CORNELL TECH

HOME OF THE JACOBS INSTITUTE

Closing the Sensing-to-Intervention Loop in Precision Psychiatry

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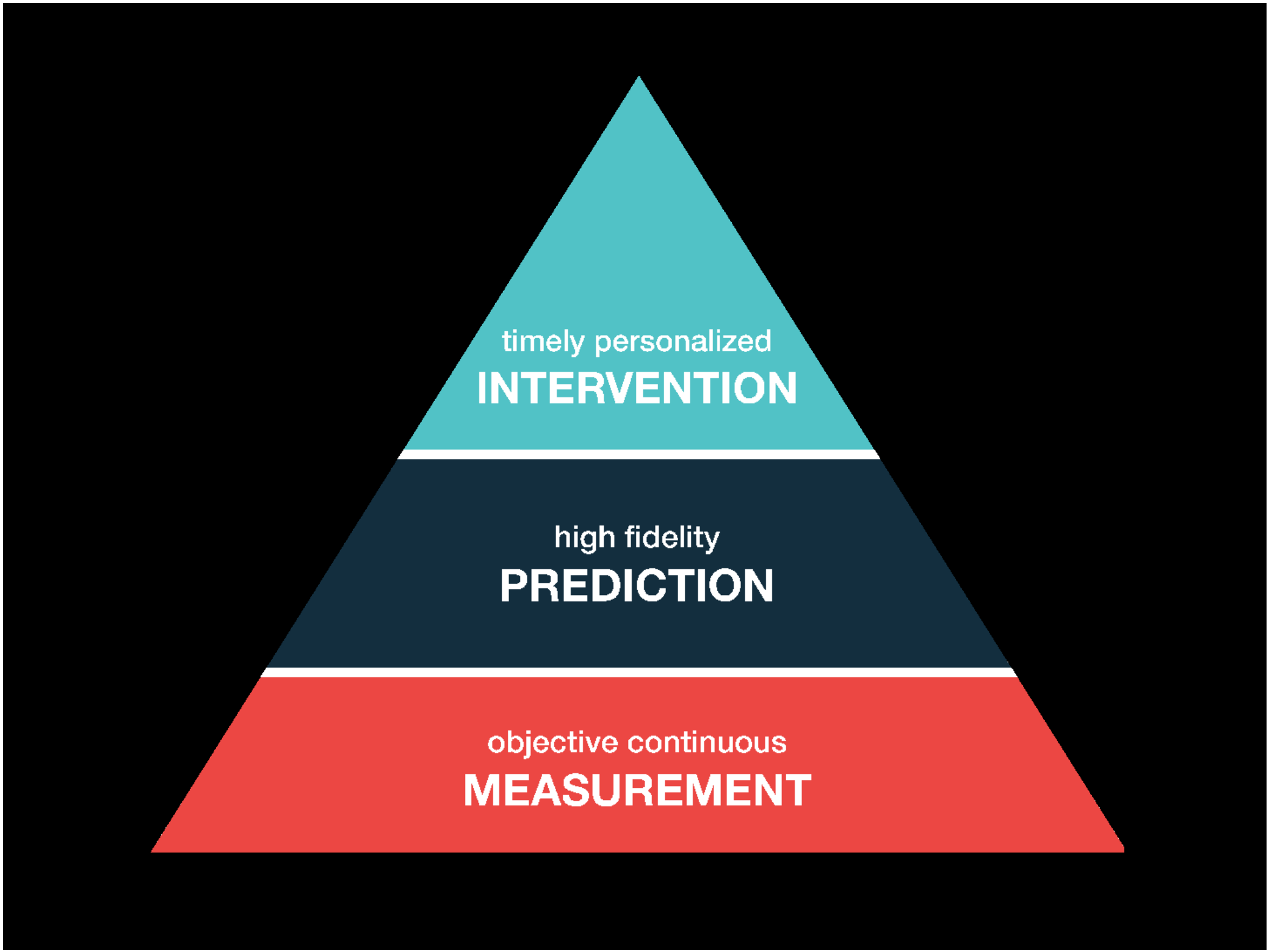

timely personalized
INTERVENTION
high fidelity
PREDICTION
objective continuous
MEASUREMENT

Measurement Gap

PATIENT HEALTH QUESTIONNAIRE (PHQ-9)

NAME: _____ **DATE:** _____

Over the *last 2 weeks,* how often have you been bothered by any of the following problems?
(use "✓" to indicate your answer)

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself—or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite—being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead, or of hurting yourself in some way	0	1	2	3
add columns:		+	+	

(Healthcare professional: For interpretation of TOTAL, please refer to accompanying scoring card.) **TOTAL:**

Now we can continuously track subtle signals that get missed in current clinical practice


Heart Rate
10:09
58
BPM
65 BPM, 5m ago
801 Jessie St
Set Pickup
3:19
Tuesday, September 18
amazon

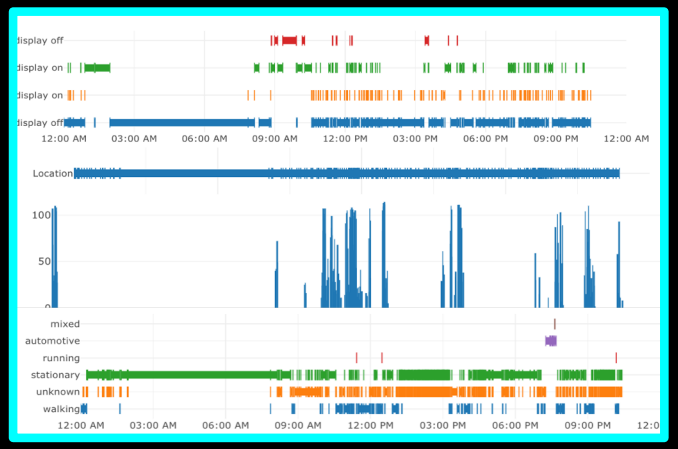
Continuous measurement of actionable signal

Raw data [phones & wearables]

