

# Deepening Public Contributions to Occupational Health

Rocky Mountain Center for  
Occupational and Environmental  
Health (RMCOEH) Retreat

Aug 14, 2024

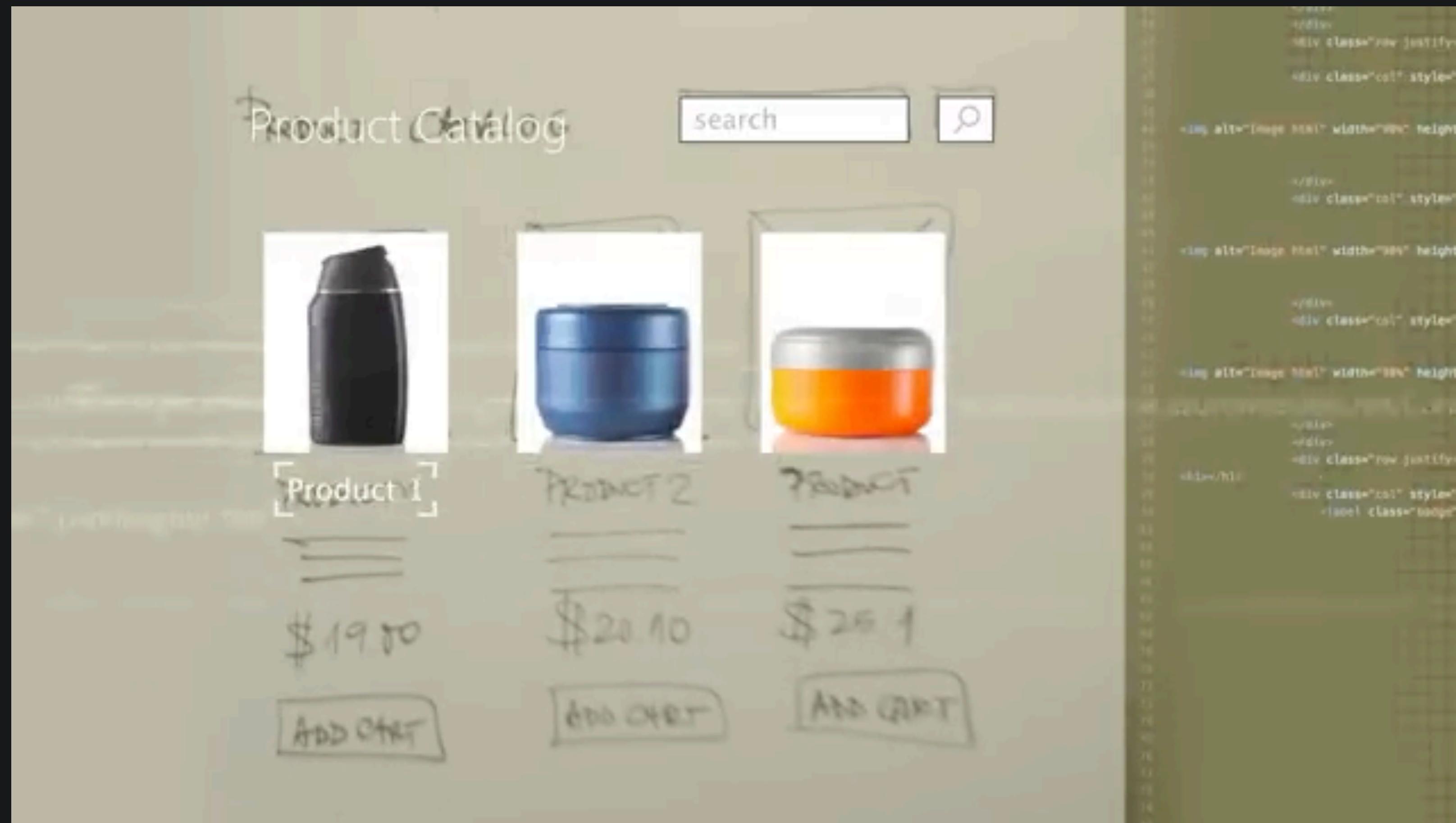


**Vineet Pandey**  
Assistant Professor  
Kahlert School of Computing  
University of Utah

# Which are some of your favorite apps?

Here's one peek at the future

<https://www.youtube.com/watch?v=V6pqqPPHyYM>



# Why does this matter for Occupational Health?

# In health settings, the gap between cause and effect is large

Traditional approach:

1. Design a study (many months)
2. Get everything in place (some months)
3. Run the study (depends)
4. Analyze the data (many months)
5. Publish the results (Depends on how many times the manuscript gets rejected)

This is an investment of years into evaluating a small set of hypotheses

In health settings, the gap between cause and effect is large

My hunch:

The rate-limiting step in health science is not generating ideas about what effects health but rather rapidly evaluating them with

...rigorous study design

...rapid data collection

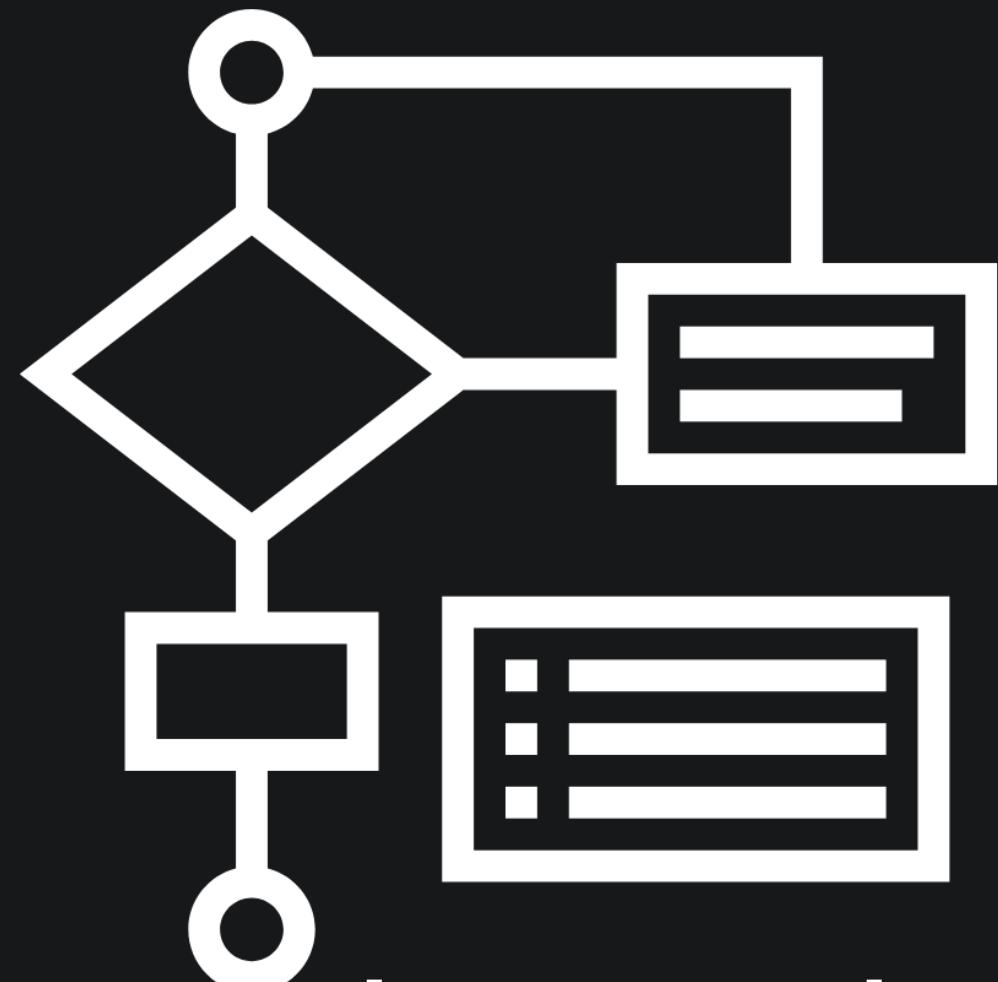
...broad access and inclusion

What if domain experts offloaded many  
of these activities to a phone?

