Digital Phenotyping

mindstrong

Tom Insel, MD
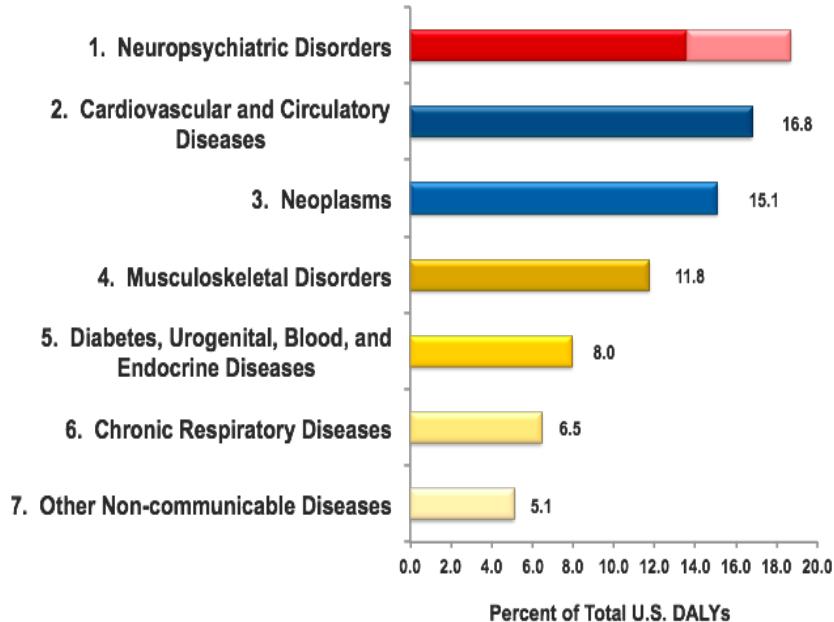Co-founder and President, Mindstrong Health
May 15, 2019
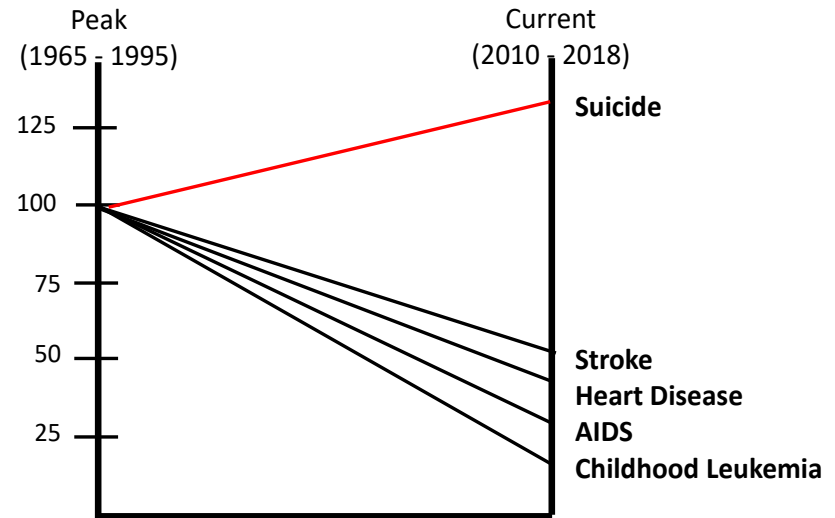
What is the Problem We Need to Solve?

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No change in morbidity or mortality

1. Neuropsychiatric Disorders

2. Cardiovascular and Circulatory Diseases — 16.8

3. Neoplasms — 15.1

4. Musculoskeletal Disorders — 11.8

5. Diabetes, Urogenital, Blood, and Endocrine Diseases — 8.0

6. Chronic Respiratory Diseases — 6.5

7. Other Non-communicable Diseases — 5.1

Percent of Total U.S. DALYs

US Burden of Disease Collaborators, *JAMA*, 2013.

Peak (1965 - 1995)   Current (2010 - 2018)

125

100

75

50

25

Suicide

Stroke
Heart Disease
AIDS
Childhood Leukemia

https://www.cdc.gov/vitalsigns/suicide/index.html

Why have we failed to bend the curve?

Imprecise Dx — *Lack of biological validity*

Lack of Engagement — *60% not receiving care*

Quality — *Fragmented, episodic, delayed*

Lack of Measurement — *We don't manage what we don't measure*

Why have we failed to bend the curve?

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Lack of Engagement	*60% not receiving care*
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MEASURING MOOD, COGNITION, AND BEHAVIOR