Second-Level Behaviorgram

Behaviors

Disease-specific Models



social

physical

sleep

circadian

psycho-motor

Patient trajectories

Score Predictions

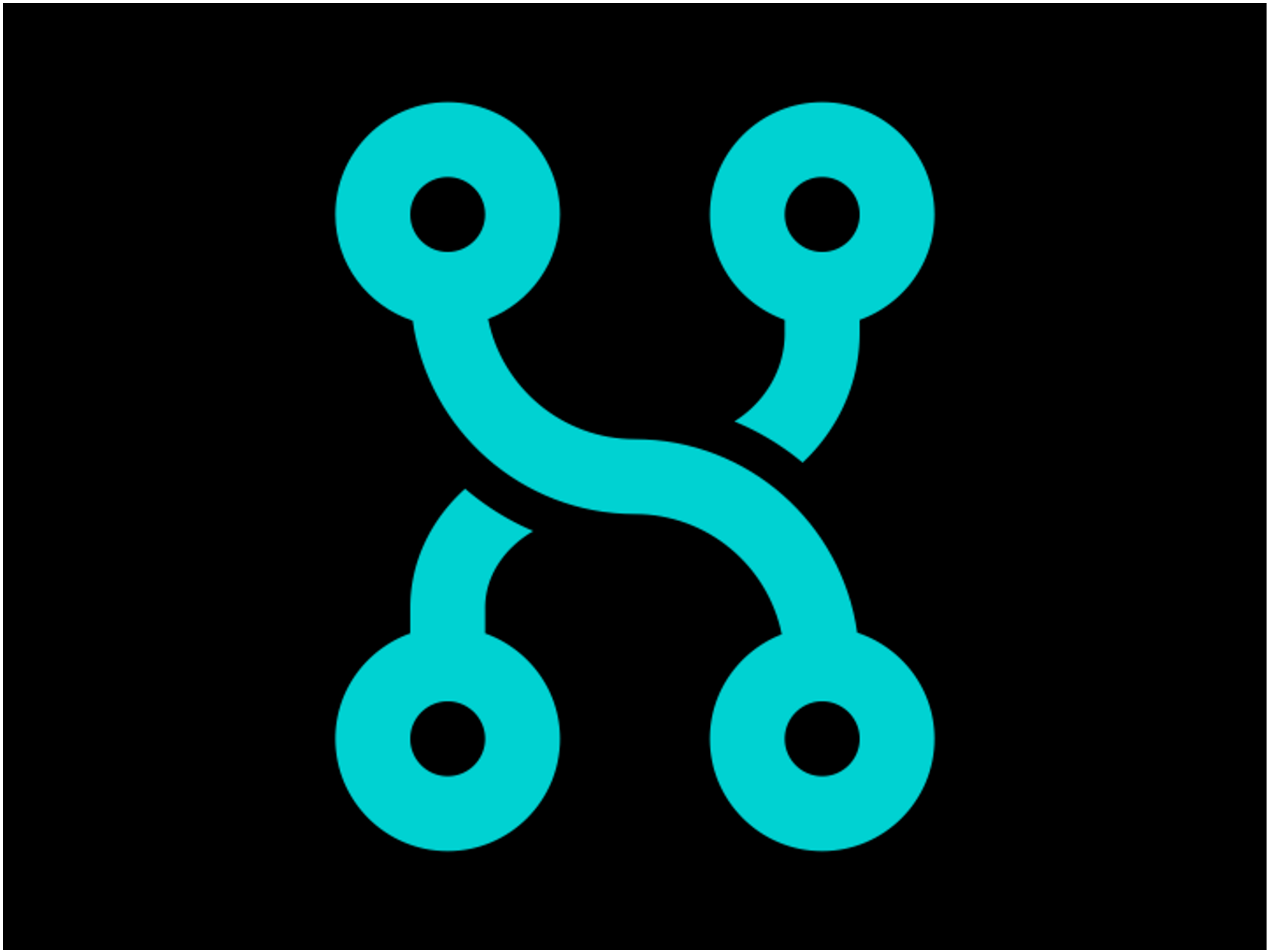
Battery life management, bandwidth management, data coverage

Data cleaning, aggregation

Clinically-informed feature modelling

Machine Learning

technical advances
clinical needs

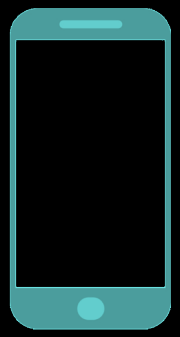


Can we create a **system that can predicts behavior changes that precede a major psychiatric event**?

Case study: CrossCheck

Detecting mental health changes
in individuals with Schizophrenia

Psychiatric hospitalization within past 12 months



1 year randomized control trial

- 60 participants
- 20,137 days of continuous passive sensor data
- 726 days of data within 30 days of relapse

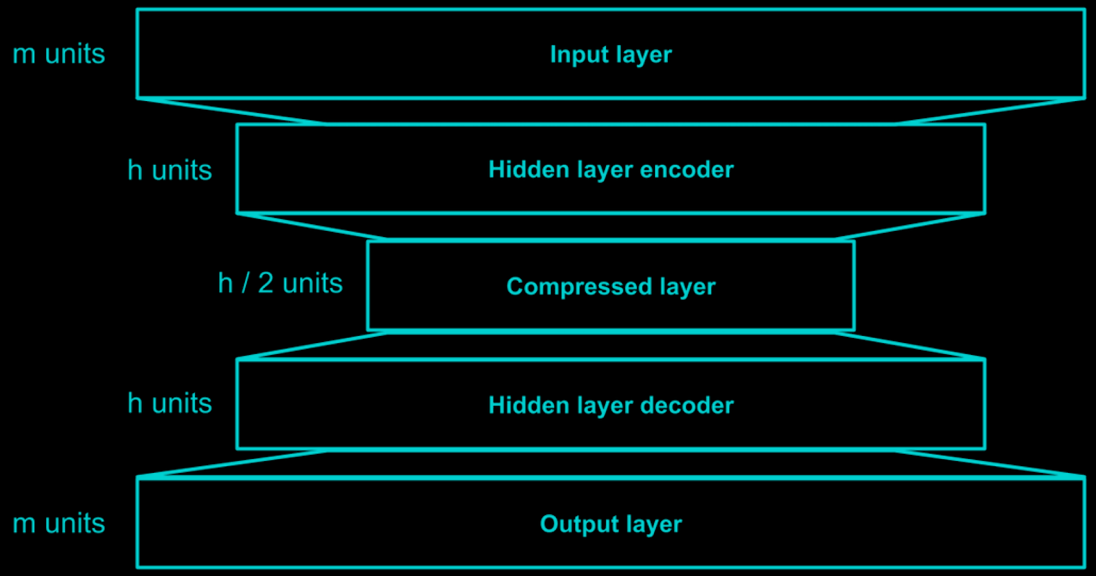
- Passive sensing data
- Ecological momentary assessment (EMA)

- Month doctor visits
- Brief psychiatric rating scale (BPRS) scores

Training an anomaly detection system for human behavior

Smartphone behaviors from days of relative health (DRH)

Encoder-decoder network



Recreated behaviors

Training an anomaly detection system for human behavior

Smartphone behaviors from days of relative health (DRH)

