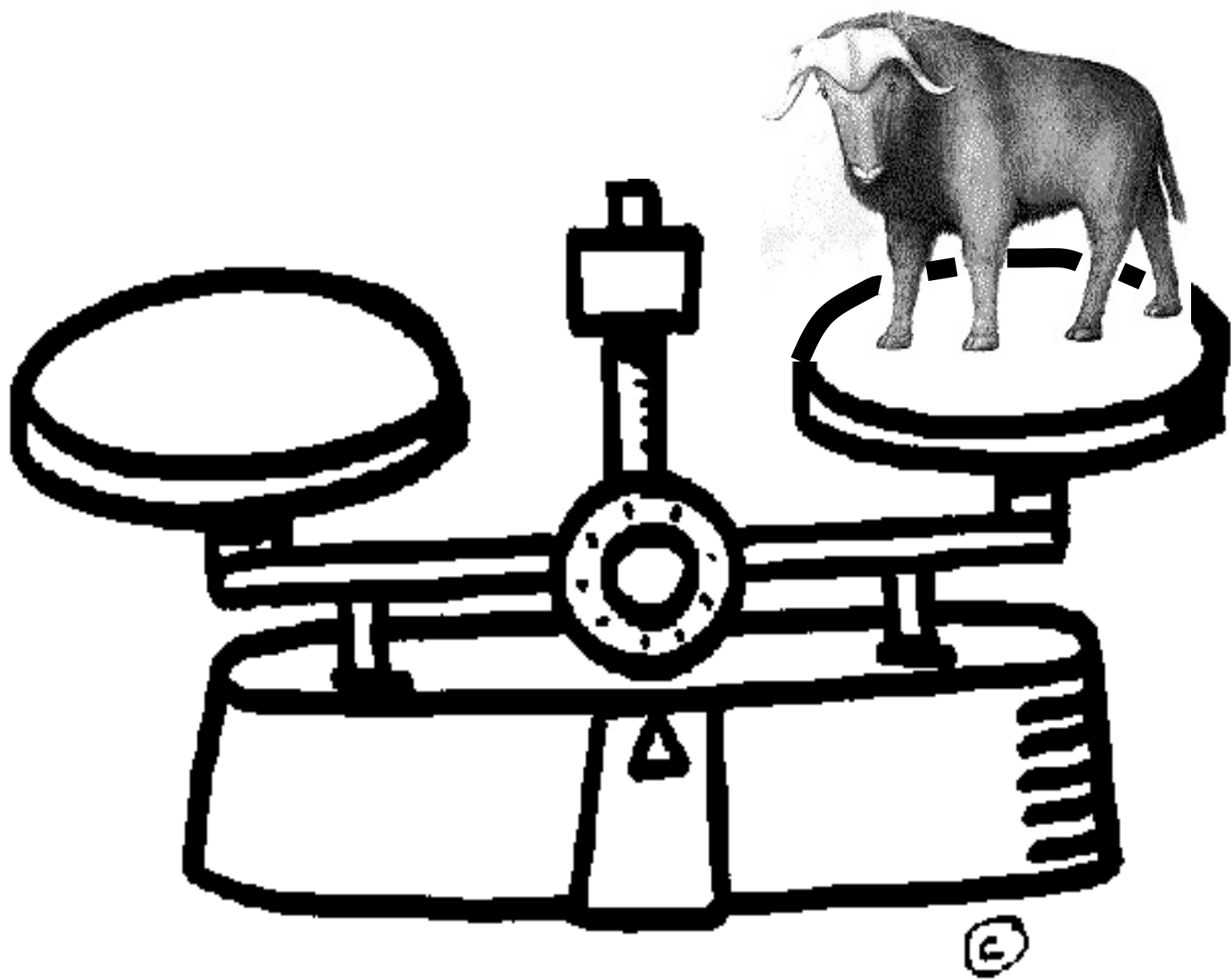


7D

Crowd sourced challenges as a framework for benchmarking



The Wisdom of Crowds



450

NATURE

[MARCH 7, 1907]

2017



**Parkinson's Disease Digital Biomarker
DREAM Challenge**

ENABLED BY

 **HARVARD**
UNIVERSITY

 **THE MICHAEL J. FOX FOUNDATION**
FOR PARKINSON'S RESEARCH

 **Robert Wood Johnson**
Foundation

 **Sage**
BIONETWORKS

 **verily**

 **UNIVERSITY OF**
ROCHESTER

EARLY  **SIGNAL**

2020



BEAT-PD DREAM Challenge
Biomarker & Endpoint Assessment to Track Parkinson's Disease