WHAT WE DO TODAY

- **Subjective**

- **Episodic**

- **Clinic-based**

- **High burden**

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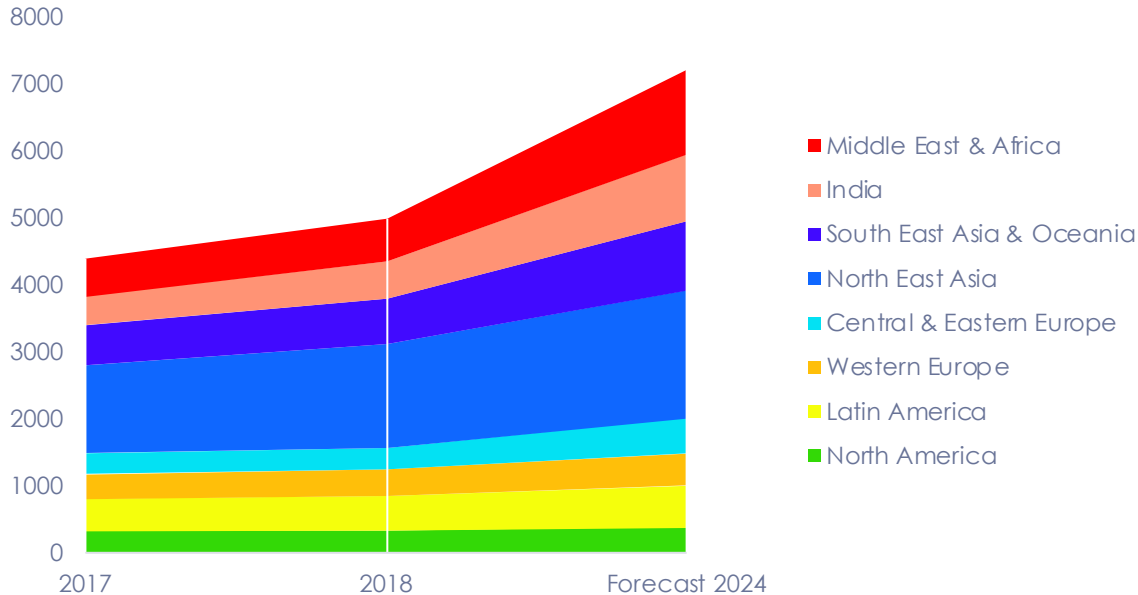- **High burden**

WHAT WE NEED

- **Objective**

- **Continuous**

- **Ecological**

- **Passive**

Smartphones

A medical tool for global health – improving diagnosis and connecting care

Smartphone Penetration (in millions)

Legend:
- Middle East & Africa
- India
- South East Asia & Oceania
- North East Asia
- Central & Eastern Europe
- Western Europe
- Latin America
- North America

Chart axis: 0, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000

X-axis: 2017, 2018, Forecast 2024

Over 4 billion globally and 7 billion by 2024

Over 70 daily checks

Over 2600 daily "touches"

More ubiquitous than clean water, indoor plumbing, and stable electricity

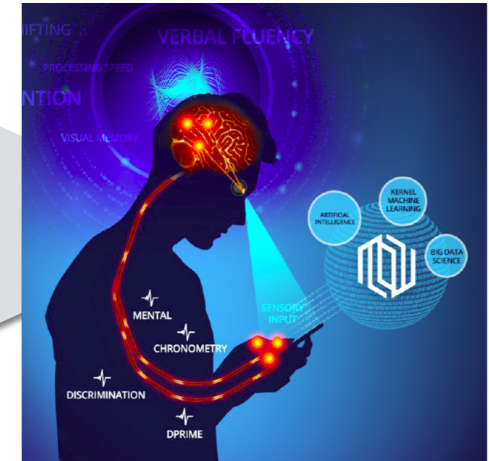https://www.ericsson.com/assets/local/mobility-report/documents/2018/ericsson-mobility-report-november-2018.pdf

DIGITAL PHENOTYPING

A New Kind of Biomarker

SENSORS
Activity
Location
Sociality

HCI - KEYBOARD
Reaction Time
Attention
Memory
Executive Function

VOICE/SPEECH
Prosody
Sentiment
Coherence

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Digital phenotype can also include "digital exhaust" (social media posts, search terms, AI personal assistants etc.)

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Digital phenotype can also include "digital exhaust" (social media posts, search terms, AI personal assistants etc.)