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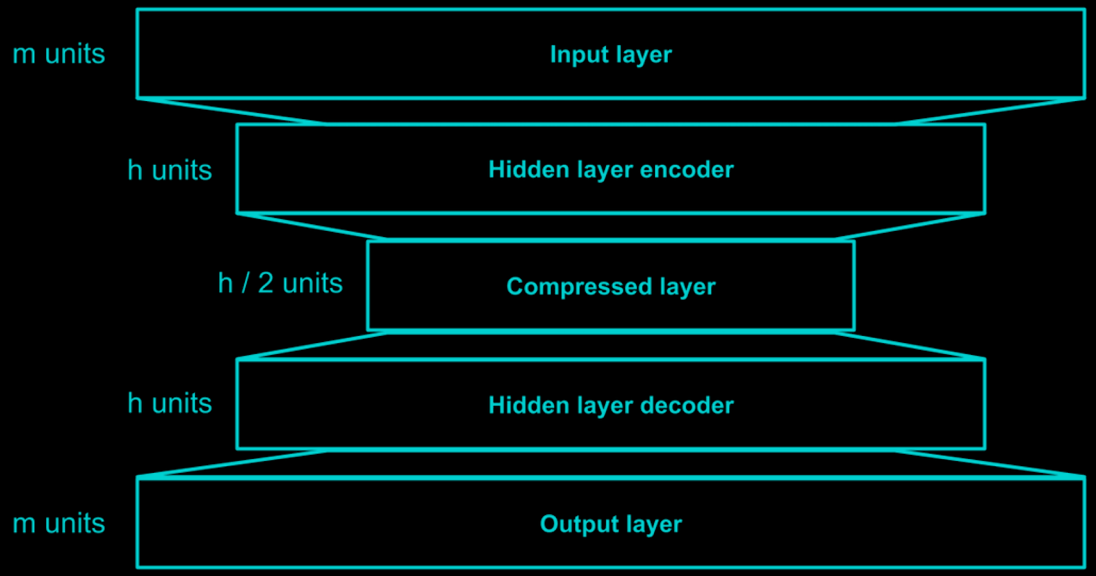

Recreated behaviors

Hypothesis:
Sustained deviation from routine behavior will occur before relapse

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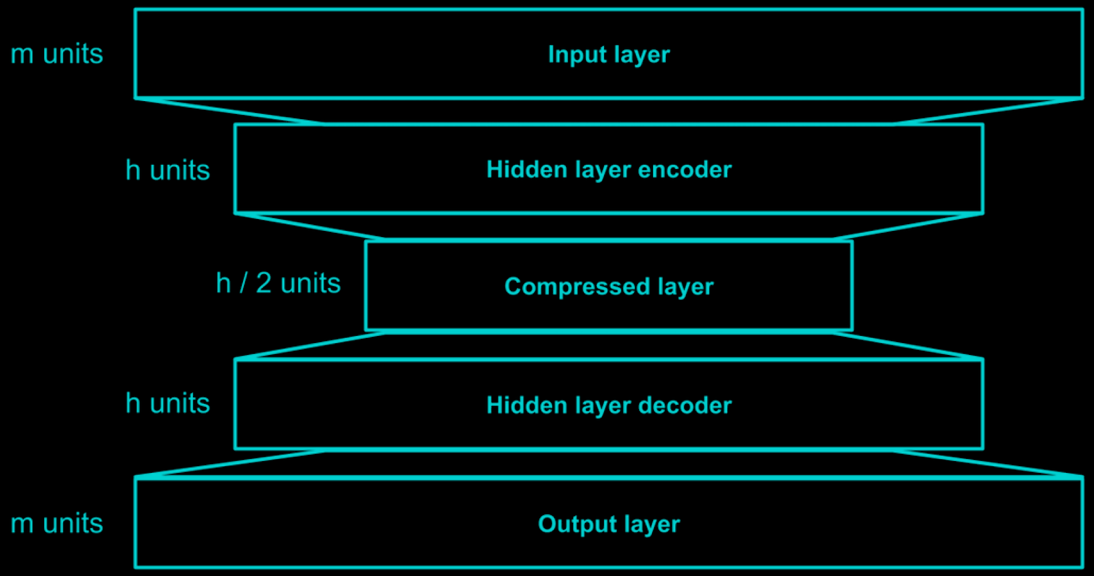

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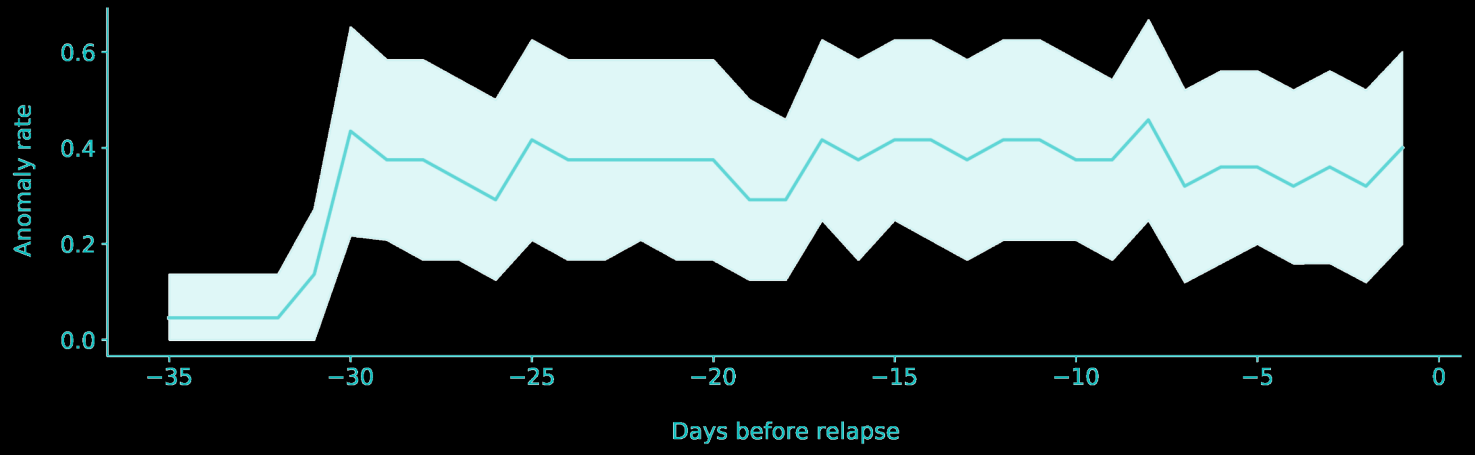
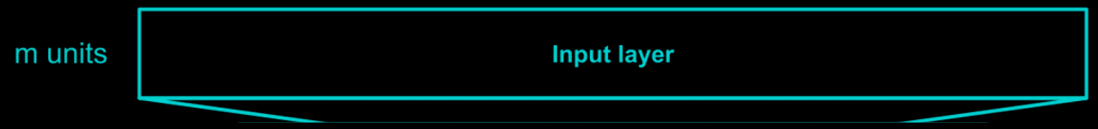


