



# **Activating Mobile Health:** *from smartphone apps and small data streams to behavioral biomarkers*

<http://smalldata.tech.cornell.edu>

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# Personalized, precision, medicine

big-data  
science

**EHRs, claims  
data, patient  
sites**

**\*omics**

**n=me small data  
(mHealth, QS,  
digital traces)**

small-  
data  
science

harness previously-unmeasured function and behavior  
to fuel personalized and evidence-producing care and behavior



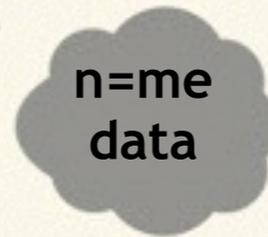
## Participant self-care

*How is this new medication working for me?*



## Clinical care

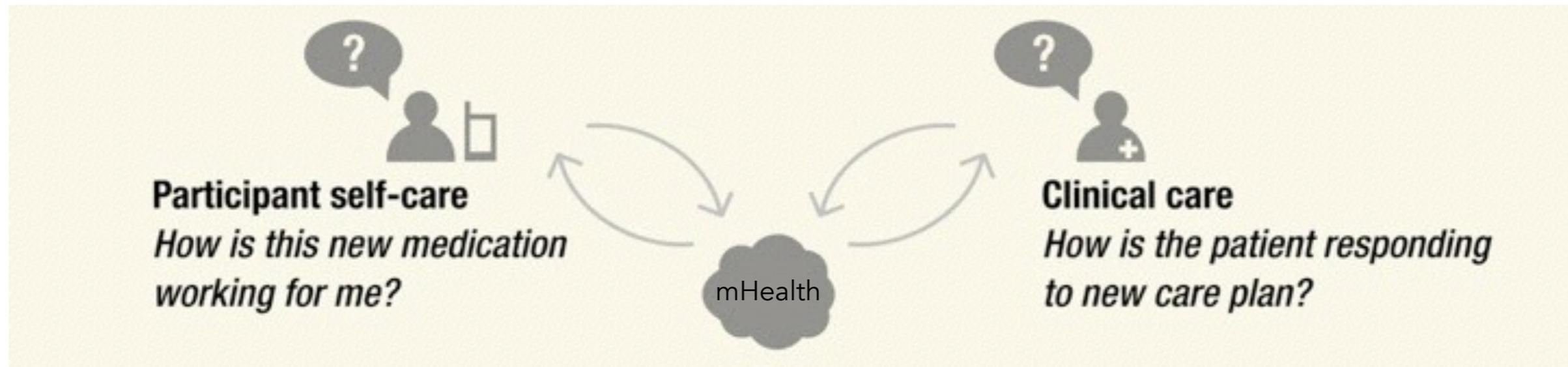
*How is the patient responding to new care plan?*