- ...rigorous study design
- ...rapid data collection
- ...broad access and inclusion

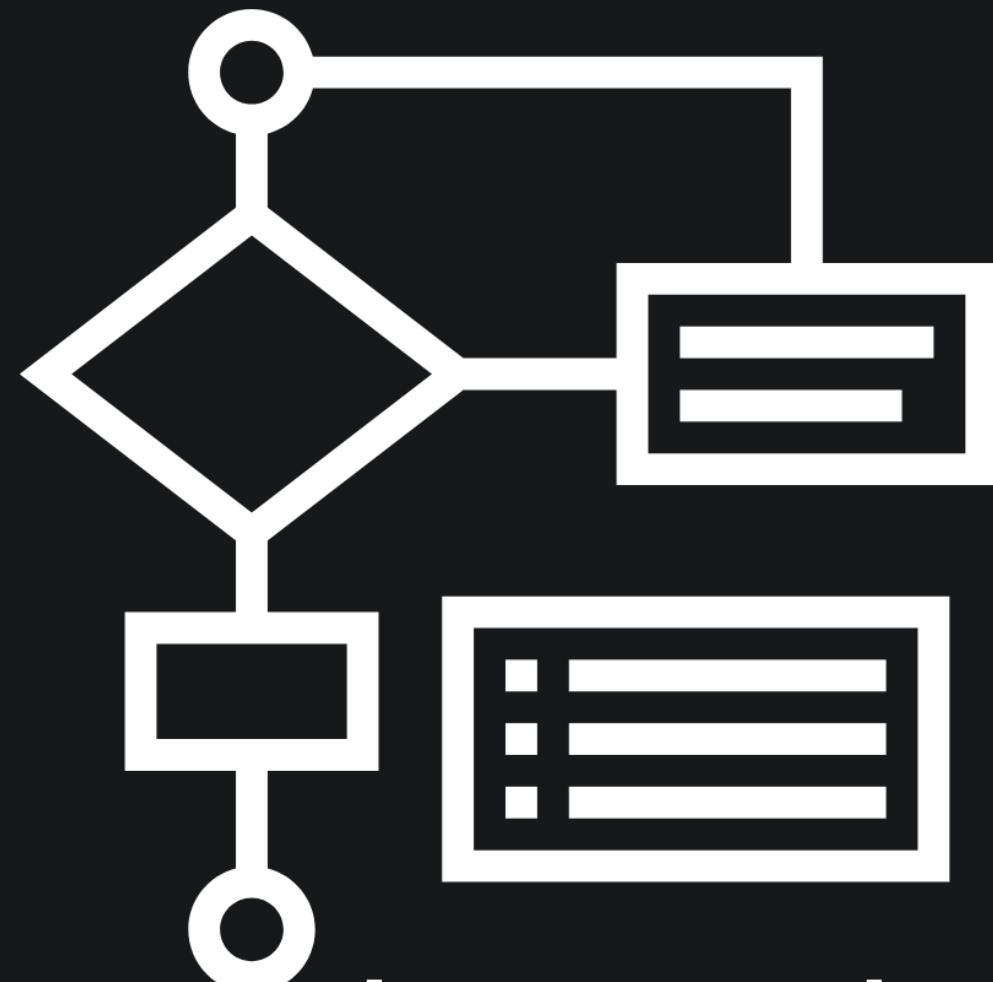
# My research # 1: Rigorous Study Design