Training an anomaly detection system for human behavior

Encoder-decoder network

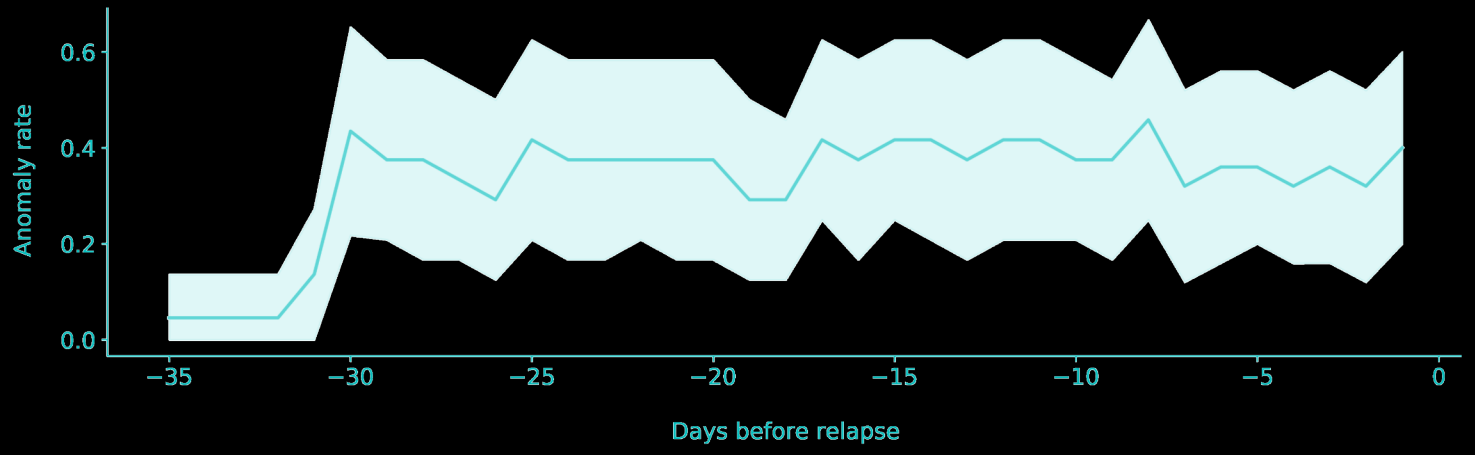


Smartphone behaviors fro
days of relati
health (DRH

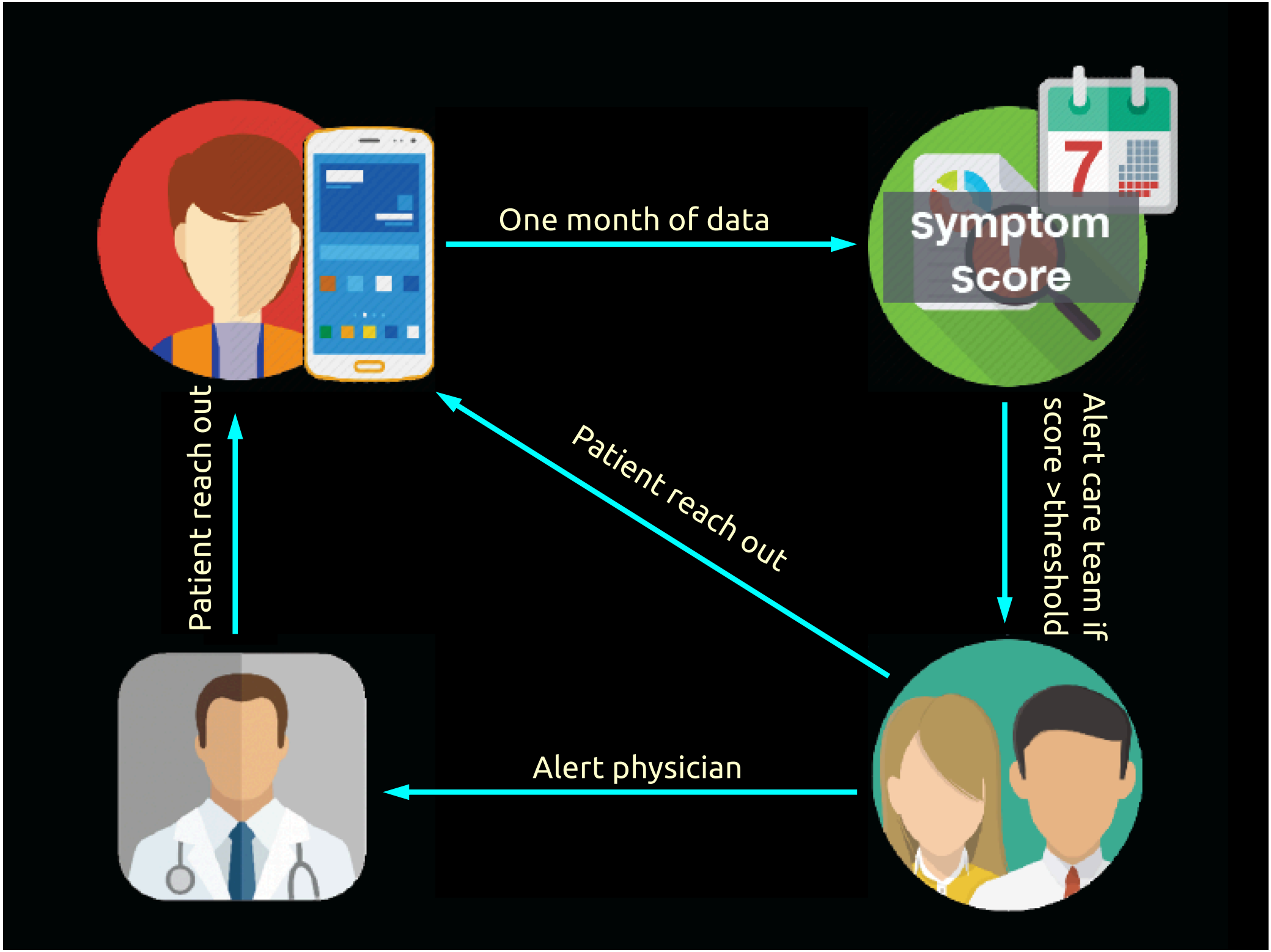
Recreated behaviors

108% increase in anomalies across patients within the 30 days preceding relapse compared to DRH

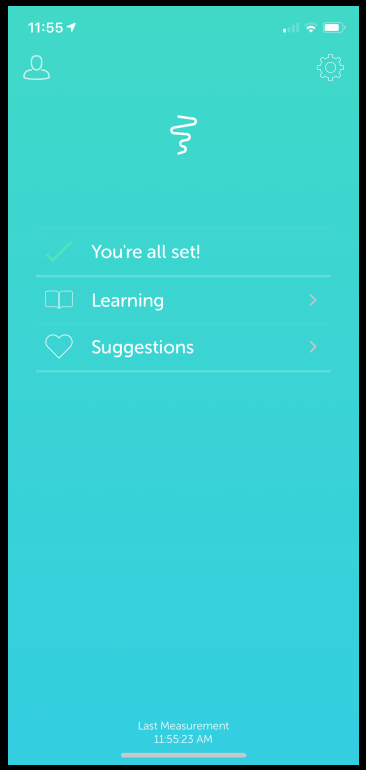
Hypothesis:
Sustained deviation from routine behavior will occur before relapse