Feature Extraction
Pattern Recognition
Machine Learning

Digital Phenotype =
Cognition, Mood, Behavior

# Digital Biomarkers (using HCI only) and Cognitive Traits
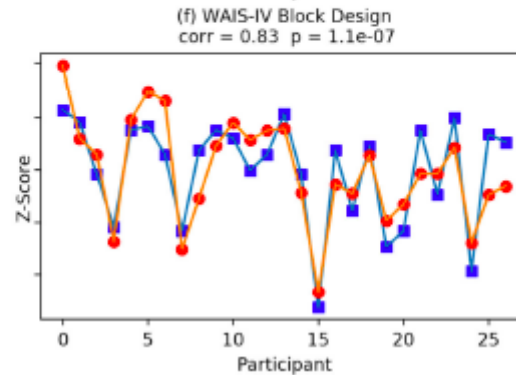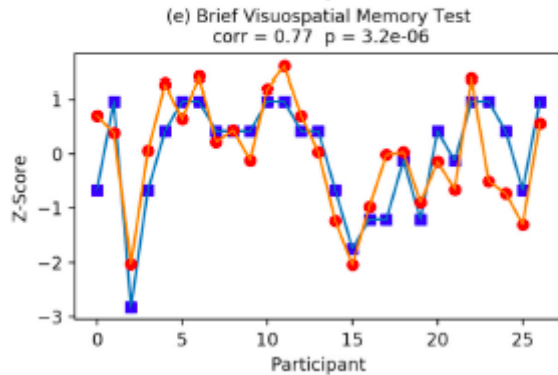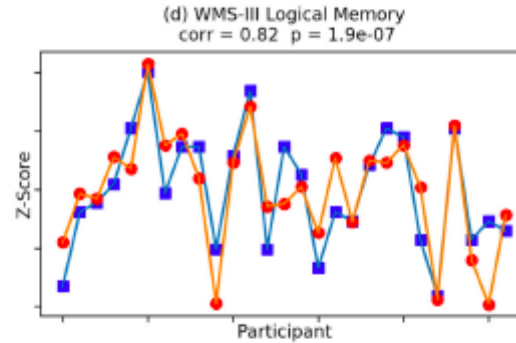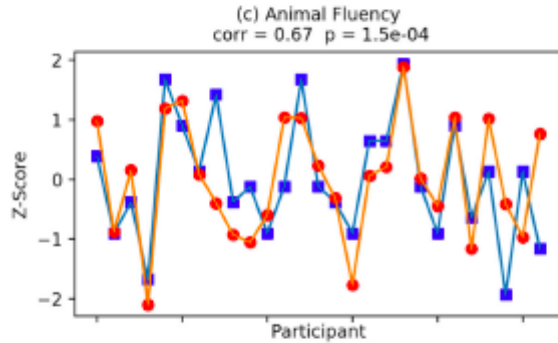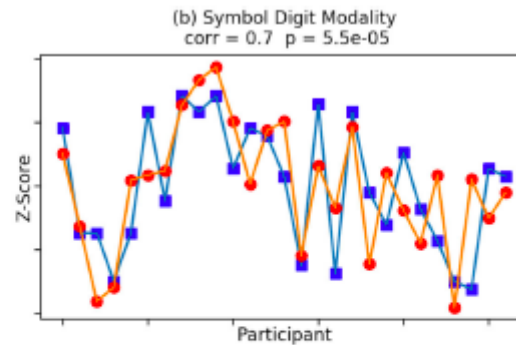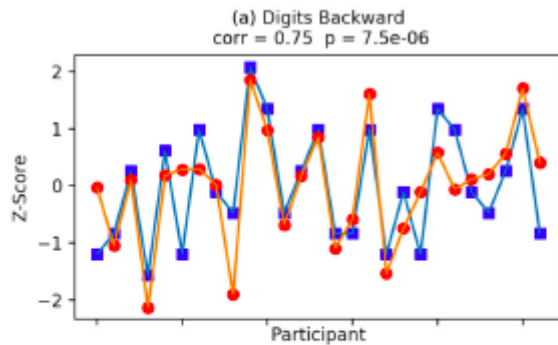
■—■ Cognitive performance

●—● Digital biomarker

Volunteers (n = 27) compared on neurocognitive tests and digital biomarkers.

Correlations across multiple cognitive trait measures = .7 - .8 (roughly test–retest variance)

Dagum, Digital Medicine, 2018

detecting deterioration
to prevent crisis

COGNITIVE CONTROL

HOSPITALIZATION

WORKING MEMORY
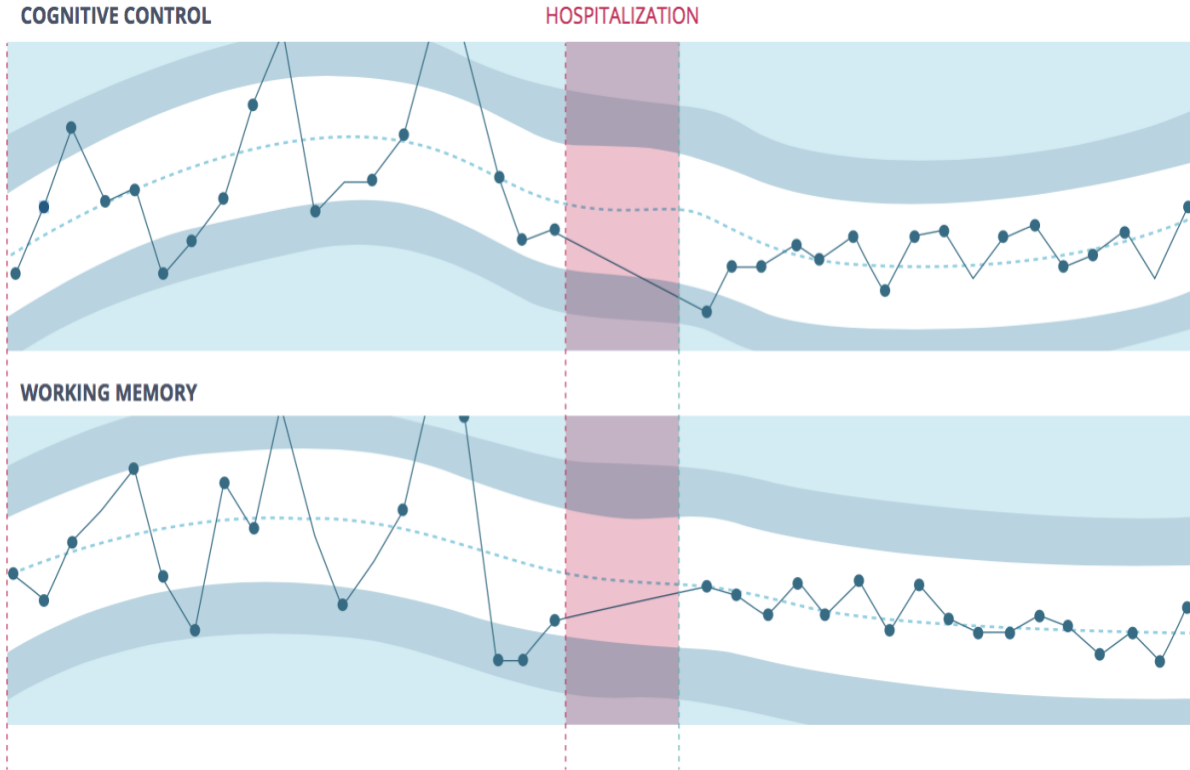
I'm doing a lot better. I was experiencing a lot of auditory hallucinations. They made it difficult to sleep which made things progressively worse.