# Experimentation is difficult



Know what makes  
for an experiment  
+ get the individual  
elements right

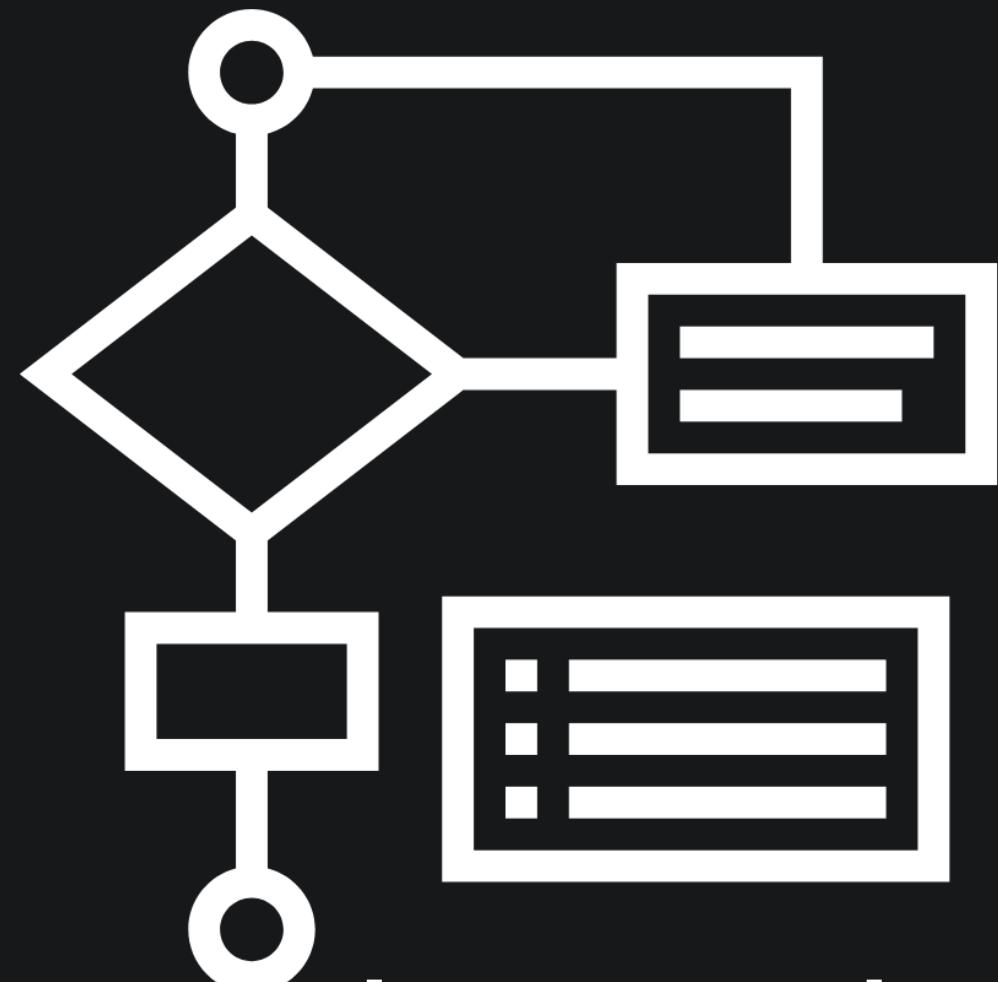
# Experimentation is difficult



Know what makes  
for an experiment  
+ get the individual  
elements right

Iterate to improve  
the design

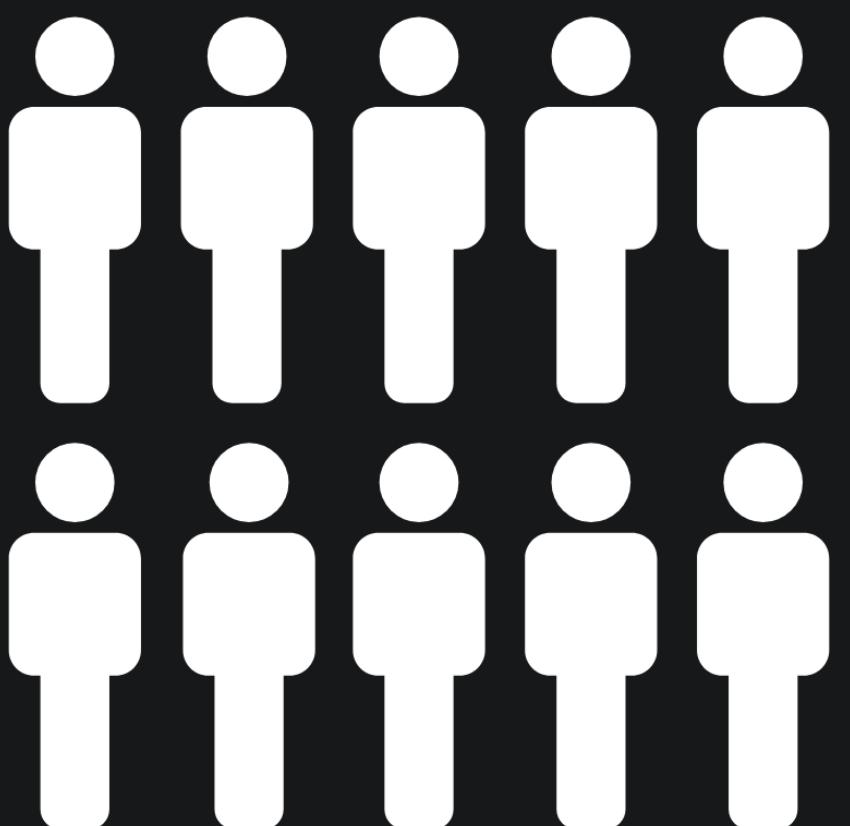
# Experimentation is difficult



Know what makes  
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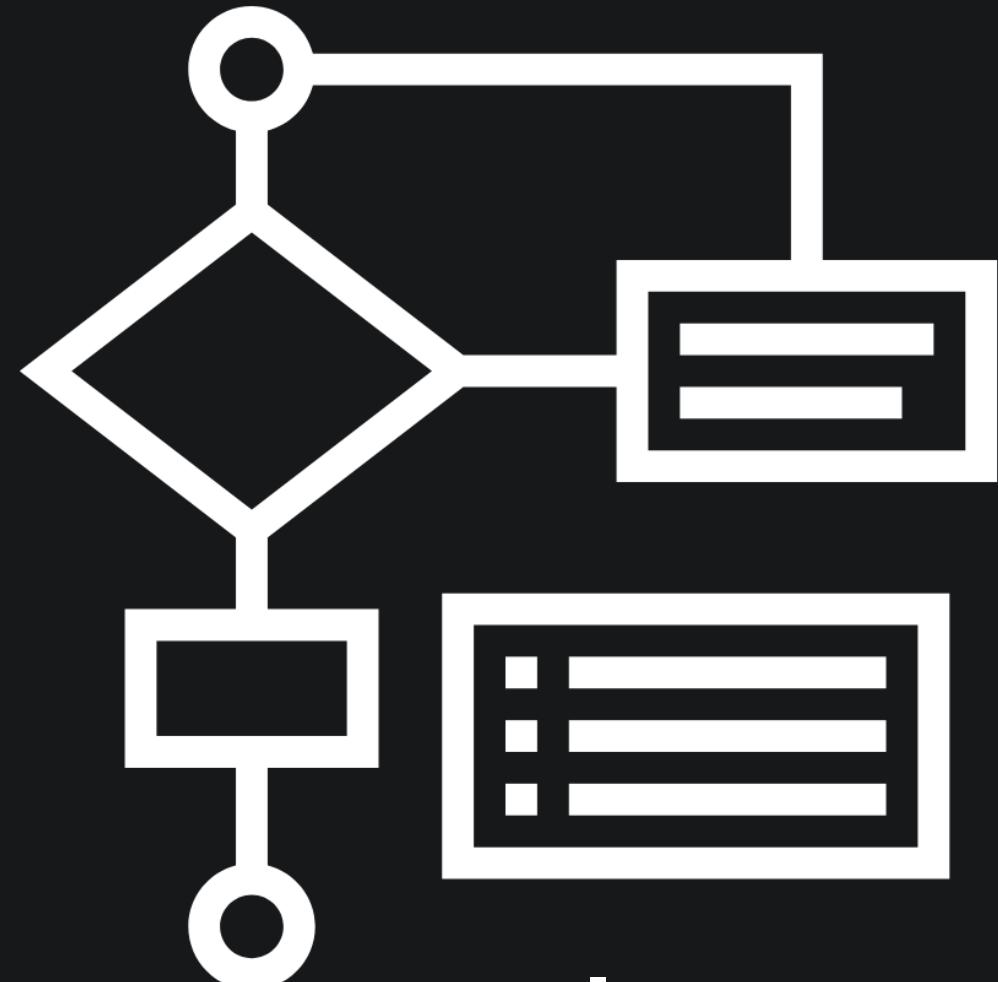


Iterate to improve  
the design

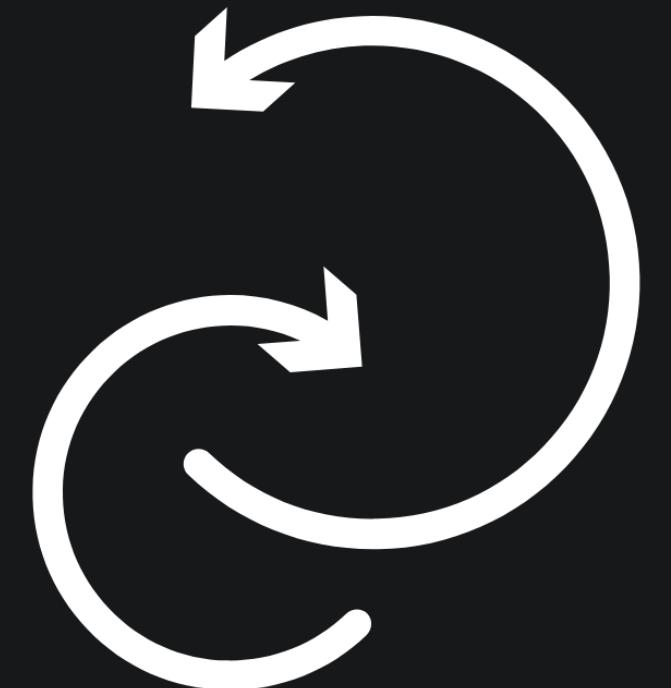


Run it correctly

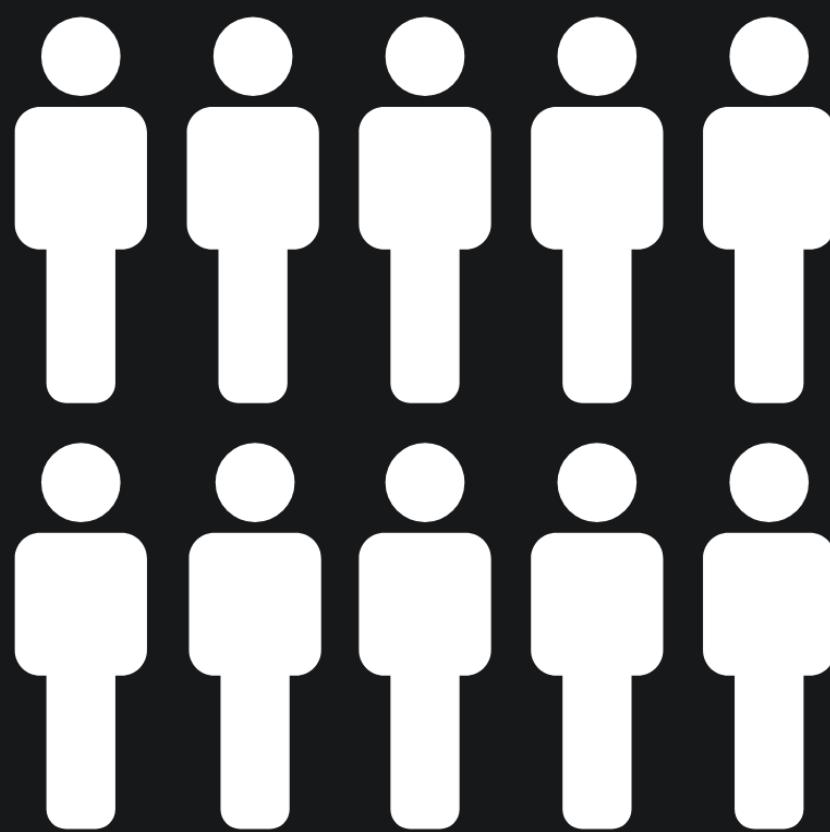
# Experimentation is difficult



Conceptual +  
Procedural training



Structured  
collaboration



Consistent  
implementation

# Galileo

## Community-designed and run experiments



**Vineet Pandey**

Tushar Koul

Chen Yang

Scott Klemmer

Daniel McDonald

Rob Knight

Mad Price Ball

Bastian Greshake Tzovaras



**UC San Diego**  
SCHOOL OF MEDICINE

american  
**gut**

 **OPEN  
HUMANS**

 **CRI**

# Design using procedural training cues integrated into the interface

## 1 Start with an intuition

Drinking kombucha makes me less bloated

These examples might help:

Cause	Relation	Effect
Drinking coffee	increases	alertness
Eating raisins every day	decreases	number of bowel movements
Not brushing teeth	results in	bad breath

**Cause**      **Relation**    **Effect**

Drinking kombucha      improves      stool consistency

## 2 Measure the cause

**Drinking kombucha** improves stool consistency

To conduct an experiment, you need to

1. change the cause (called manipulation) and then
2. record the effect.

How will you manipulate **Drinking kombucha** in your experiment?

(To keep your experiment simple, choose **one** option)

**Absence or Presence**

E.g. Milk in your diet could be present or absent

E.g. Exercise in your day could be present or absent



EXAMPLES



number of bowel movements  
bad breath

improves stool consistency



TEMPLATE

## 3 Set up data collection messages

Send all participants a reminder to provide **Bristol Scale Value** of **stool consistency** at

8:00 pm



edit the content for the reminder text message to track **stool consistency** at 8:00 pm

Hello from Galileo! This is your 8:00 pm reminder to measure "stool consistency" today.

How would you classify stool consistency on the Bristol Stool Chart? Please refer to the chart ([https://en.wikipedia.org/wiki/Bristol\\_stool\\_scale](https://en.wikipedia.org/wiki/Bristol_stool_scale)) and reply with a value between 1 to 7.

## 4 Set up exp/control conditions

Your **Hypothesis**: Drinking kombucha improves stool consistency

Your **Experimental Group**:

Drinks Kombucha

Your **Control Group**:

Does not drink Kombucha

# Reviewers use a scaffolded interface that enables boolean and open-ended comments

Kombucha and Kefir Experiments   Design An Experiment   Dashboard   Help us improve!    vipandey\_ucsd

**Experiment Details**

Hypothesis: Drinking Kombucha improves stool consistency

Cause	Relation	Effect
Drinking Kombucha	improve	stool consistency

Mechanism:  
kombucha has beneficial probiotics to help keeping a normal stool consistency

Related Work:  
There are papers about Kombucha benefits but they do not look specifically at stool consistency. Dufresne and Farnworth (Tea, Kombucha, and health: a review) gives an overview of kombucha benefits (mostly from drinker's testimony) and indicates the need to investigate it with a more scientific approach. This is an old paper, though (from 2000). We have more recent papers, but I could not find one specifically related to stool consistency. There are some related to diabetes, for example.

How is Drinking Kombucha manipulated?

- Participants measure Absence/Presence of Drinking Kombucha
- Reminder sent every day at 6 pm with the following message:

"Hello from Austin! This is your 6:00 pm reminder to measure "Drinking Kombucha" 🍶 today. Was Drinking Kombucha absent or present in your day today? Reply Yes for present, No for absent."

How is stool consistency measured?