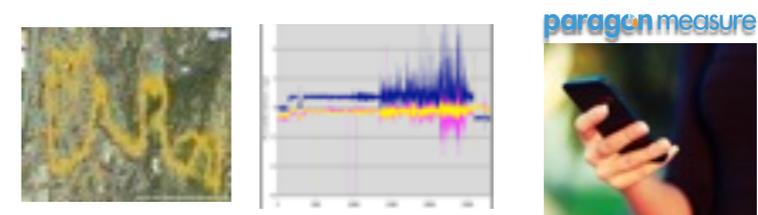
## Research evidence

*What works best in different contexts?*

# mHealth data and feedback loops of health



**Passively-recorded activity, location**



**Mobile apps: data, metadata, usage**



**Digital traces: purchases, entertainment**



**"Real Sensor" streams too**



# Smart(er) self report/EMA: Photographic Affect Meter, PAM

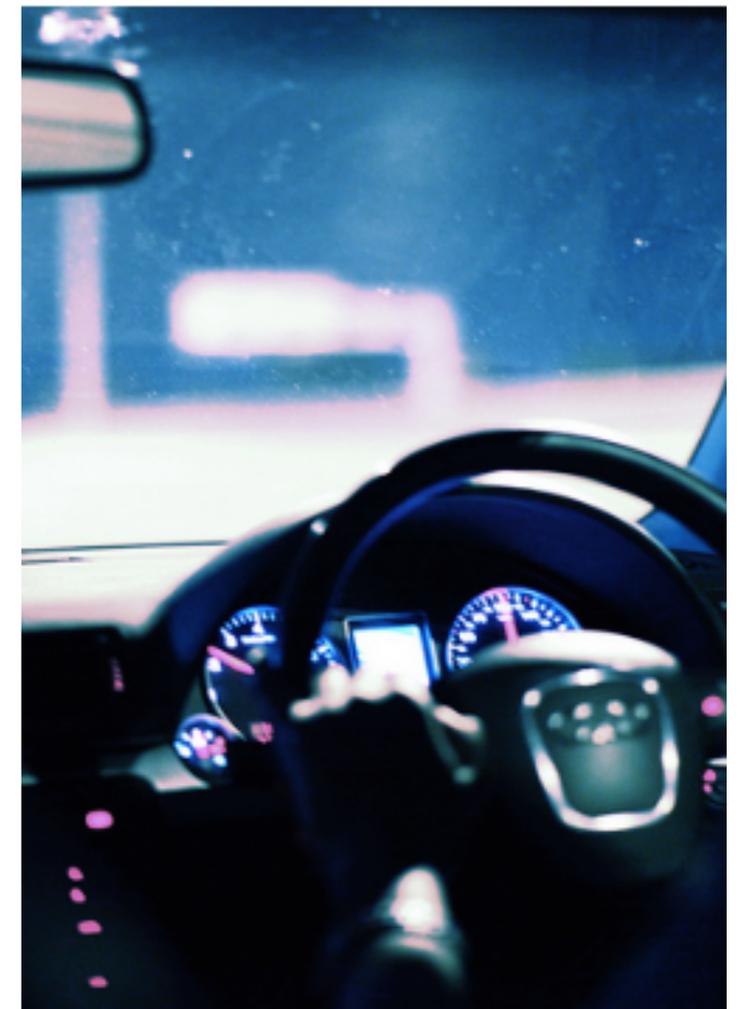
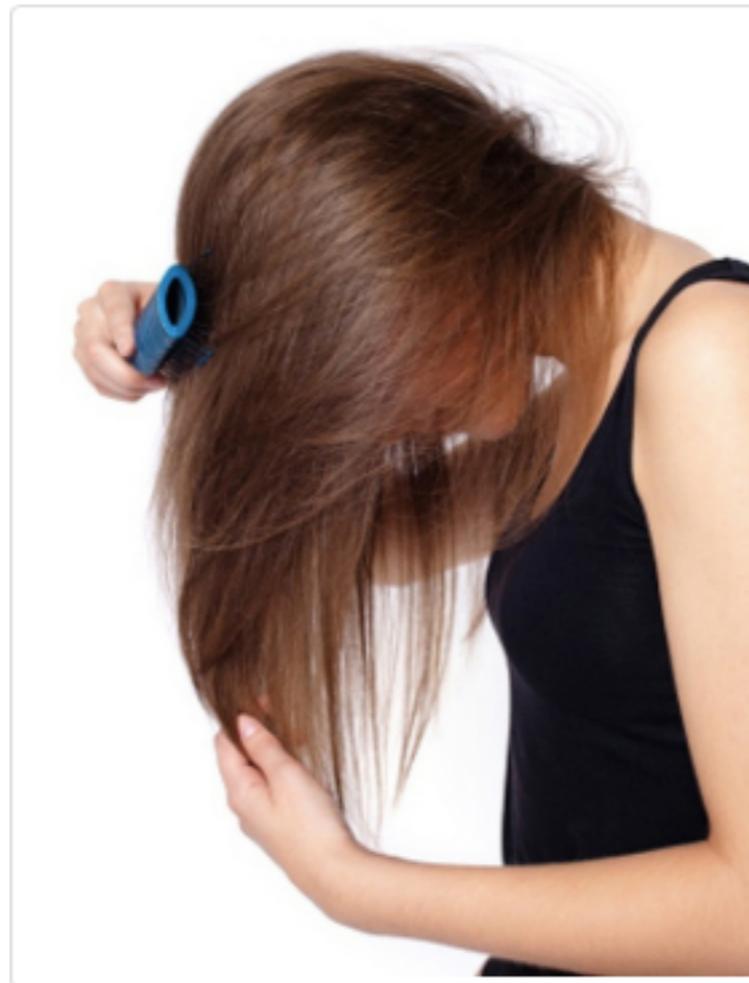


Demo:

[yadl.yadagame.com](http://yadl.yadagame.com)

# Your Activities of Daily Living (YADL)

How difficult is this activity because of your Rheumatoid Arthritis?



# Calendar view

Your daily active minutes, time out of home and max walking speed on your calendar



# measure paragon measure

## Novel Platform for Continuous and passive monitoring

Typing Behavior

Touch Gestures

Inertial Sensors

Machine Learning & Predictive Modeling

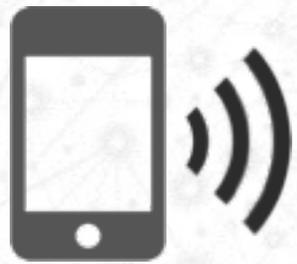
Actionable Health Insights



Peripheral Neuropathy Identify events Tremor Gait Velocity Fatigue Bradykinesia ...

# The Ginger.io Platform informs clinical intervention with communication and activity data:

Continuous & Passive  
Ginger.io fills in data gaps that are often missed when using self-report measures. This reduces patient burden and results in improved data quality.



Data Collection



Behavior Patterns



Check Engine Light  
Identify at-risk patients based on objective patient data, and alert a provider or caregiver.

Health Status



Protecting Privacy  
Ginger.io is HIPPA compliant, and collects statistics, not specific contacts, locations, or content.

Assess intervention  
Track outcomes more explicitly, and determine efficacy of outreach approaches