 **BRAINCOMMONS**

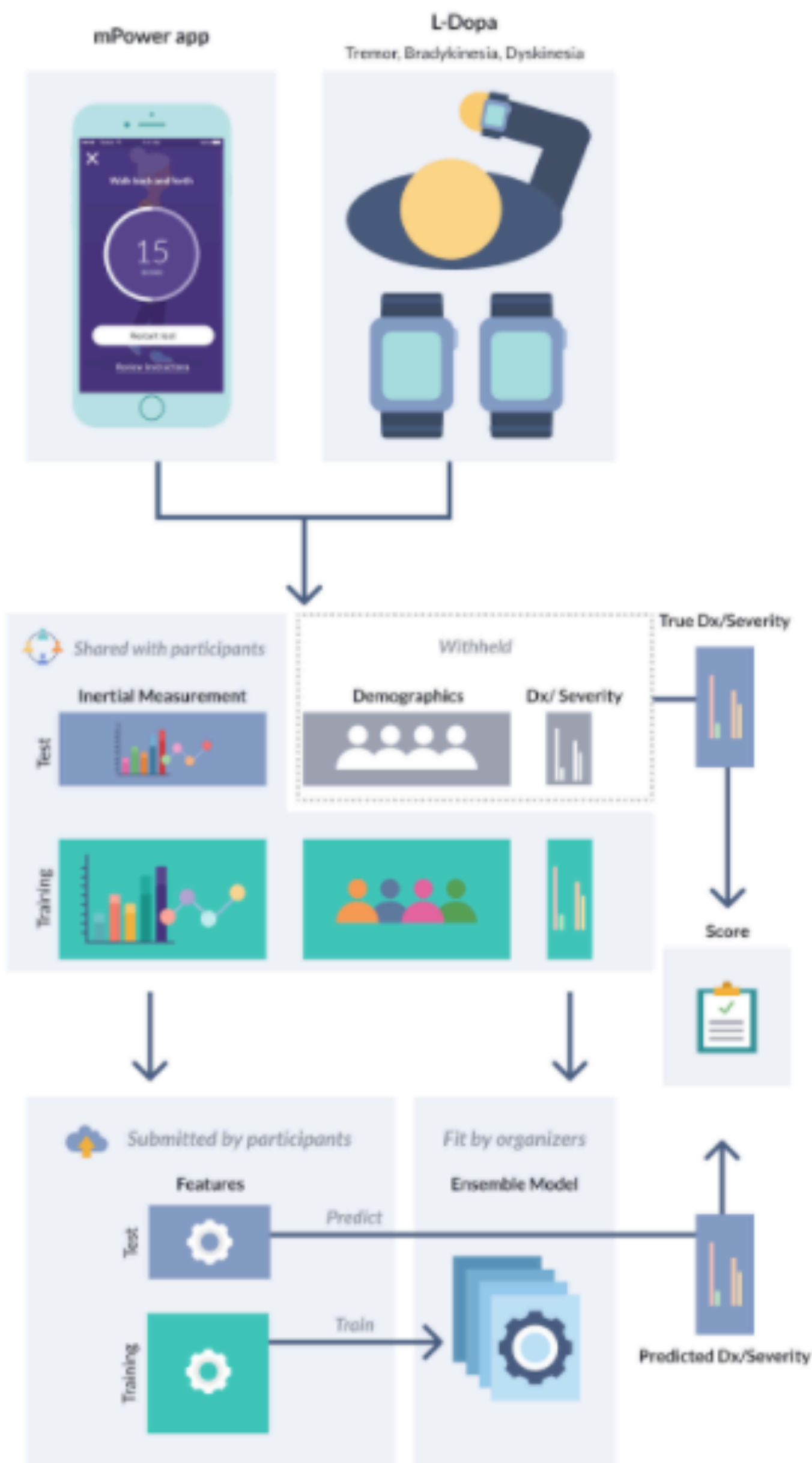
evidation

 **THE MICHAEL J. FOX FOUNDATION**
FOR PARKINSON'S RESEARCH