- Participants measure Bristol Scale value of stool consistency

**The Bristol Stool Chart**

Type	Looks like	Consistency	Indicates
Type 1		Separate hard lumps	Very constipated
Type 2		Lumpy and sausage like	Slightly constipated
Type 3		Sausage shaped with cracks in the surface	Normal
Type 4		A smooth, soft sausage or snake	Normal
Type 5		Soft blobs with clear-cut edges	Lacking fibre

Feedback request from the creator of the experiment:  
none

**People's review of the hypothesis**

Is the cause specific?  
Yes  1 | No  0

Is the effect specific?  
Yes  1 | No  0

Is the relation between cause and effect clear?  
Yes  1 | No  0

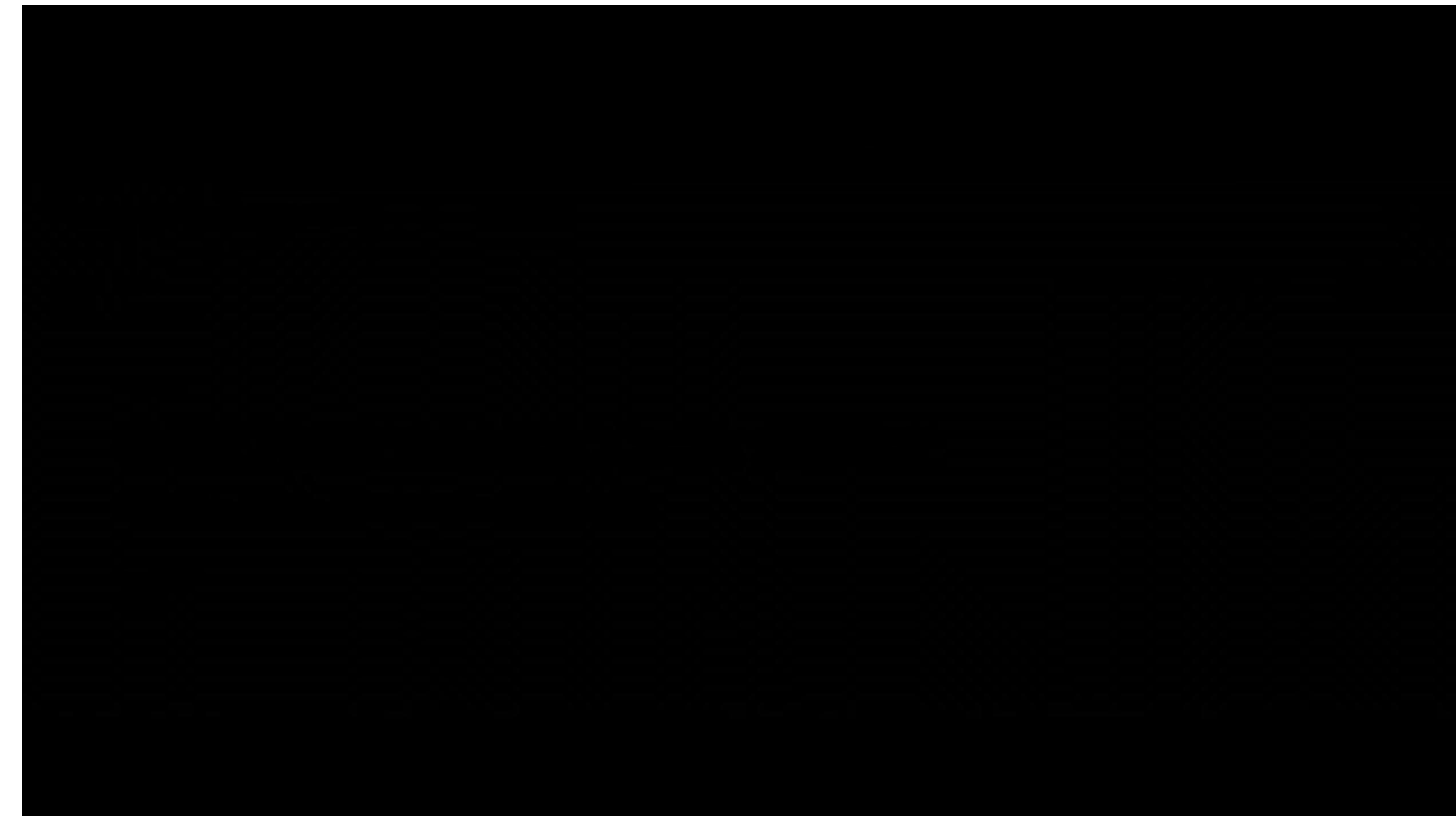
Is the hypothesis concrete i.e. it either holds or it does not hold?  
Yes  1 | No  0

Is this mechanism the most plausible explanation?  
Yes  0 | No  0

Is the related works description comprehensive?  
Yes  0 | No  0

**NEXT SECTION**

# **Participants join online and provide data via text reminders**



People join and provide data using text messages



Kombucha and Kefir Experiments

Design An Experiment

Dashboard

Help us improve!



vipandey\_ucsd



Ongoing Experiment

Ready-to-run Experiments

Under-review Experiments 2

Incomplete Experiments 2

Completed Experiments 1

All Experiments 3

My Contributions

Reviewing Experiments 1

Participating Experiments 2

Account

Notifications

Edit My Profile

Log out



Design



Review



Run



Under Analysis

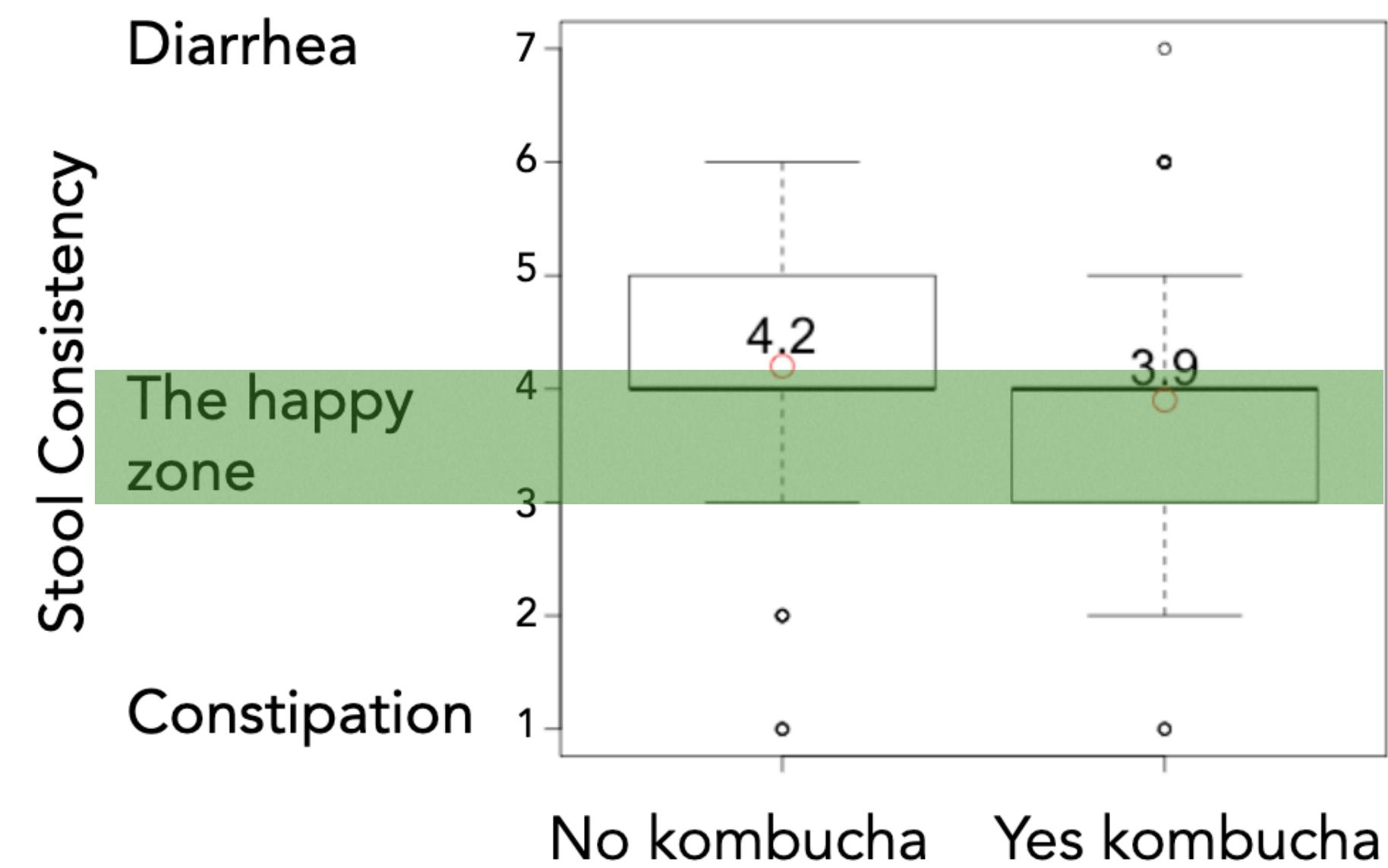
Congratulations, your experiment is under analysis!