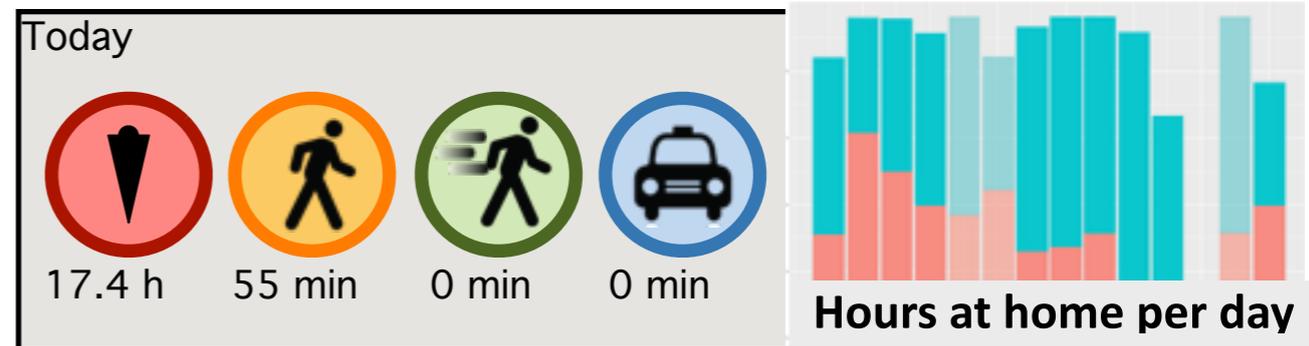
# Behavioral Biomarkers

*move up the information food chain*

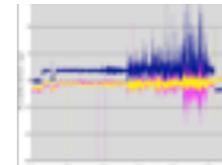
patient function  
(behavioral biomarkers)