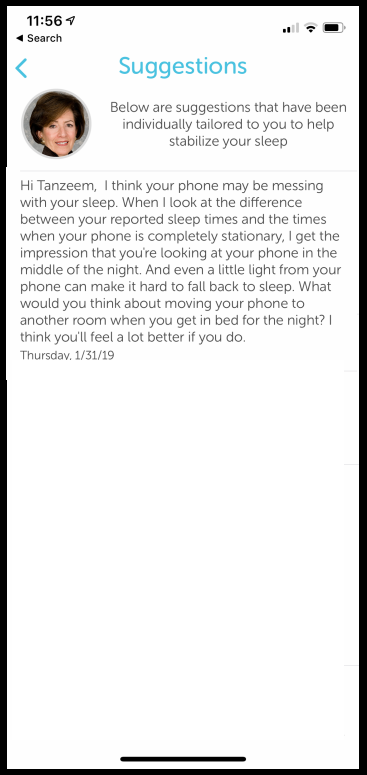
Intervention Gap


One month of data
symptom score
Alert care team if score >threshold
Patient reach out
Patient reach out
Patient reach out
Alert physician

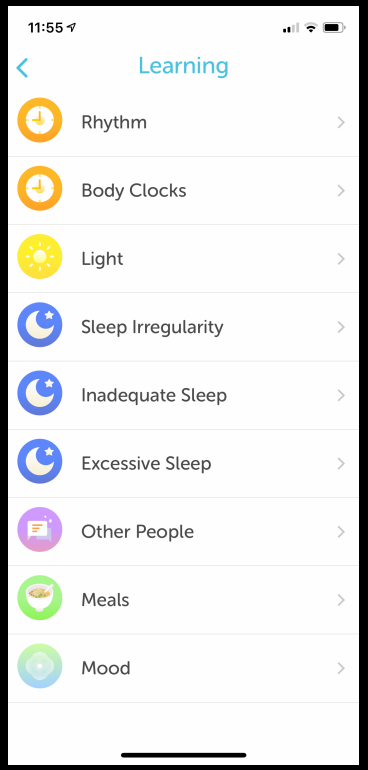
Personalized Sensor Driven Health Program