I checked myself into the hospital. They adjusted my medications, gave group therapy, and monitored me. I believe I slept for 12 hours each night 3 days in a row. What a relief! The hallucinations finally subsided.

tracking brain health in a 48 year old woman
under care for bipolar disorder with psychosis
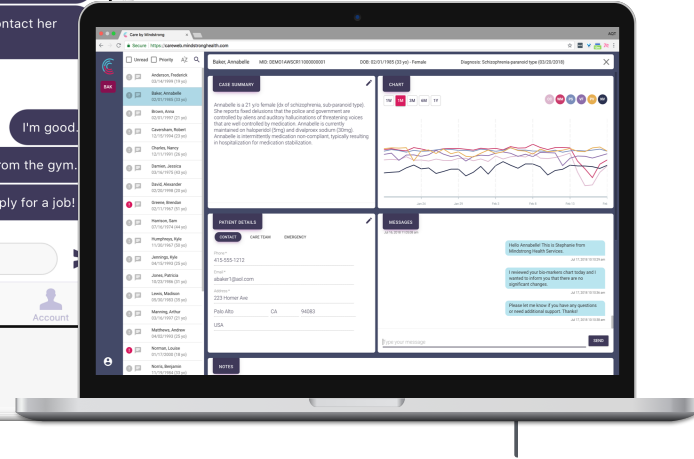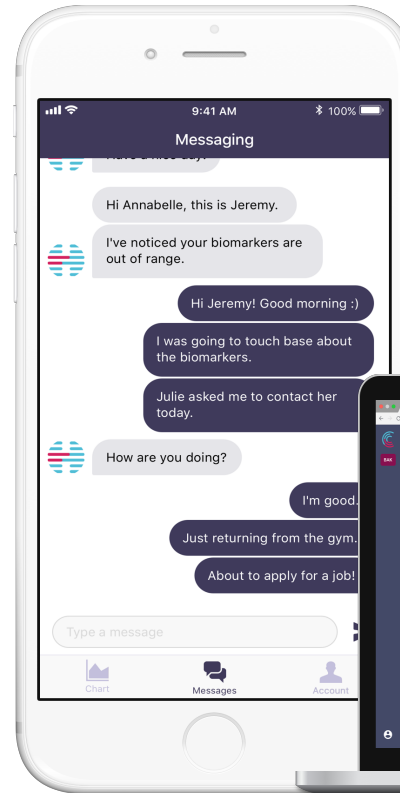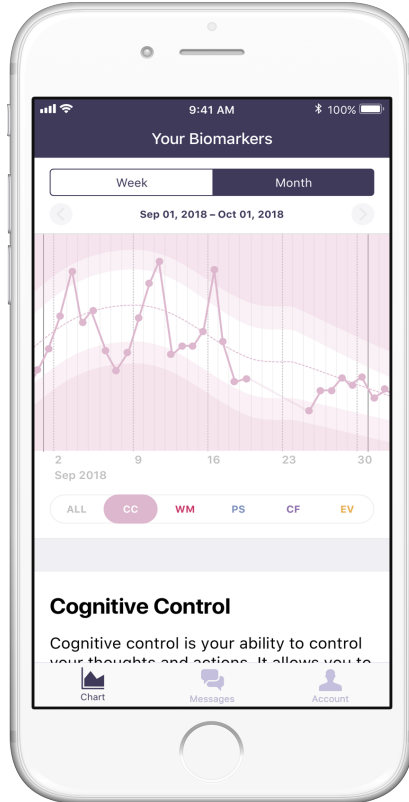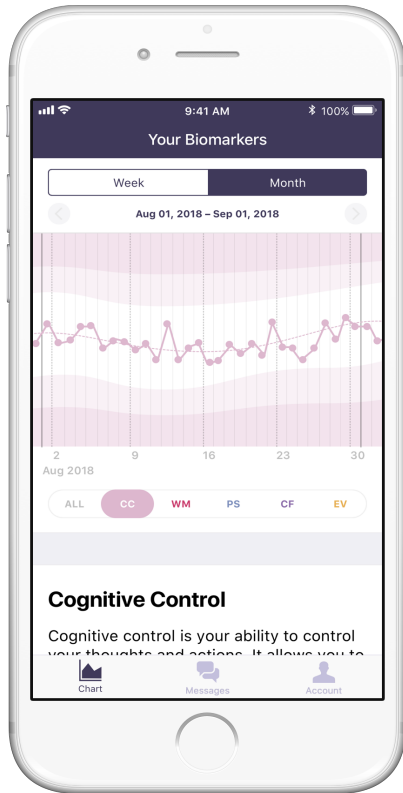
Ketamine : A Paradigm for Learning the Predictors of Recovery and Relapse