summarization, fusion



raw measurements

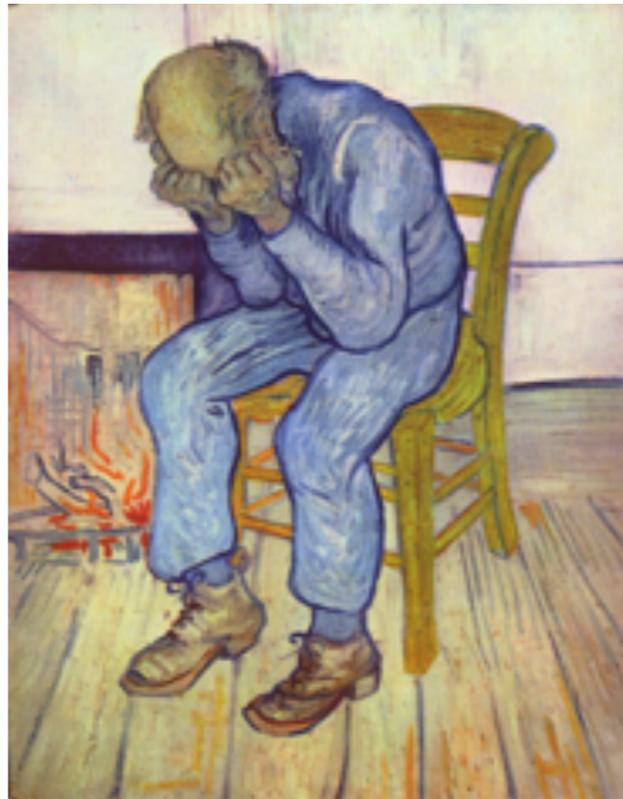


# small data fueled applications

personalized Rx,  
treatment, self-care



detect progression of  
cognitive impairment

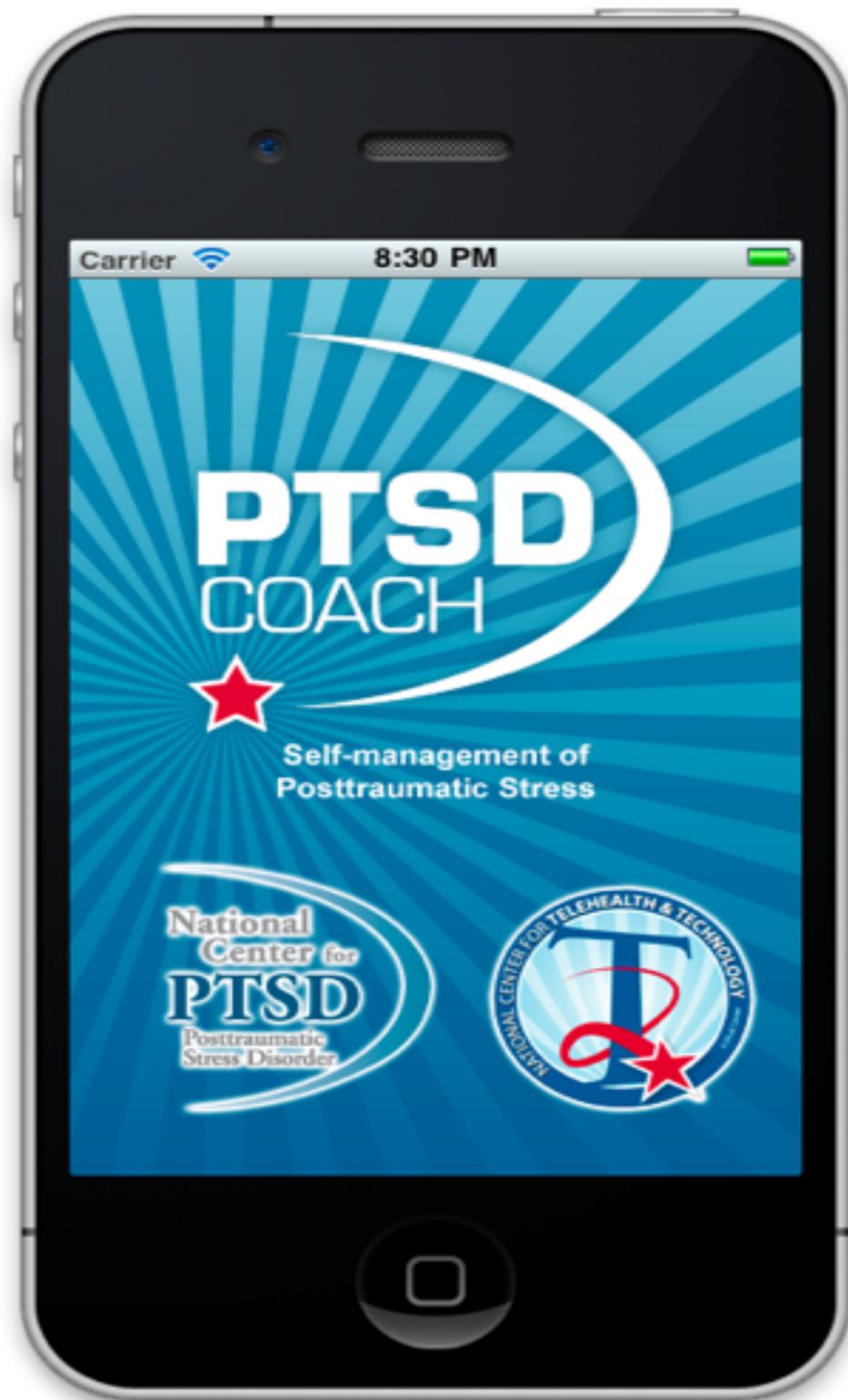


improve household  
food environment



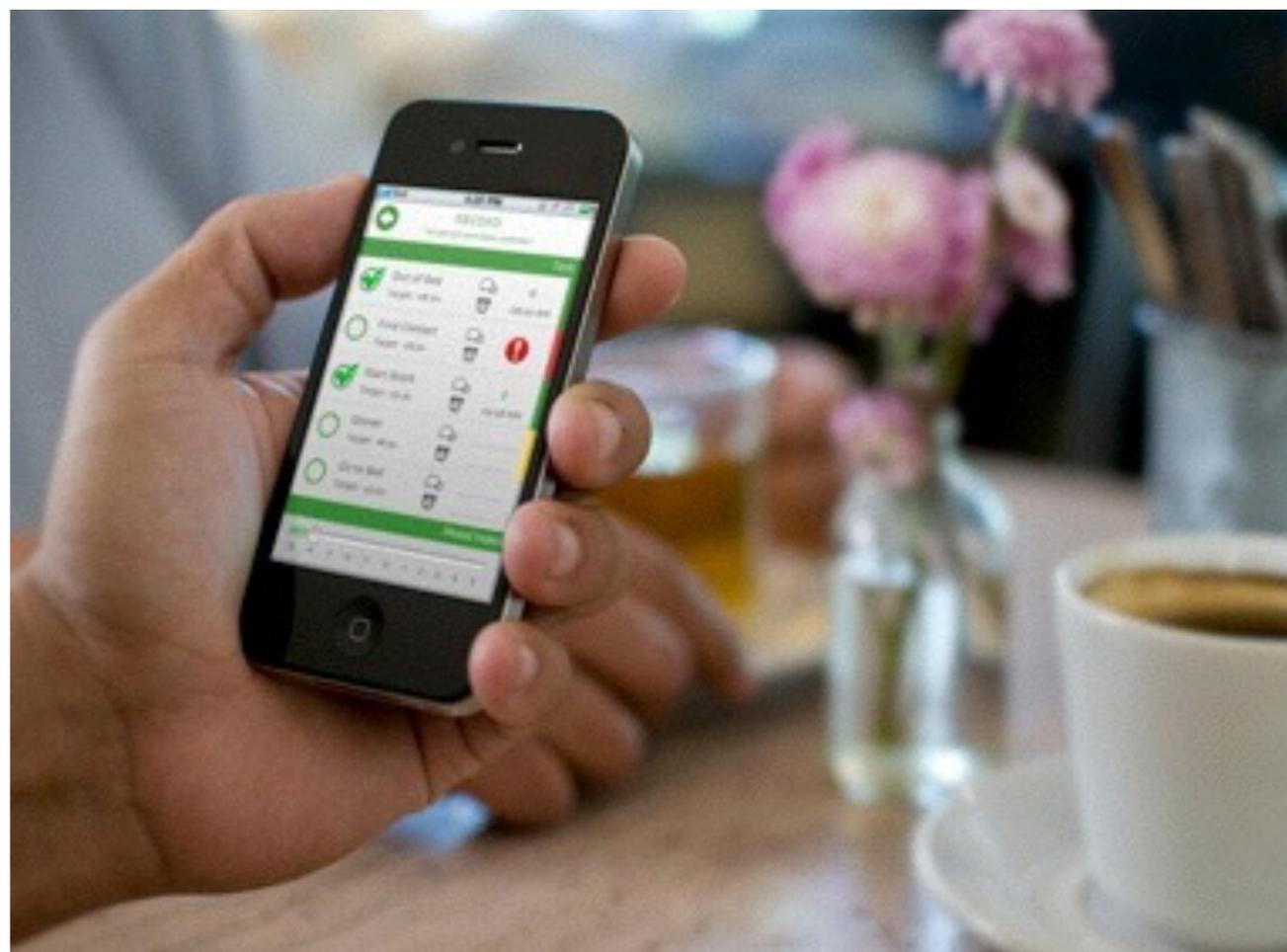
**measure, motivate, modify, maintain**  
**aspirational health behaviors**