## Experiment Participants

HIDE USER INFO				Day 1		Day 2			
MORE DETAILS				Cause	Effect	Cause	Effect	Cause	
Ctry	Participant	Location	Timezone (rel. to GMT)	Value	Value	Value	Value	Value	
Control Condition									
BR	cont01	Belo Horizonte	-3	No	2,4,6,6	No	5,5	Yes	
US	cont02	Sunnyvale	-8	false	3	true	3	true	
IN	cont03	Bangalore	5	No	4	Absence	4	-	
US	cont04	Spring Valley	-8	No	3	No	3	Yes	
US	cont05	San Diego	-8	false	3	false	4	false	
US	cont06	Ann Arbor	-5	-	-	-	-	-	

N=36

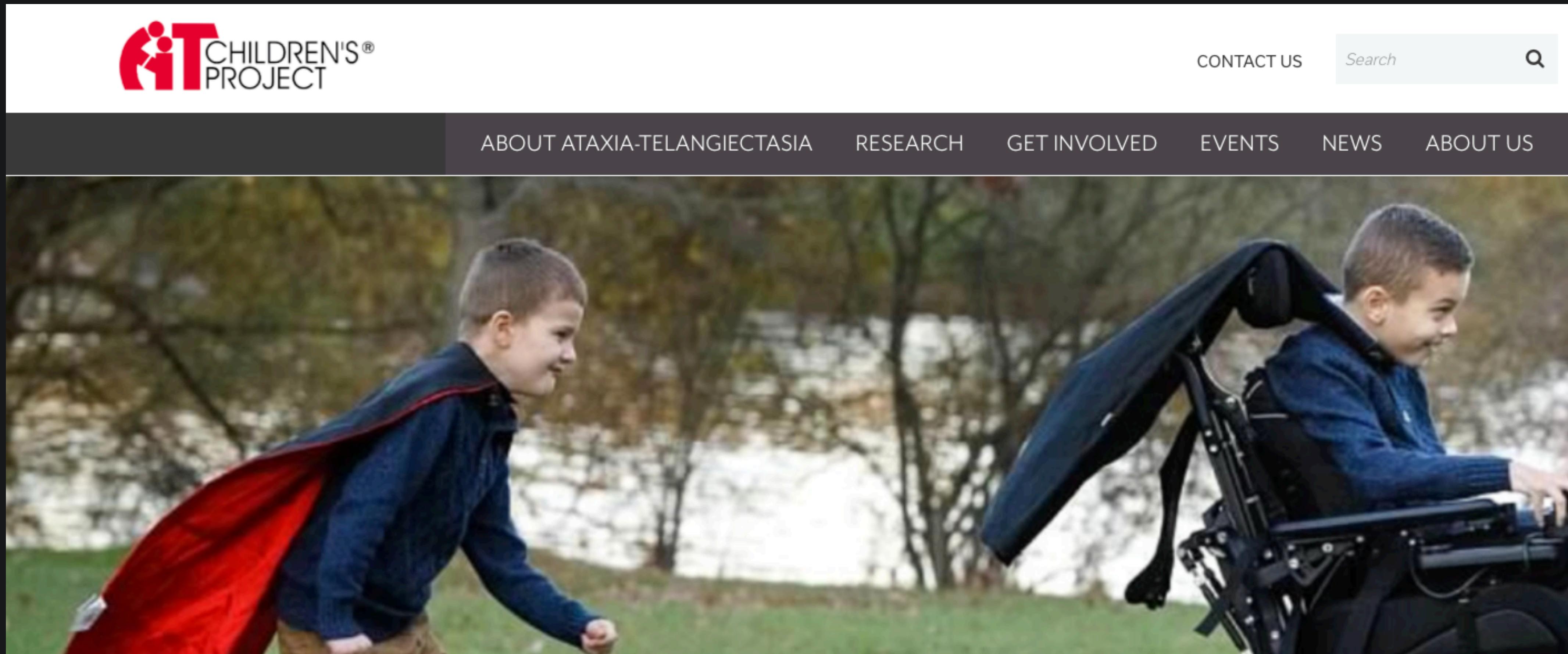
# Kombucha community: Does drinking kombucha improve stool consistency?



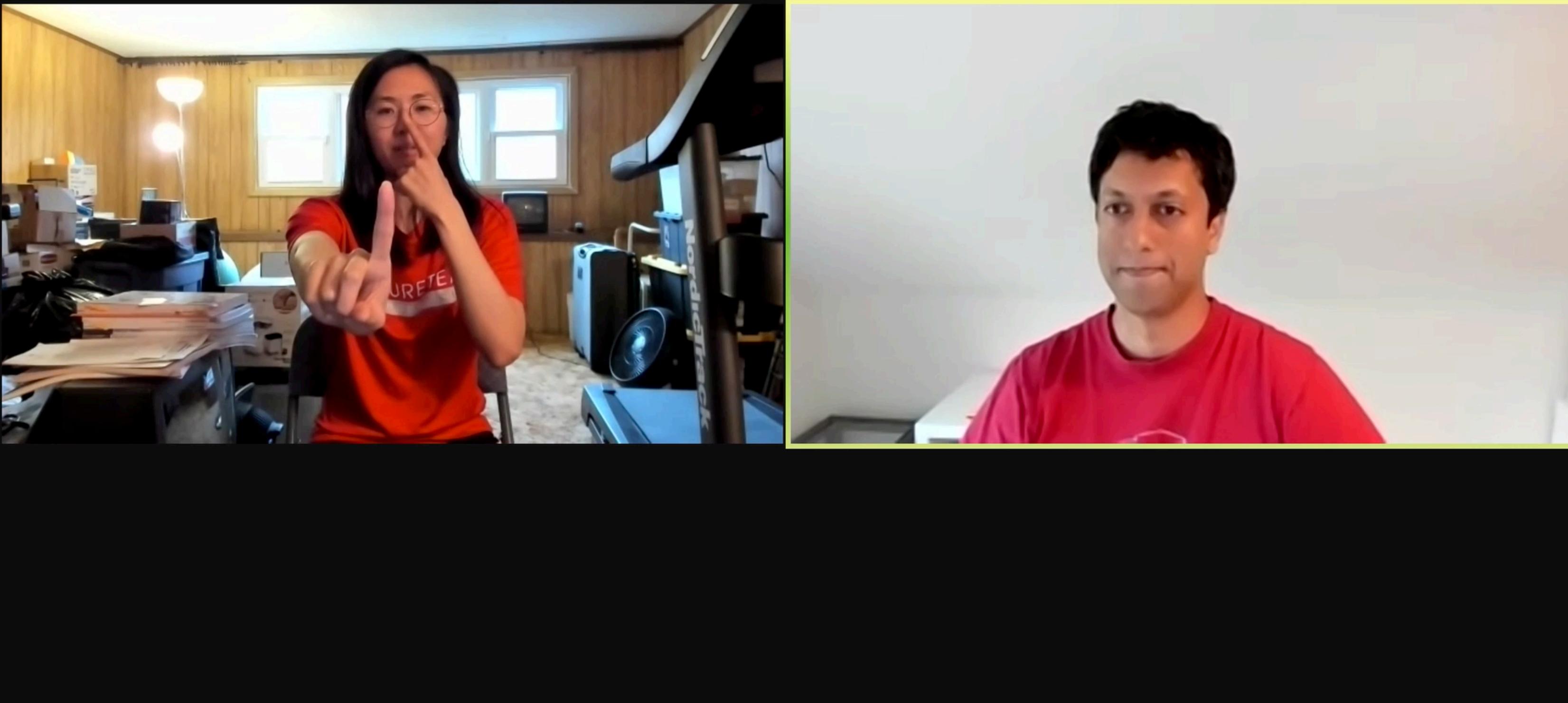
**between-subjects  
experiment;  $p < 0.03$**

# My research # 2: Rapid Data Collection

# How to perform valid motor impairment assessments from home?



# Problem: Assessing motor impairment is difficult



# Problem: Assessing motor impairment is difficult



12. Finger-to-nose test: decomposition and dysmetria (Left and Right scored)
- 0: Normal
  - 1: Oscillating movement without decomposition of the movement
  - 2: Segmented movement in 2 phases and/or moderate dysmetria in reaching nose
  - 3: Segmented movement in more than 2 phases and/or considerable dysmetria in reaching nose
  - 4: Dysmetria preventing the patient from reaching nose.

More challenging  
over video

Requires  
contextual  
expertise

Categorical assessment  
on a 5-point scale

# Problem: Assessing motor impairment is difficult

Unsupervised,  
Interactive web-  
based tasks using  
mouse trajectory

More challenging  
over video

Automated  
comparisons to  
normative data

Requires  
contextual  
expertise

Draw objective,  
quantitative measures  
from mouse trajectories

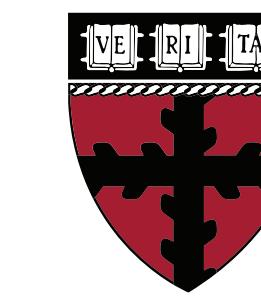
Categorical assessment  
on a 5-point scale

# Hevelius at home

## A motor impairment assessment tool for remote use



Vineet Pandey  
Krzysztof Z. Gajos



**Harvard** John A. Paulson  
**School of Engineering**  
and Applied Sciences

Nergis C. Khan  
Anoopum S. Gupta



MASSACHUSETTS  
GENERAL HOSPITAL

**2020. Movement Disorders. Gajos, Gupta et al.** Computer mouse use captures ataxia and parkinsonism, enabling accurate measurement and detection.