- Rapidly–acting antidepressant (6 hours)

- Frequent relapse (80% depressed again at 4 weeks)

- Multiple treatments over 6 months provide within-subject training for relapse and recovery
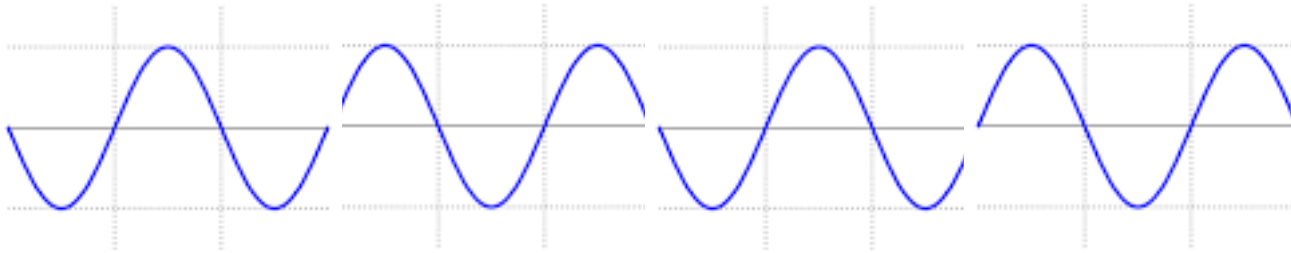
Digital Biomarkers and Affective States – Tracking Depression

HAMD LOOCV Predictions for TRD Patients
corr = 0.77 p = 2.9e-36
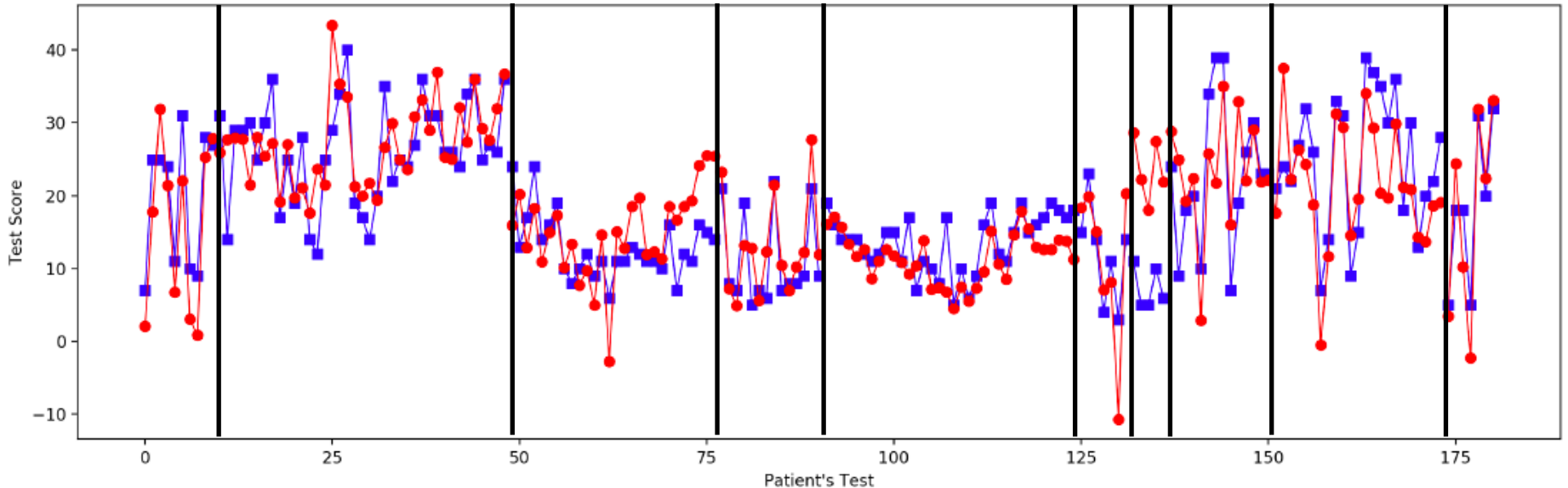
Ham-D Score

Digital biomarker

Ketamine treatment of MDD (n = 10, 180 observations)
Overall correlation = 0.77, p = 2.9 x 10^{-36}