**Early(iest) example of small data fueled health application!**



**Photo: VA and DOD. Adapted from Julia Hoffman (VA), et al.**

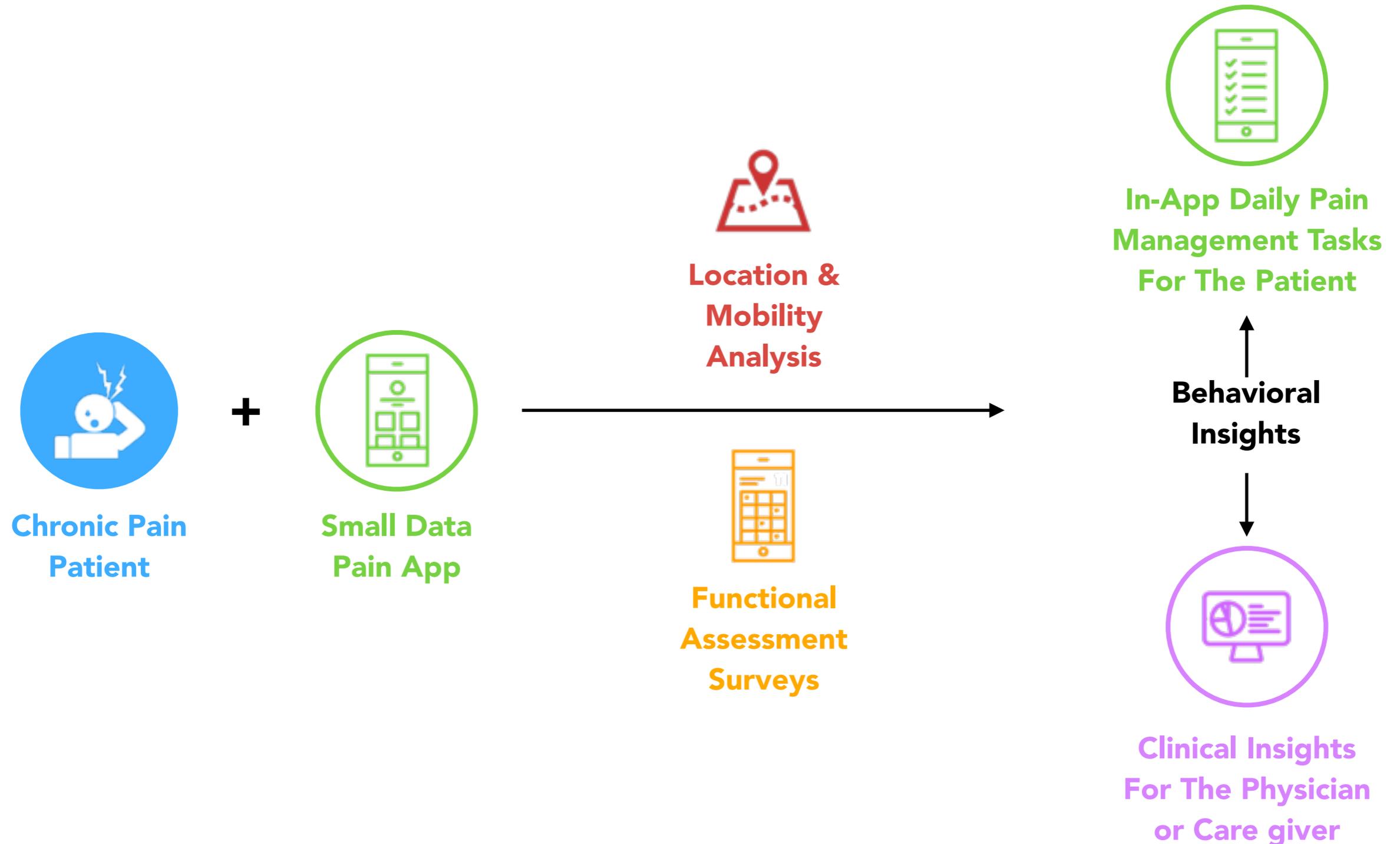
# MoodRhythm(TM) provides tools for Bipolar patients to measure and manage their own daily routines