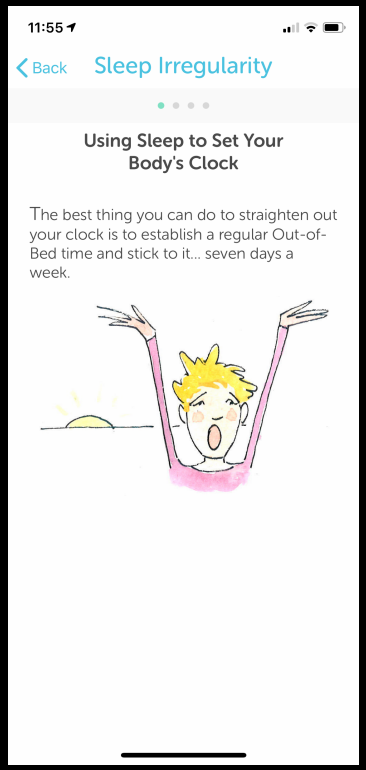


Continuous sensor measurement

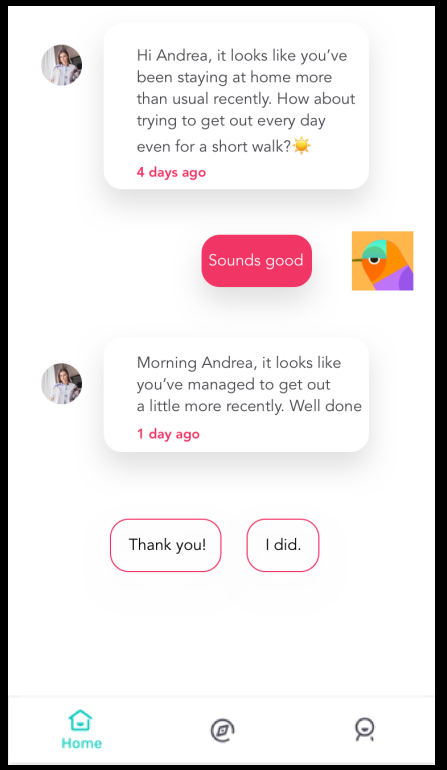


Sensor-driven activity suggestions



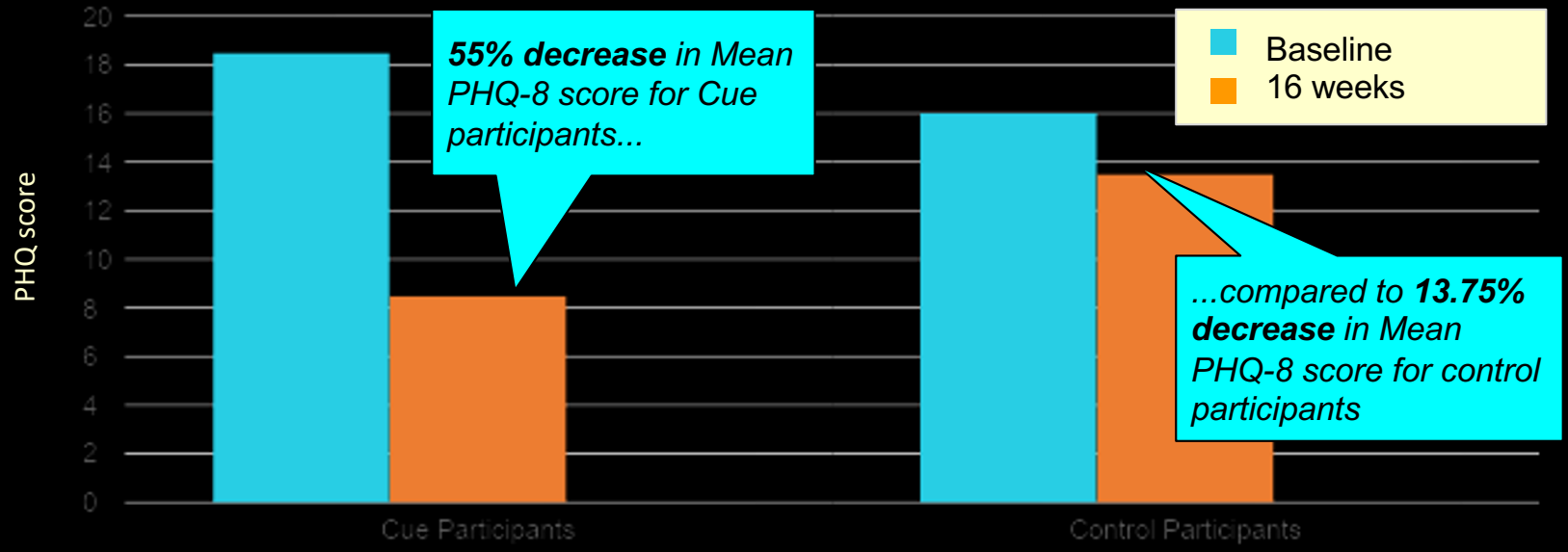


Engaging psychoeducational content



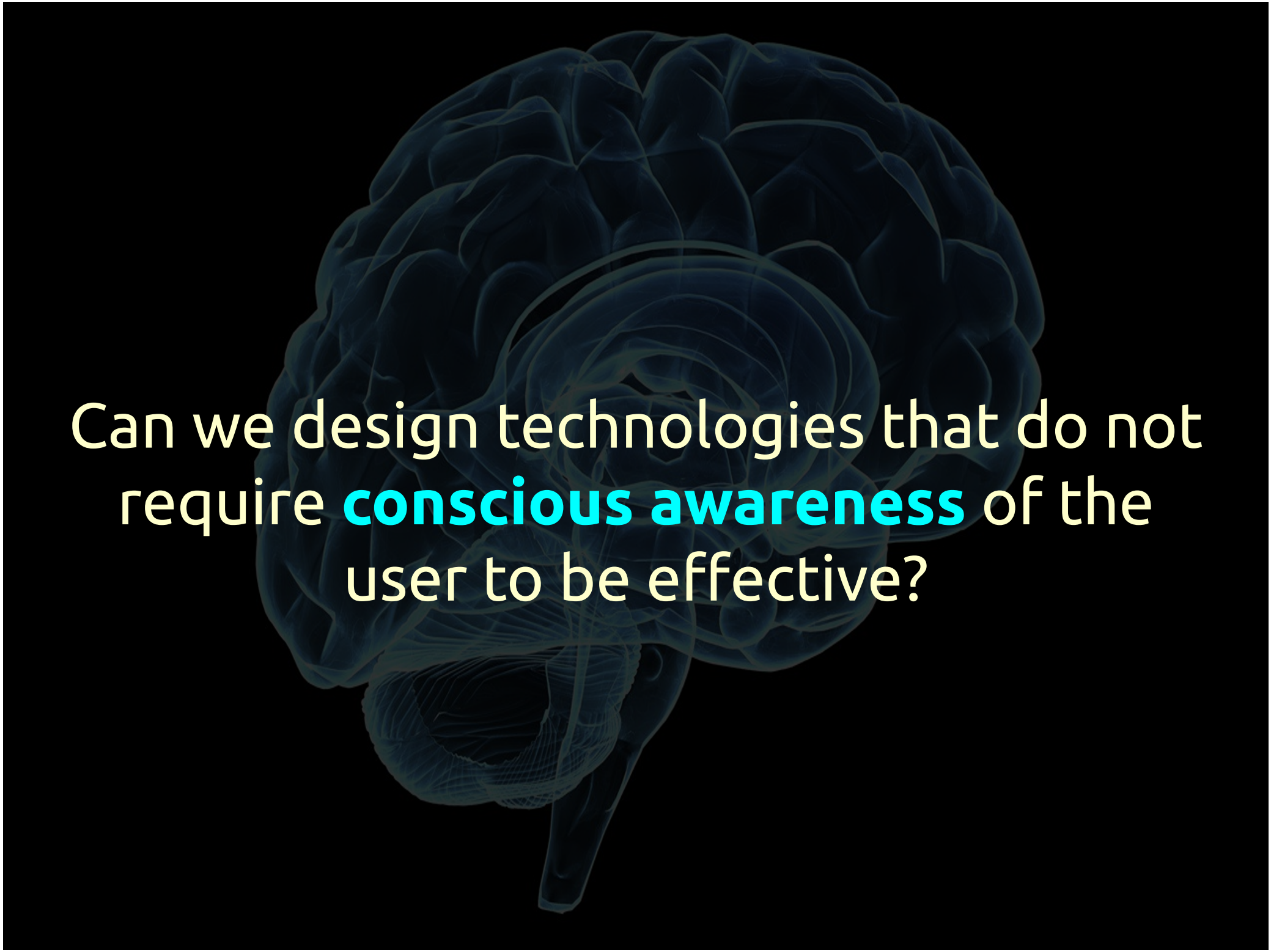
Personalized Messaging

Cue digital therapeutic shown to increase efficacy of treatment in RCT completed January 2020



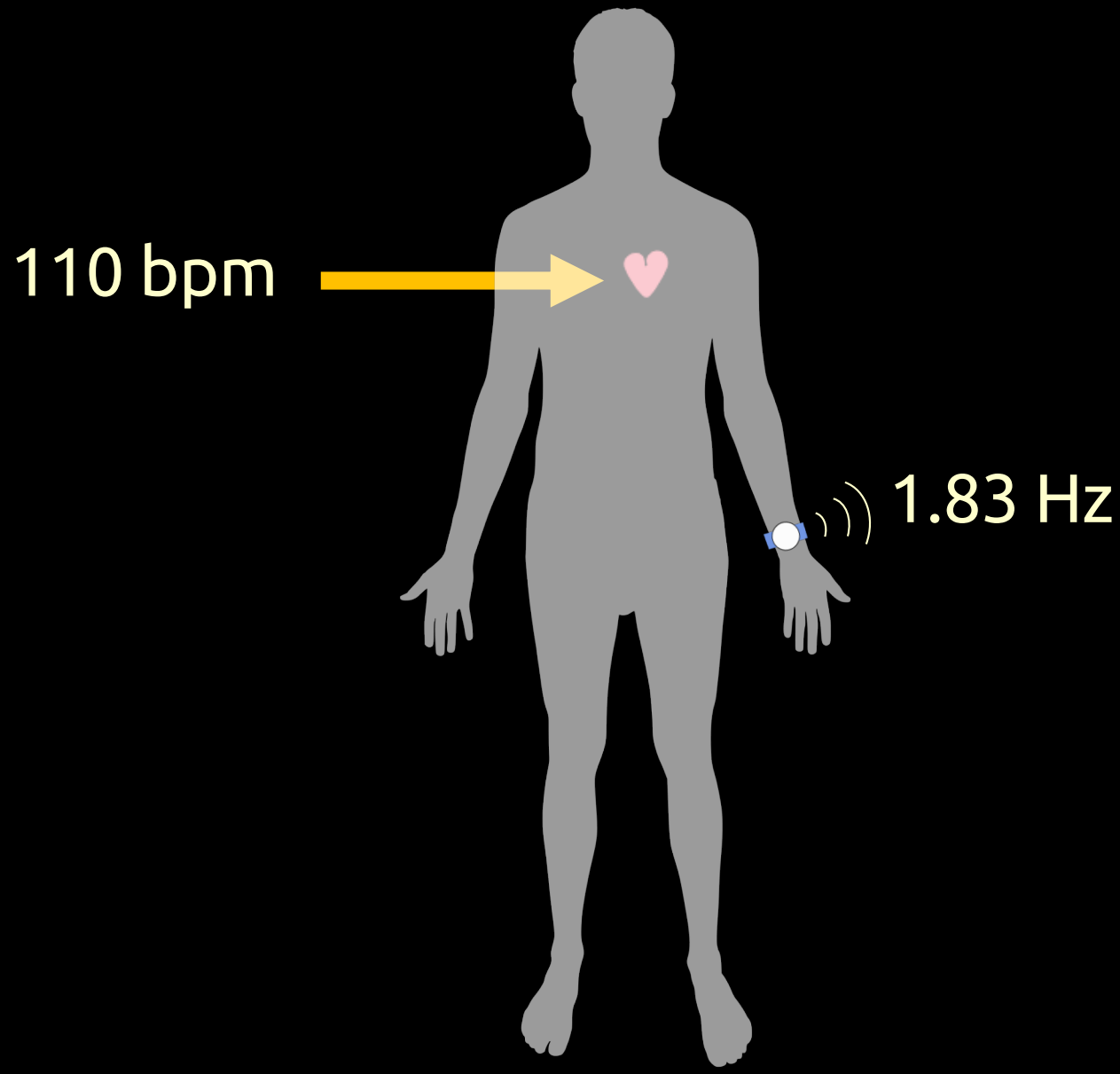
- Protocol: 16 weeks
- Coverage: 24/7 data coverage on 93% of study days
- Total participants: 135
- Drop-outs: 4