MEASURING MOOD, COGNITION, AND BEHAVIOR

WHAT WE DO TODAY

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- Episodic

- Clinic-based

- High Burden

WHAT WE NEED

- ✓ Objective

- ✓ Continuous

- ✓ Ecological

- ✓ Passive

The Digital Health Landscape

Not an App But An Operating System

CBT, DBT, IPT; Coaching; Peer Support; Crisis Intervention

Mobile Interventions

Learning Engine

Digital Phenotyping

Care Management

Sensors
HCI
Voice
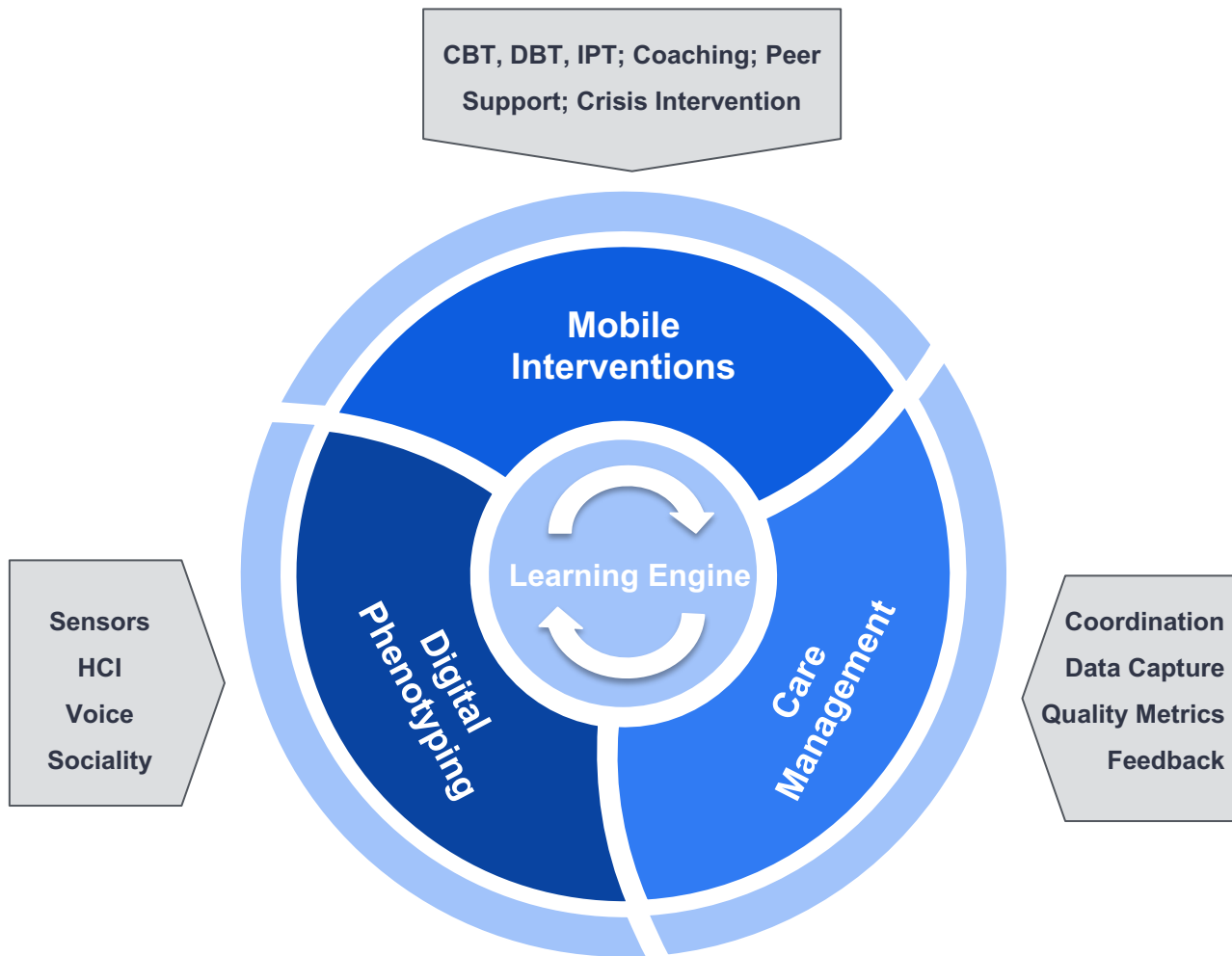Sociality

Coordination
Data Capture
Quality Metrics
Feedback

WHITE STAR CAPITAL

MENTAL HEALTH TECH LANDSCAPE

CCBT

HEADSPACE · joyable · 10% HAPPIER · unmind · pzizz · Big Health · Sync Project · PEAR THERAPEUTICS · Calm · SIMPLE HABIT · INSCAPE · pacifica · QuitGenius · AKILI · happify · moodpath · CureApp

33% OF COMPANIES ANALYZED / $5.8M AVG FUNDING AMOUNT

TELEPSYCHIATRY

BlueCall · competencer · Selfapy · talkspace · AbleTo · LYRA · Ginger.io · Kip · regroup · ieso · Workit Health · Breakthrough · 1 DOC WAY · wecounsel

16% OF COMPANIES ANALYZED / $6.7M AVG FUNDING AMOUNT

PROVIDER TOOLS

Quartet · inflexxion · CMHC Systems · valant · core · silvercloud · mindstrong · agile health · MindCare · ValeraHealth