**2020. ACM ICT4S Workshop on LIMITS. Pandey et al.** From novices to co-pilots: Fixing the limits on scientific knowledge production by accessing or building expertise

**2021. The Cerebellum. Khan, Pandey et al.** Free-Living Motor Activity Monitoring in Ataxia-Telangiectasia

**2022. Preparation. Pandey et al.** At-home Use of a Computer-based Pointing Task Accurately and Reliably Estimates Motor Impairments.

Task 5 out of 8

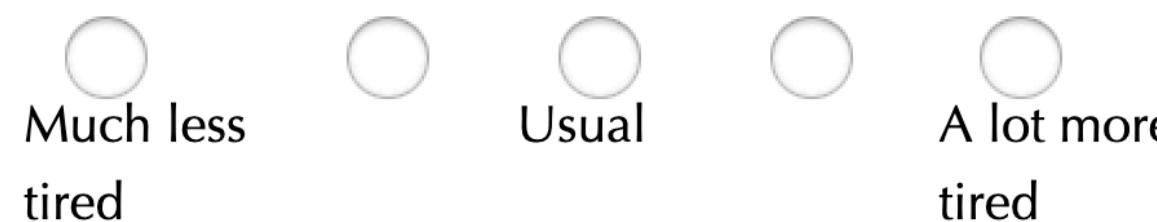


Pointing task

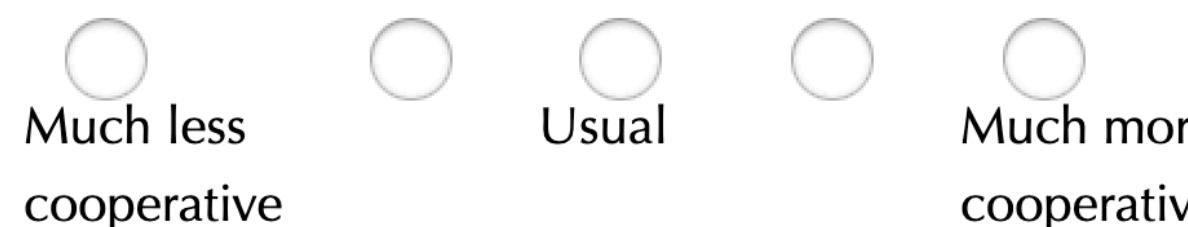
# Tool

The Hevelius system includes caregiver inputs, dot clicking tasks, and follow-up questions

How tired is your child right now compared to most other times?



How cooperative is your child right now compared to most other times?



How many times has your child stumbled or tripped in the past week?



What have been some current events for your child since they last used this tool?

Any information that you provide will help researchers better understand the data.  
E.g. a trip, a big family gathering, tummy troubles, social or school events

## What is your mood right now?



## How alert do you feel right now?



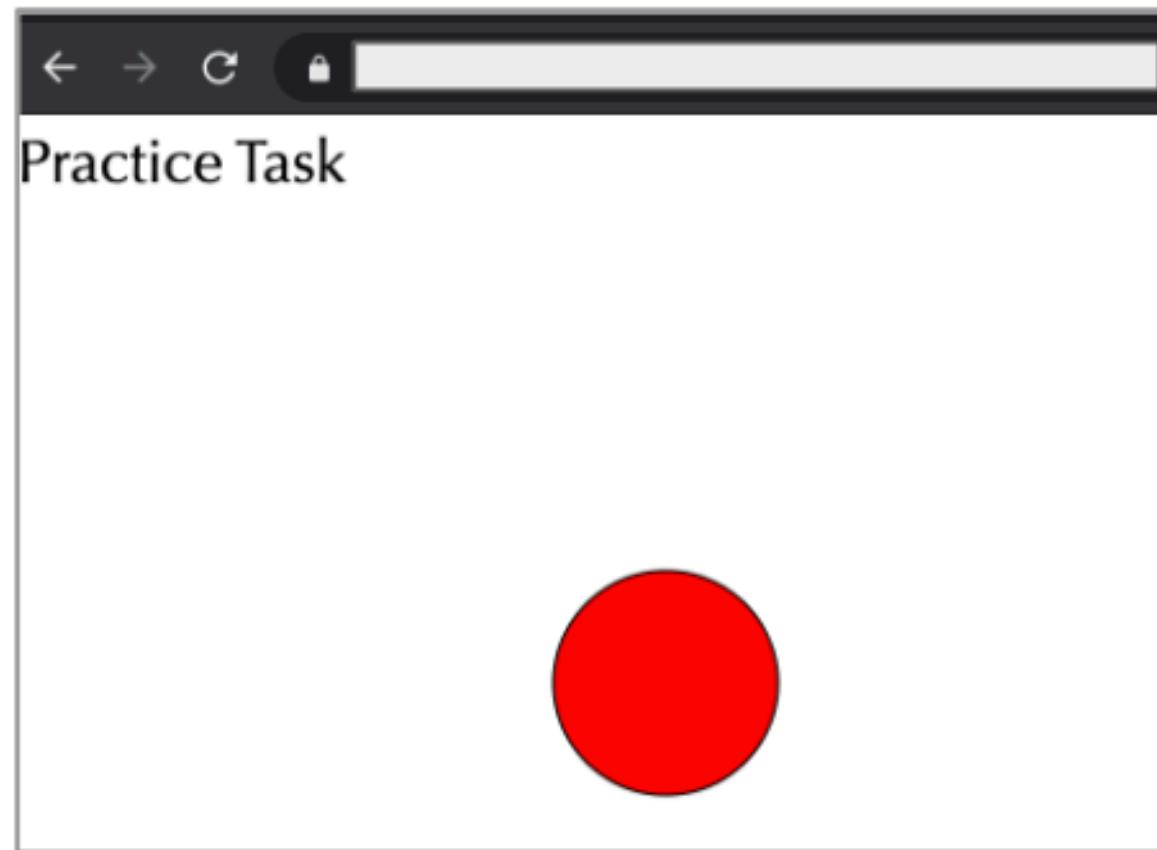
## How well did you sleep last night?



# Tool

## Hevelius estimates clinical scores with regression models over the interpretable movement features

Participant clicks on dots for a few mins



Neurologist-approved features drawn from mouse trajectories



```
movement_time:  
4084 msec  
execution_time: 2100  
msec  
num_pauses: 6  
Duration of longest  
pause: 1137msec  
...
```



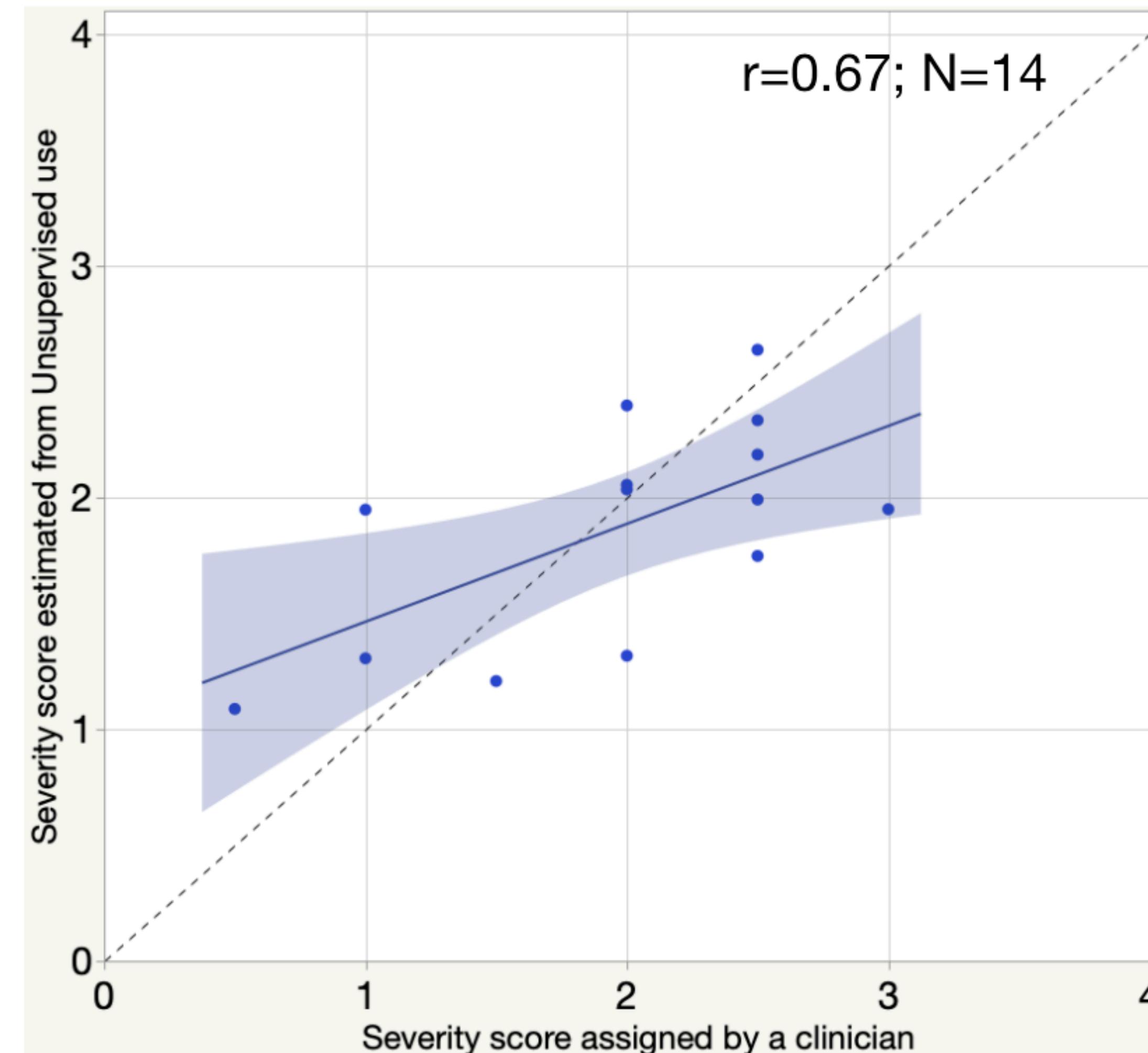
Z-scores after comparing to normative data

```
movement_time: 2.4  
execution_time: 3.57  
num_pauses: 5.03  
...  
...  
...
```