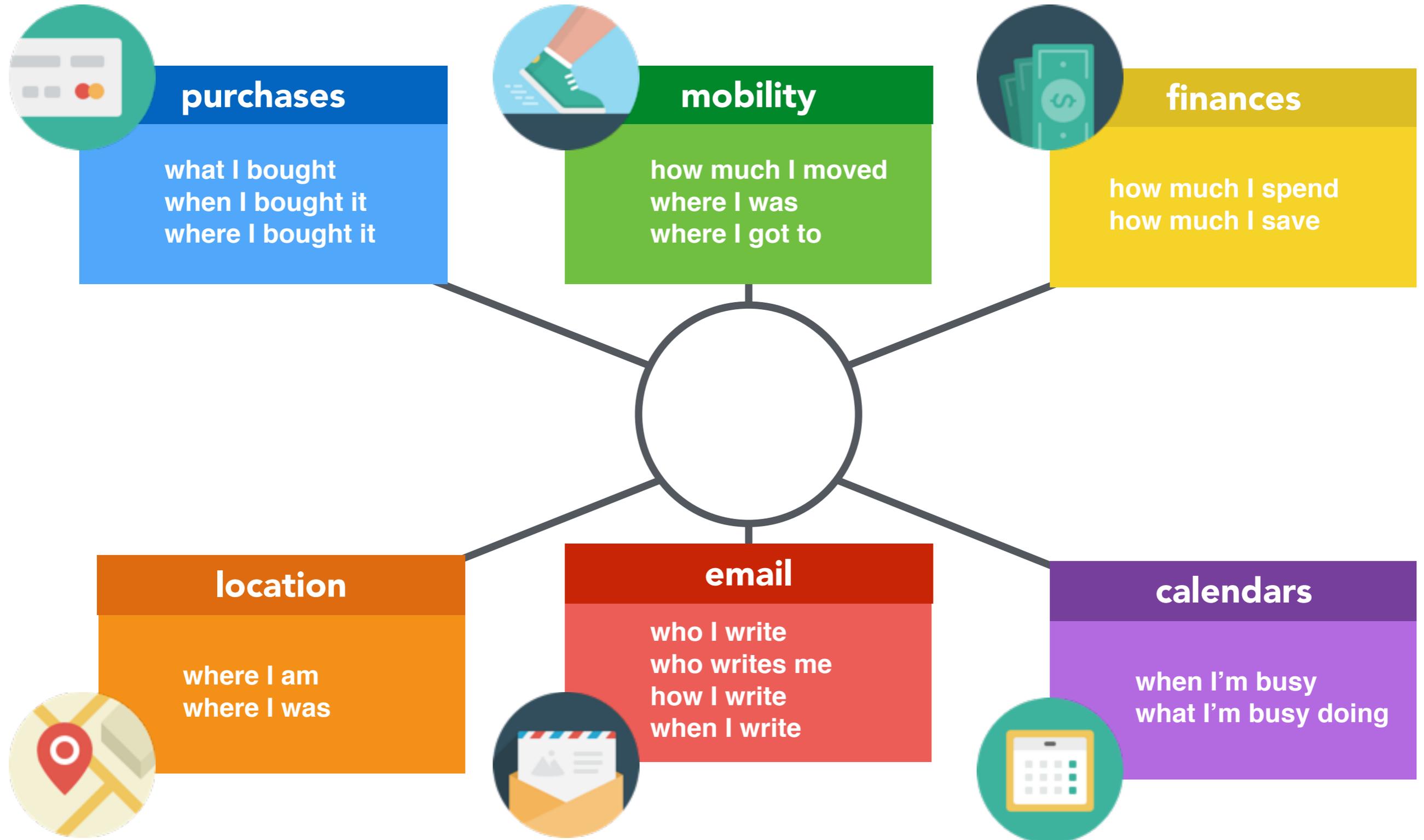
Tanzeem Choudhury et al

# chronic pain

Using personal data traces to manage chronic pain and reduce overmedication



# small data: beyond mobile



# what got me started with **small data**?

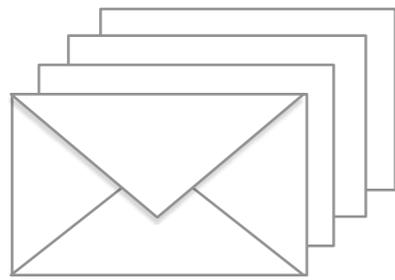
**Gerald & Thelma  
Estrin**



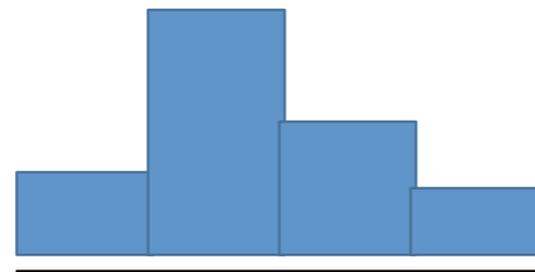
**Gert**



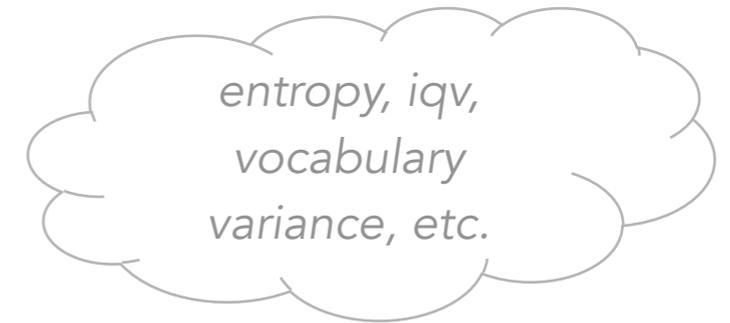
# Beyond Mobile: communication language patterns as small data (cognitive performance, fatigue, impairment)



The goal is to transform text communication...



...into a "bag of words" model (a categorical distribution)...

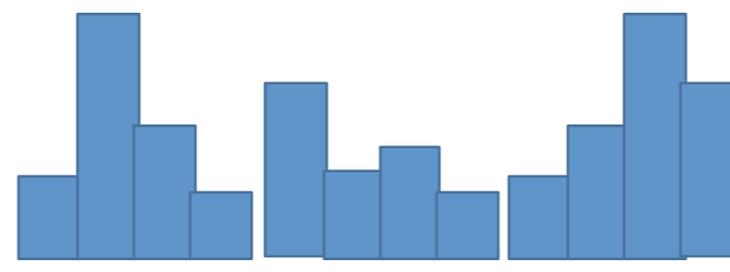


...on which descriptive statistics can be computed.