15% OF COMPANIES ANALYZED / $5.7M AVG FUNDING AMOUNT

CONSUMER TOOLS

WEConnect · webpsychology · inquisithealth · huddle · connected health · THRIVE GLOBAL · find circles. · Remente · TalkLife

13% OF COMPANIES ANALYZED / $1.8M AVG FUNDING AMOUNT

HARDWARE

ybrain · RENEWED · CARROT · NEUROFLOW · muse · find-me · psious · somatix · feel · sana · Limbix · FLOW · Kognito

12% OF COMPANIES ANALYZED / $1.1M AVG FUNDING AMOUNT

APPLIED AI

meQuilibrium · shine · neurotrack · Woebot · spring · koko · cognoa · BIOBEATS · Avalon AI · bark · Psyomics

11% OF COMPANIES ANALYZED / $3.8M AVG FUNDING AMOUNT
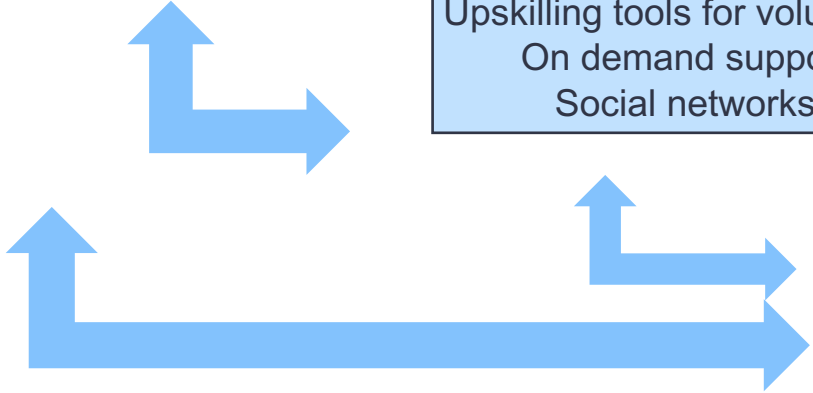
Digital Tools to Reduce Suicide

High Tech
+
High Touch

Predictive signals
HCI data
Speech/text signals
Online classifiers

Crisis intervention
Upskilling tools for volunteers
On demand support
Social networks

Postvention
Care management
Peer support
AI nurse
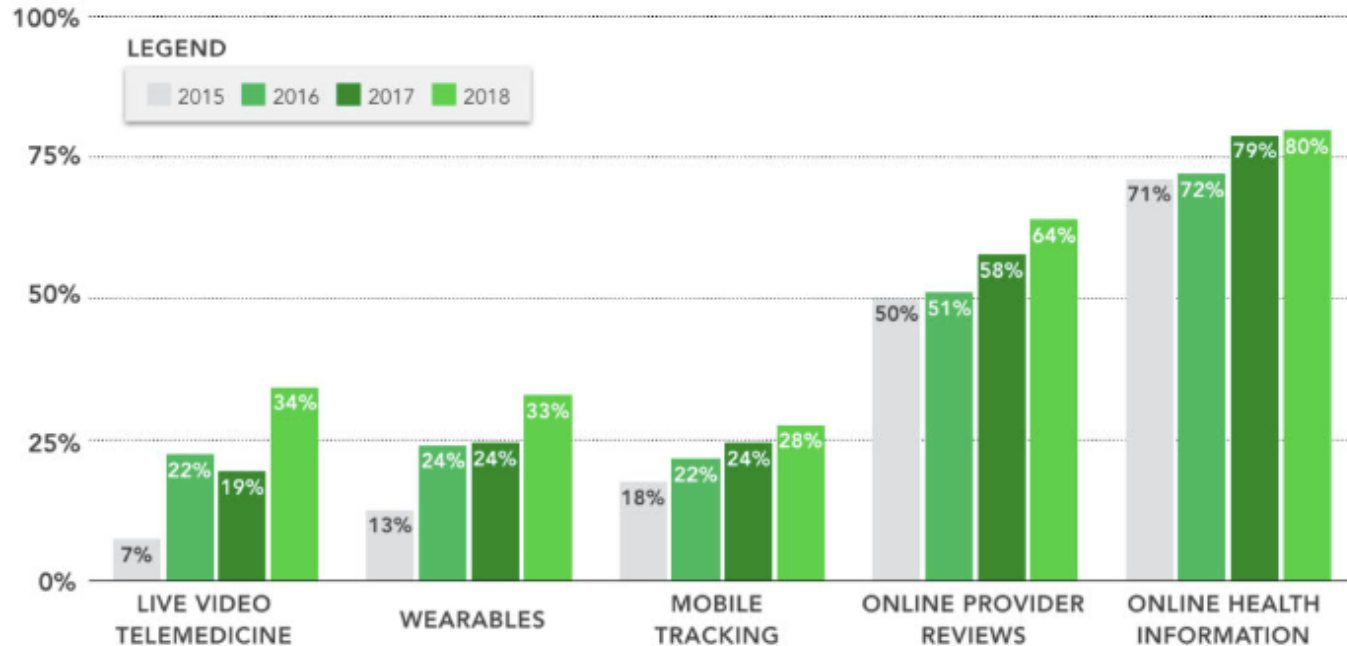
The Digital Mental Health Challenge Where Are We?