Tighter synchronization between sensing and intervention is needed

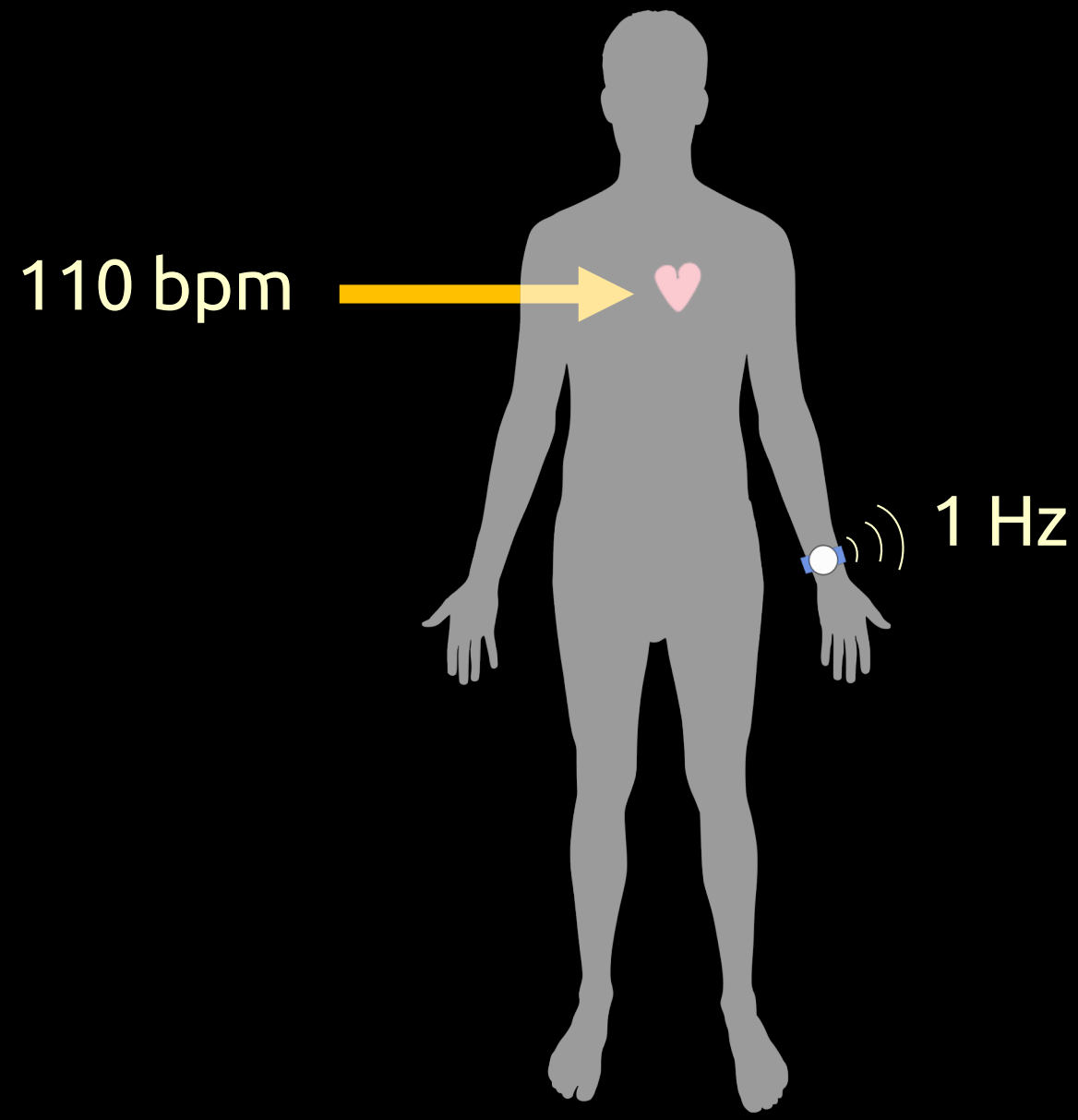

Can we design technologies that do not require **conscious awareness** of the user to be effective?