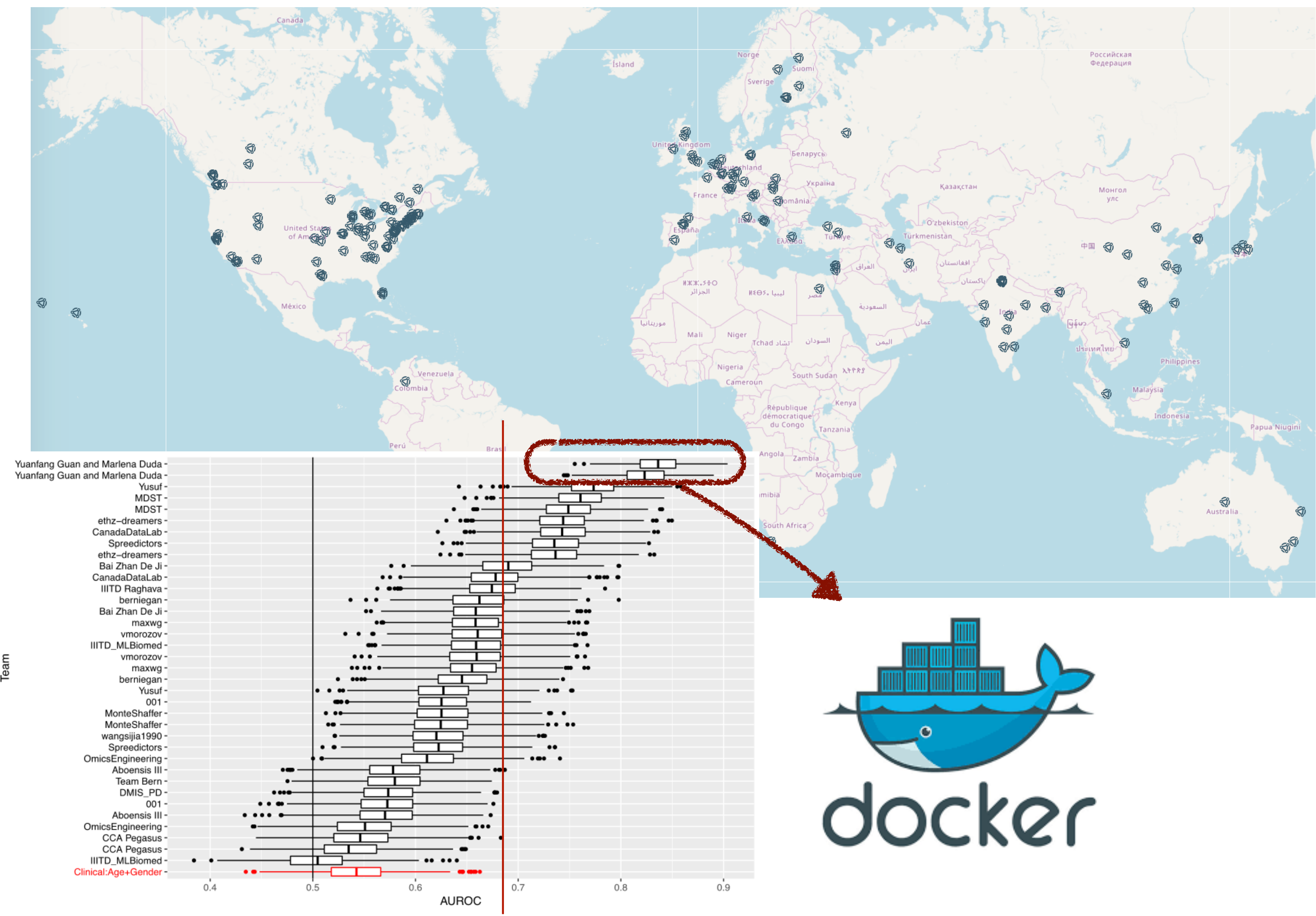
Radboudumc
university medical center

Shirley Ryan
Abilitylab.