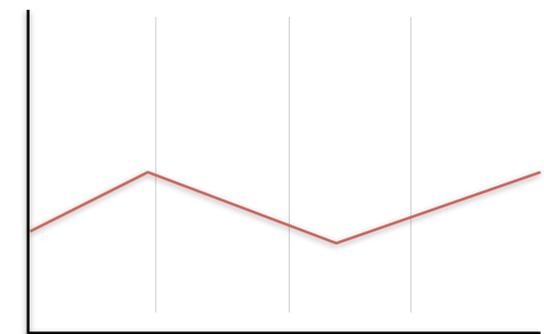
Sept Oct Nov

Since we have a progression of emails over time...



Sept Oct Nov

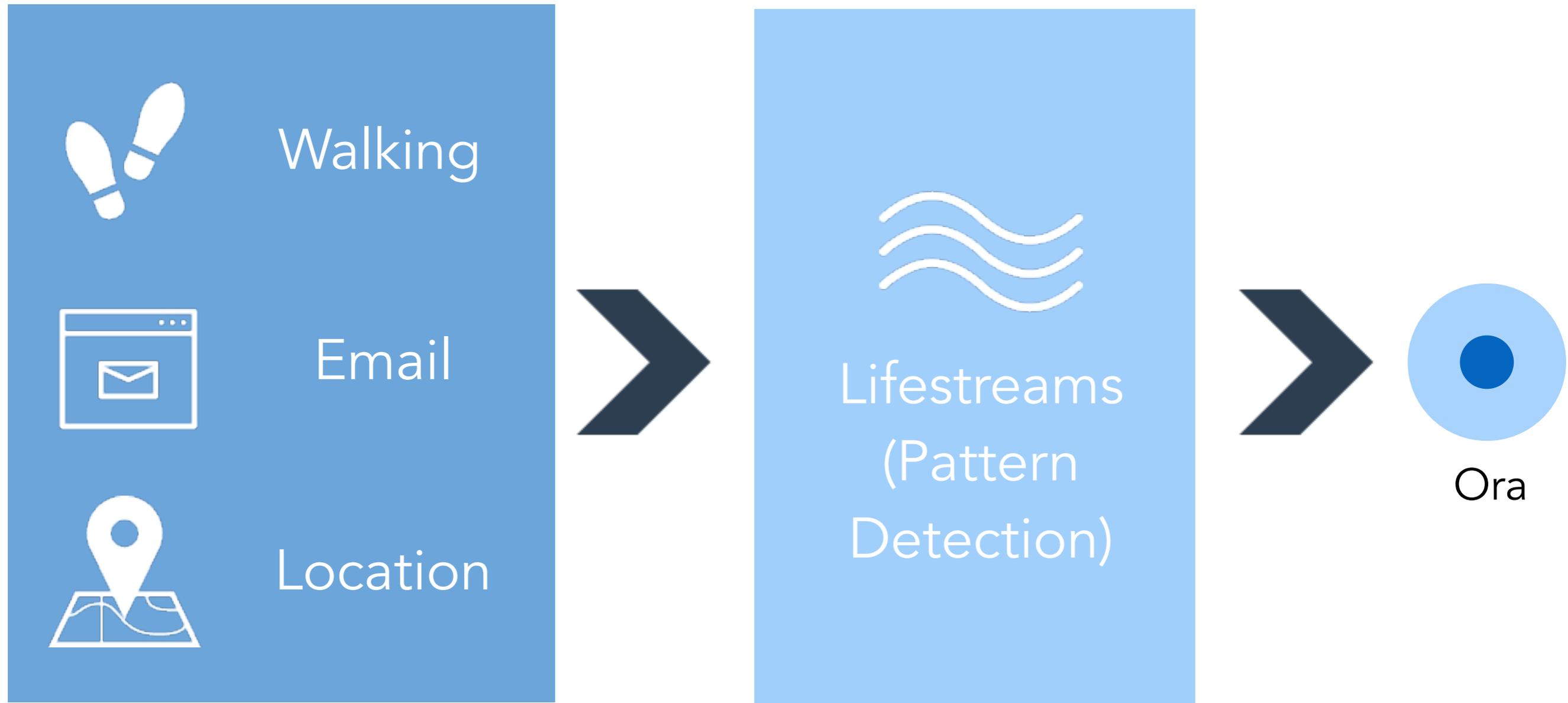
...we can examine how the resulting distributions change...



...and plot the statistics for each time frame, resulting in a time series which can then be correlated against other time series.