→ Severity score

# Quantitative measurements of motor function from home

Severity score estimated from tool usage correlates well with clinician-assigned severity



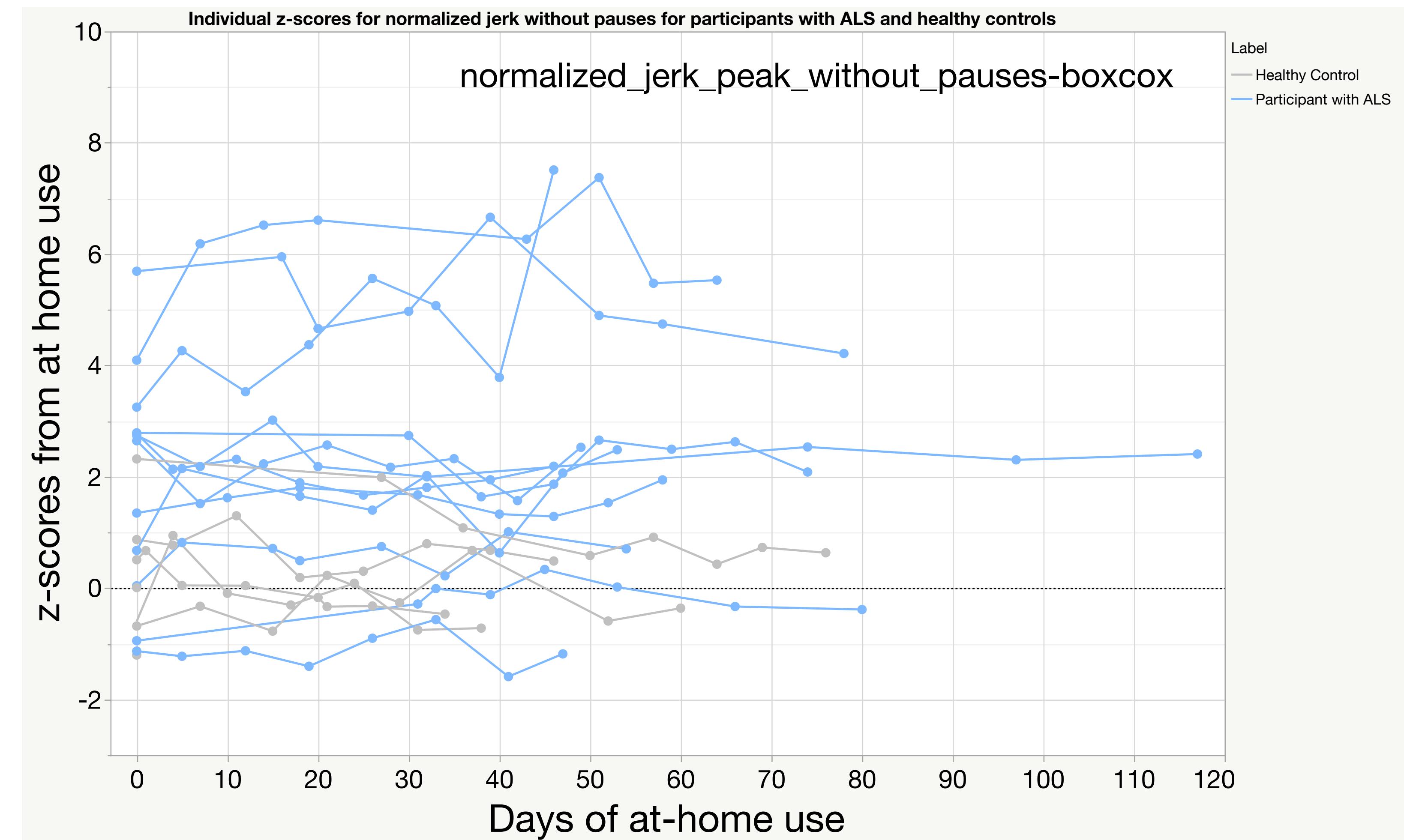
# Results

## Many measures are reliable over eight weeks

#	Feature name	Feature description	ICC (A-T)	ICC (Con- trols)
1	Duration of the longest pause	Duration of the longest pause of 100ms or longer. If not such pause occurred, 0ms is recorded for this measure	0.988	0.899
2	Number of pauses	Number of pauses of 100ms or longer	0.987	0.906
3	Movement time	Complete movement time from target onset to the end of the successful click on the target	0.985	0.931
4	Verification time	The time interval between the end of a movement inside a target and the beginning of the click (i.e., the time when the mouse button was pressed)	0.909	0.9
5	Click duration	The time between mouse button press and release during the correct click on the target	0.907	0.94
6	Execution time	Time from the first to the last mouse movement (excluding any movement that occurred while the mouse button was pressed)	0.887	0.951
7	Click slip	Distance between the point where the mouse button was pressed down and where it was released during click on the target	0.825	0.758
8	Execution time variability	Coefficient of variation of execution times in a block of trials	0.808	0.899
9	Verification time	Standard deviation of verification times in a block of trials  normalized jerk = $\frac{(ET)^3}{v_{max}^2} \int_t \left( \frac{da}{dt} \right)^2 dt$	0.799	0.915
10	Normalized jerk [4, 10]	where $\frac{da}{dt}$ is the jerk, ET is the execution time without pauses and $v_{max}$ is the peak speed during the movement.	0.799	0.95

# Results

## Participants across neurological disorders show unique profiles



What if domain experts offloaded many  
of these activities to a phone?

- ...rigorous study design
- ...rapid data collection
- ...broad access and inclusion

What if domain experts offloaded many of these activities to a phone?

We could develop insights in a fraction of the time with greater generalizability!

# In health settings, the gap between cause and effect is large

My hunch:

The rate-limiting step in health science is not generating ideas about what effects health but rather rapidly evaluating them

One way ahead:

Support domain experts (you!) in defining what these mobile experiences should look like