 **SageBionetworks**

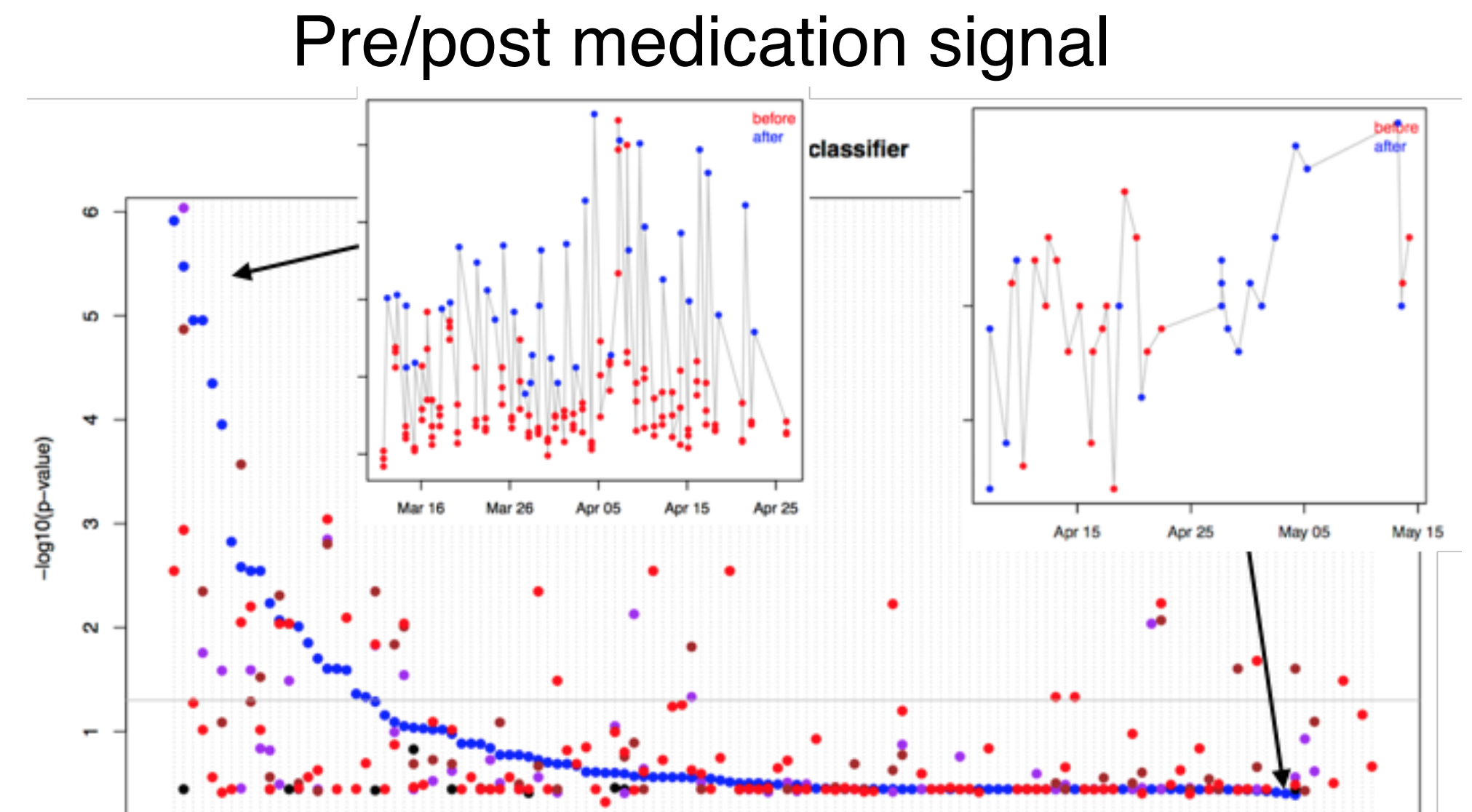


Create impartial Benchmarking



Challenge Provides Rich Opportunities for Post-Hoc Analysis

- Are feature sets associated with other disease severity (e.g. patient reported outcomes)?
- Are features good predictors of medication effects? Can they distinguish medicated PD patients from controls?
- Can we determine orthogonal features across submissions? Can we identify concise sets of features?
- Is the Gyroscope data useful for predictive features? Does app version matter?
- Are best predictive features clinically interpretable?
- How many repeated measures are necessary to classify PD/Control?



Develop Reusable Code and Pipelines

open collaborative methodologies



reusable



[https://github](https://github.com)

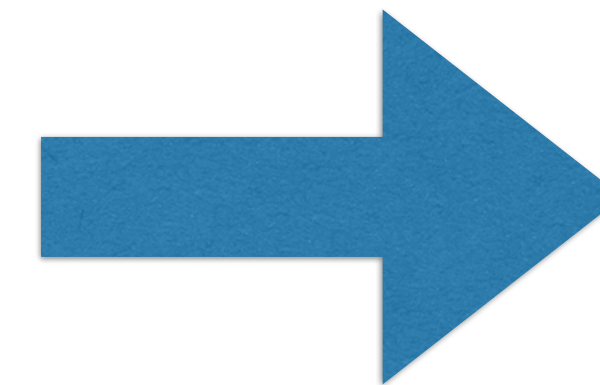


[syn12144677](#)



Sage-Bionetworks / mpowertools

```
10 process_medicationChoiceAnswers <- function
11   tryCatch({
12     d <- jsonlite::fromJSON(json_file)
13     data.frame(medication = paste(unique
14       collapse = "+"), medicationTime
15       collapse = "+"))
16   }, error = function(err) {
17     data.frame(medication = "NA", medic
18   })
19 }
```



Cloud enabled workflow

<https://github.com/Sage-Bionetworks/mhealthtools>

Thank You



Elias Chaibub Neto,
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Phil Snyder,
Brian M. Bot,
Dan Webster,
Sonia Carlson,
Alex Mariakakis,
Meghasyam Tummalacheria
Lara Mangravite

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