EmotionCheck: Leveraging Bodily Signals to Reduce Anxiety in Real-time

The vibrations represent your current heart rate

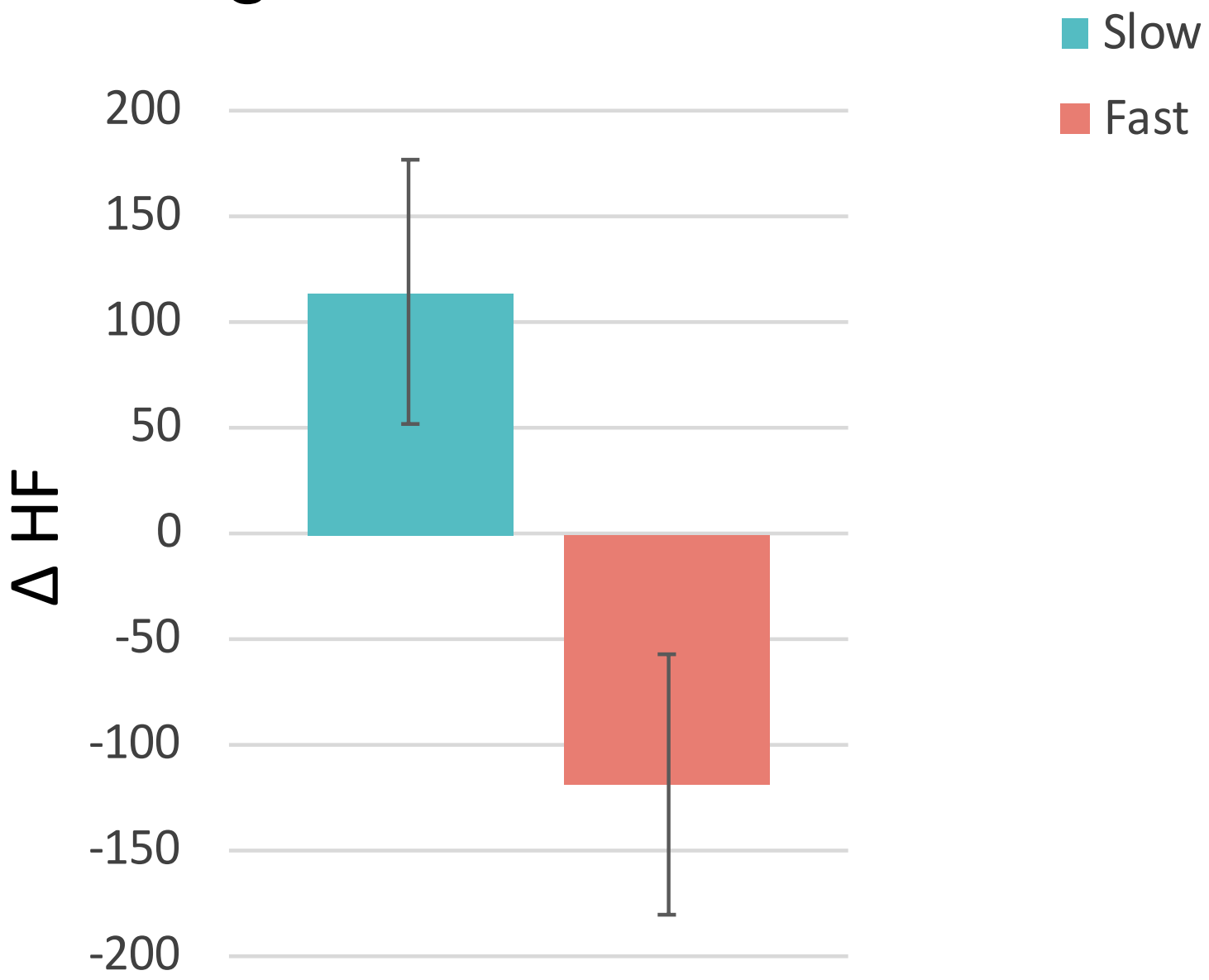


The vibrations represent false heart rate feedback




Anxiety Level
Δ Anxiety
4
3
2
1
0
-1
-2
-3
Slow
Fast

Changes in Heart Rate



Pitfalls

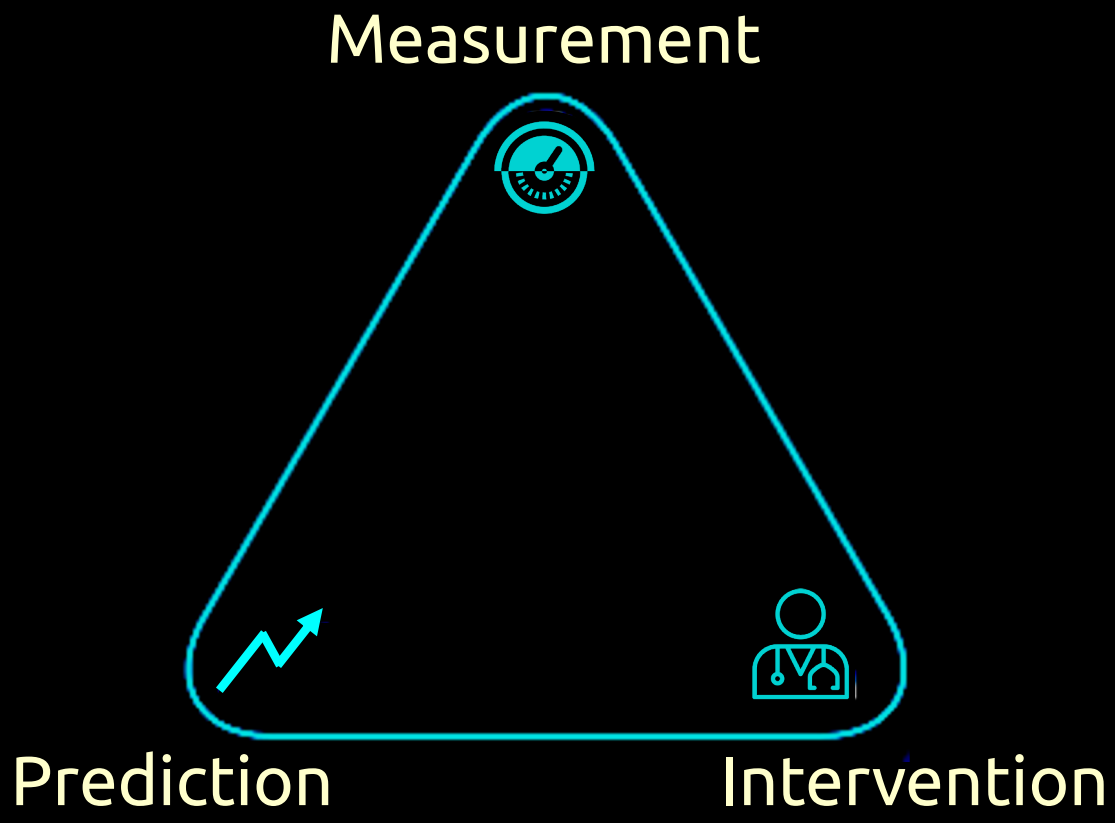
Too much focus on novel features generations and incremental accuracy improvements?

Reducing Burden


And it's for sale.
Trustworthy
sensing

Future of Integrated Care:

Continuous, personalized coupling between measurement and intervention



Technology assisted Integrated Care

Project LOOP by OPTUMLABS

High-quality integrated physical and behavioral health with three components:

- platform agnostic data capture and analysis to intercept behavioral conditions early and monitor for progression
- real-time and adaptive AI algorithms that determine engagement, measurement, and intervention strategies for each patient
- transparent and integrated clinical decision support that gives providers actionable insights and maximizes care efficiency and effectiveness.


Precision
Behavioral
Health
Home
The Precision Behavioral Health Initiative @ Cornell Tech
aims to advance the role of precision technology in transforming behavioral health.

Thank you!


Alex Adams


Vincent Tseng


Dan Adler


Yiran Zhao

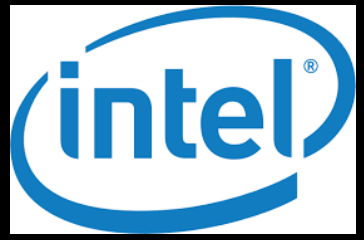

Jatin Arora


Jean Costa


Tauhidur Rahman


Saeed Abduallah

Collaborators: Dror Ben-Zeev, Andrew Campbell, Deborah Estrin, Malte Jung, John Kane, Cecilia Livesey, David Mohr




Microsoft Research

Google