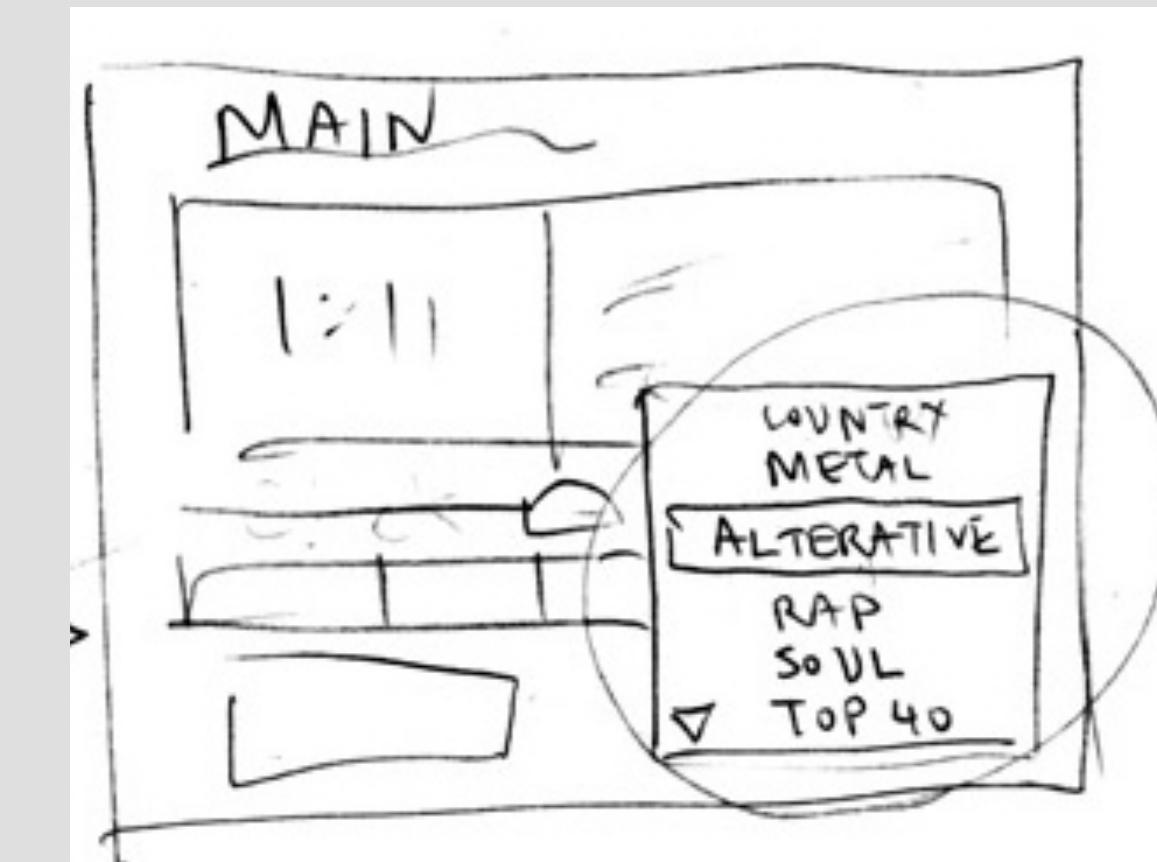
# Prototype Fidelity

- "Fidelity" is level of detail

- Low fidelity



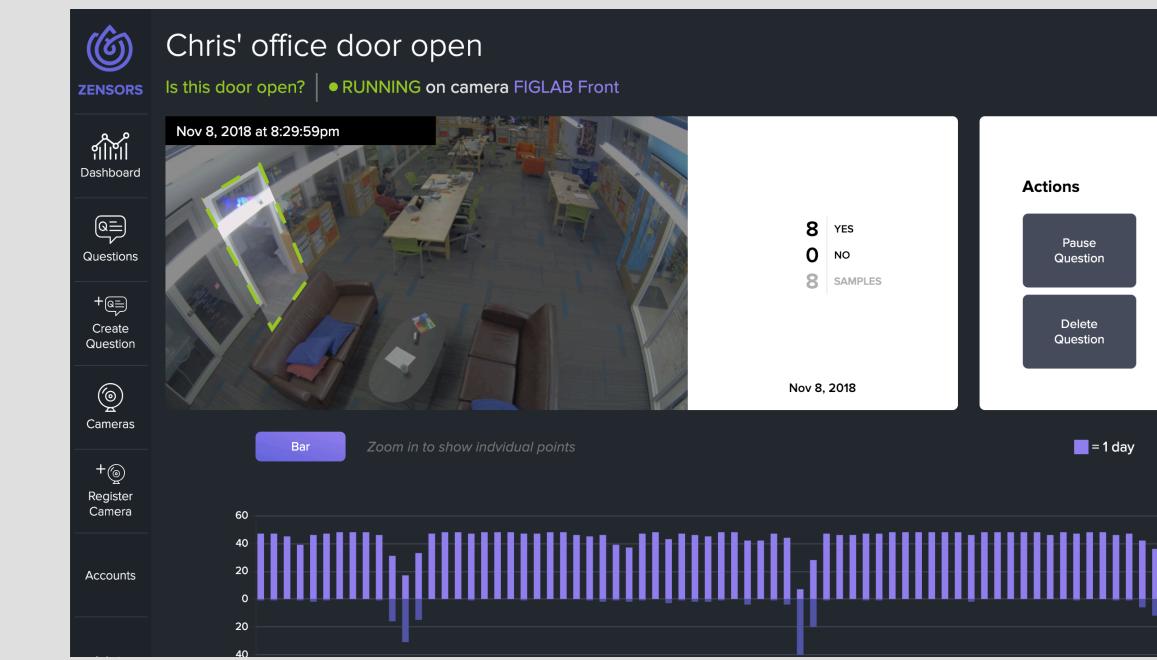
- Sketch/rendition with many details missing
- Often done on paper



- High fidelity



- Prototype looks like the final product
- Often using digital tools



# The Basic Materials for Low-Fi, Paper Prototypes

- White paper (heavier stock is better)
- Pens & markers (many colors & sizes)
- Index cards & Post-its
- Tape & Glue
- Whiteout
- Scissors, X-acto knives
- Overhead transparencies

# Constructing the Paper Prototype

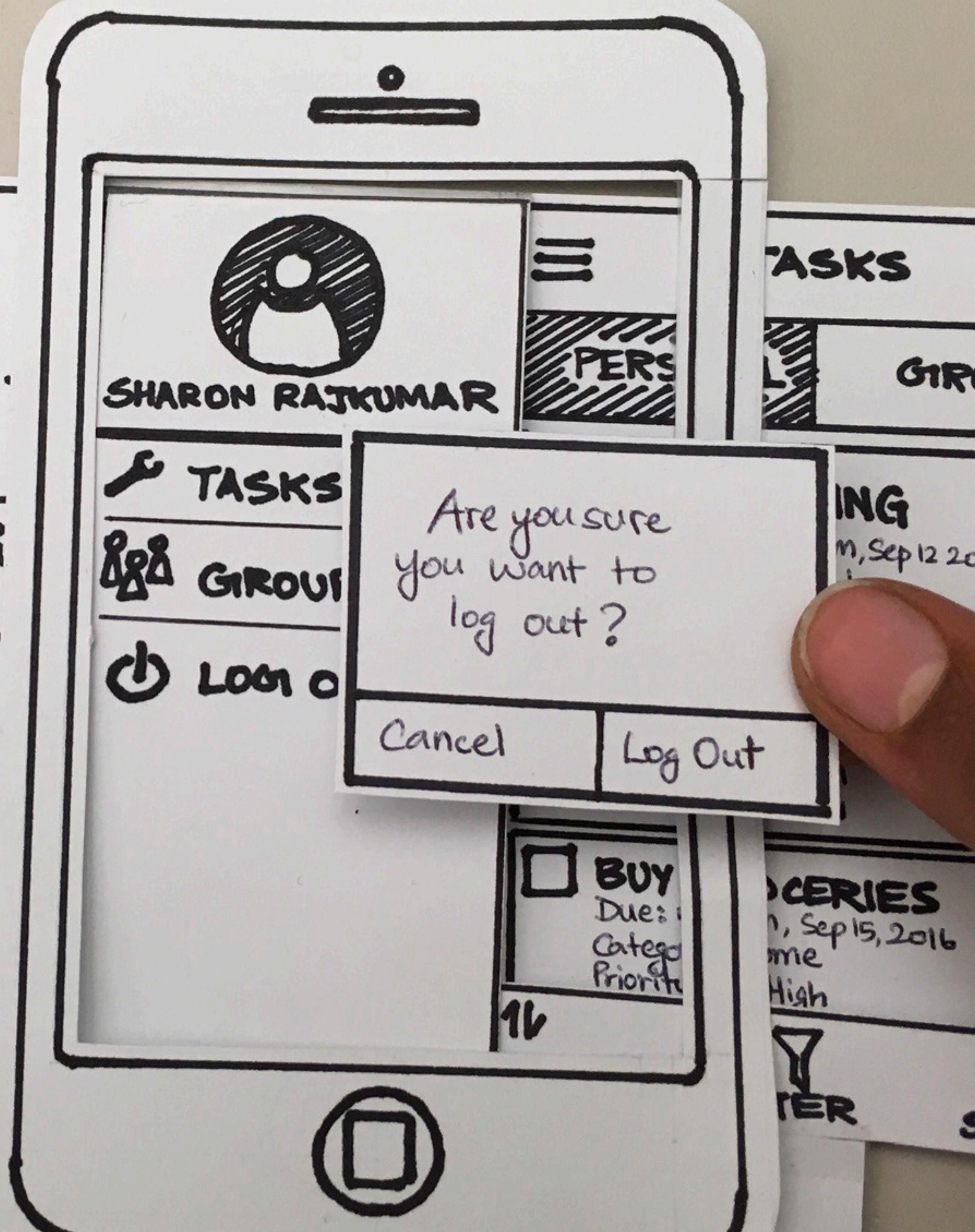
- Set a deadline
  - a few hours or 1-2 days
  - don't think for too long - build it, test it!
- Draw a window frame on large paper
- Put different screen regions on cards
  - anything that moves, changes, appears/disappears
- Ready response for any user action
  - e.g., have those pull-down menus already made
- Use photocopier to make many versions

The prototype illustrates a mobile application for managing tasks and groups. Key features include:

- Dashboard:** Shows a list of tasks (e.g., PUI READING, UCRE H-W.2, BUY GROCERIES, PAINT FENCE) with sorting and filtering options.
- Task Creation:** A "NEW TASK" screen with fields for Task Name, Assign To, Date Due, Time Due, Category, and Priority.
- Assignment:** A "ASSIGN TO" screen showing users (Ruby Williams, Martin Francis, Sarah Daniels) and groups (UCRE GROUP, AEROBICS CLASS, FAMILY).
- Date and Time Selection:** "DATE DUE" and "TIME DUE" screens for selecting specific dates and times.
- Category and Priority:** "CATEGORY" and "PRIORITY" screens for organizing tasks.
- Groups:** A "GROUPS" screen for creating new groups like PILATES CLASS and AEROBICS CLASS.
- Members:** An "ADD MEMBERS" screen for adding users to groups.
- New Group and Category:** Screens for creating new groups and categories.
- Confirmation Dialog:** A dialog box asking if you want to discard changes made.

**DoIt!**  
Rule your tasks!

8  
0



# Deepening Public Contributions to Occupational Health

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