Value?
Does it work?

Improve real world outcomes
Adopted by patients and providers
Save time and money

The Digital Mental Health Challenge

ADOPTION OF DIGITAL HEALTH TOOLS
2015-2018

ROCK HEAL+H

LEGEND: 2015, 2016, 2017, 2018

LIVE VIDEO TELEMEDICINE: 7%, 22%, 19%, 34%
WEARABLES: 13%, 24%, 24%, 33%
MOBILE TRACKING: 18%, 22%, 24%, 28%
ONLINE PROVIDER REVIEWS: 50%, 51%, 58%, 64%
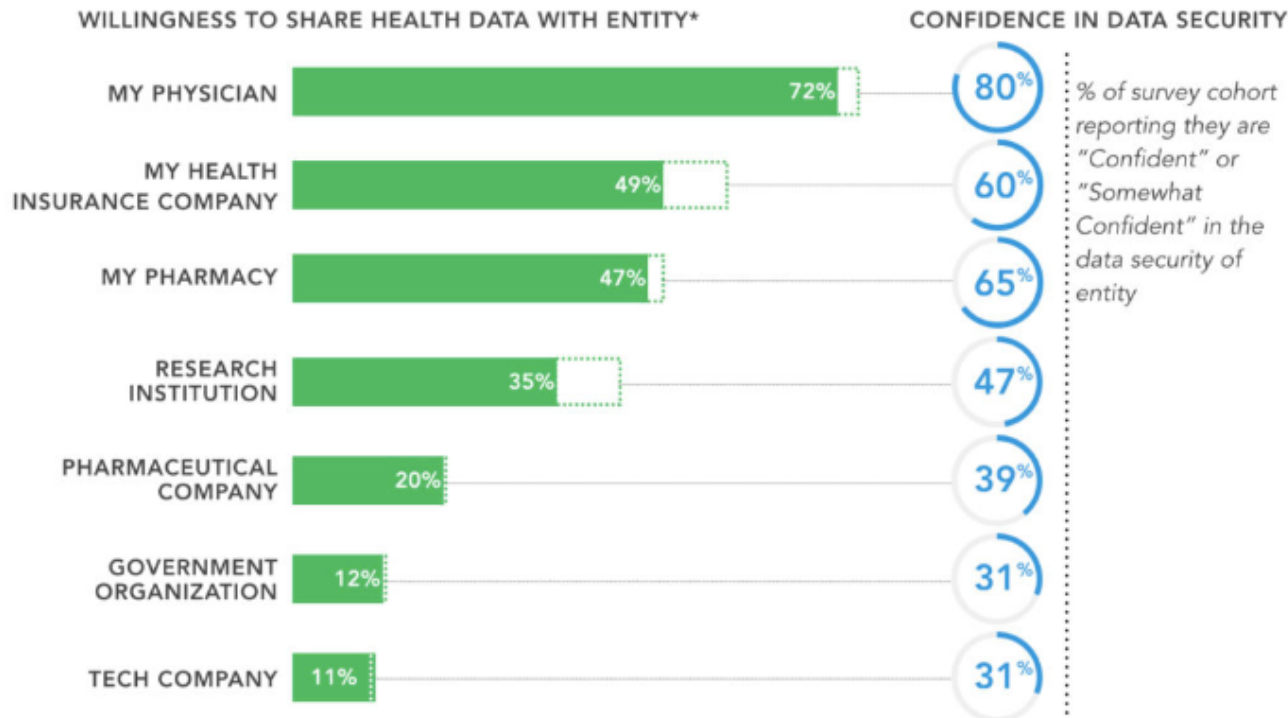ONLINE HEALTH INFORMATION: 71%, 72%, 79%, 80%

Source: Rock Health Digital Health Consumer Adoption Survey (n2018 = 4,000; n2017 = 3,997; n2016 = 4,015; n2015 = 4,017)

The Digital Mental Health Challenge

CONSUMER SENTIMENT ON DATA SHARING AND SECURITY
By entity, 2017-2018

ROCK HEAL+H

WILLINGNESS TO SHARE HEALTH DATA WITH ENTITY*

CONFIDENCE IN DATA SECURITY

Entity	Willingness	Confidence
MY PHYSICIAN	72%	80%
MY HEALTH INSURANCE COMPANY	49%	60%
MY PHARMACY	47%	65%
RESEARCH INSTITUTION	35%	47%
PHARMACEUTICAL COMPANY	20%	39%
GOVERNMENT ORGANIZATION	12%	31%
TECH COMPANY	11%	31%

% of survey cohort reporting they are "Confident" or "Somewhat Confident" in the data security of entity

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Does it work?**

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**Trust?
Acceptance?**

Privacy – Surveillance?
Agency – To me or By me?
Data – Who? When? Where?

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Empowering Patients + Families
with Information and Connection

Thank You!

mindstrong

Transforming Brain Health

tom@mindstronghealth.com