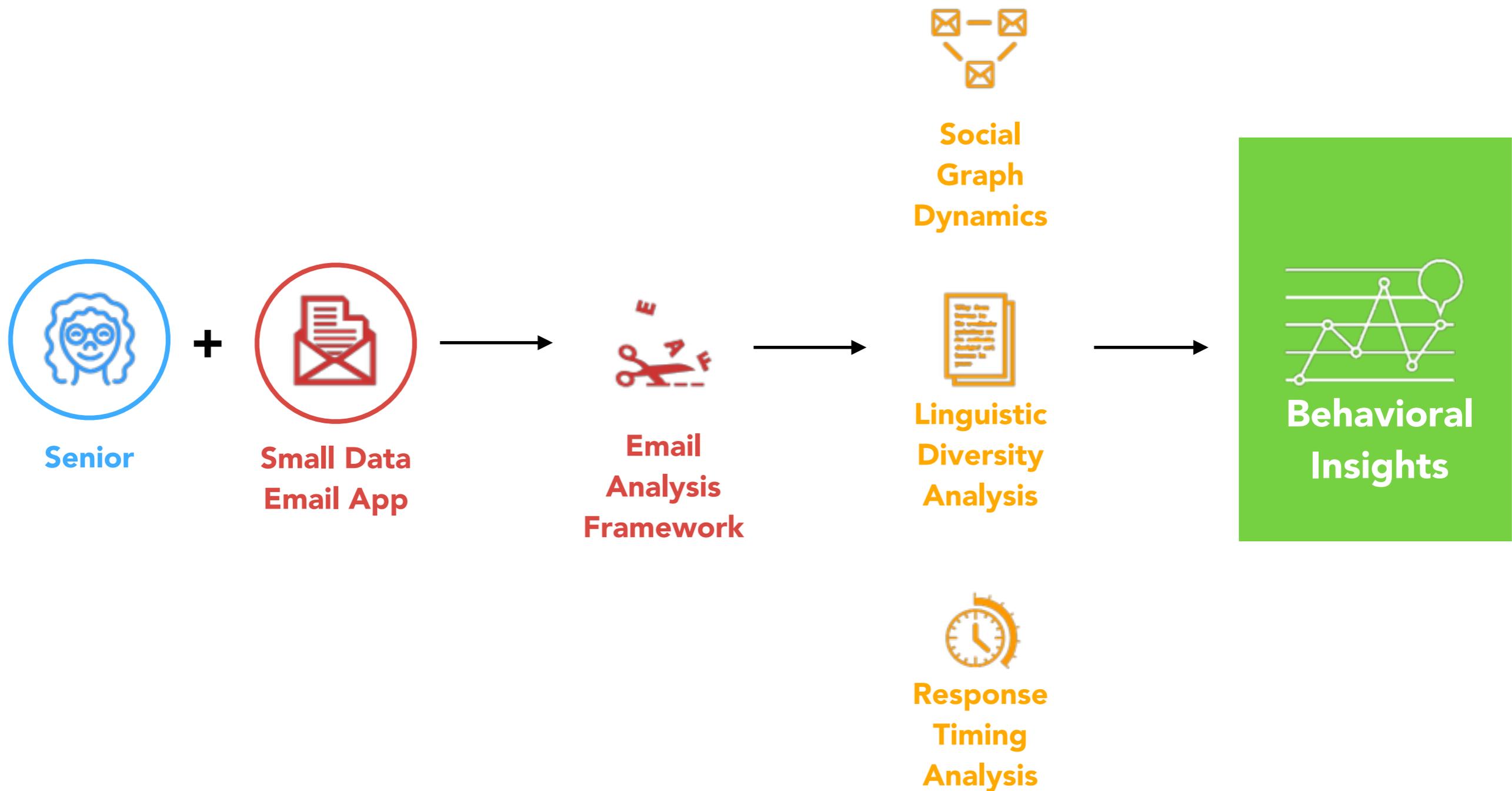
# Ora: selective, shared sensing

share how you are doing, not what you are doing



# aging/cognition

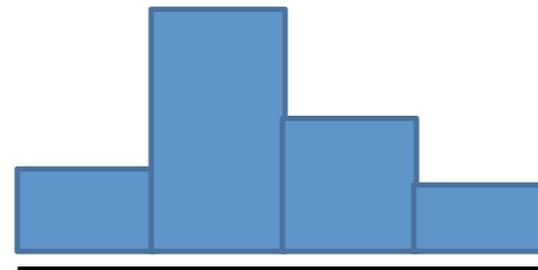
Using language data traces to observe changes in cognitive function



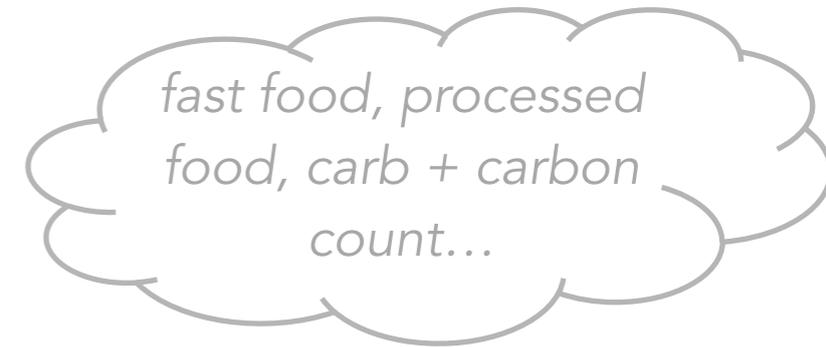
# Beyond Mobile: consumer transactions as small data



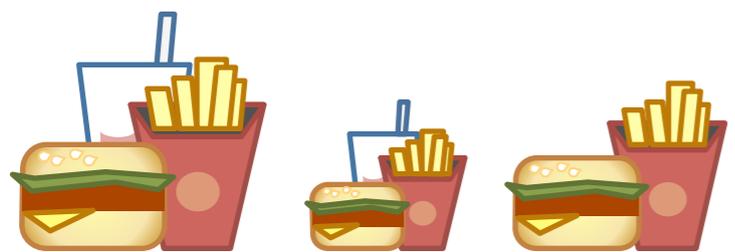
The goal is to transform purchasing patterns...



...into a consumption model (a categorical distribution of restaurant, fast food, drug store, etc. purchases)...

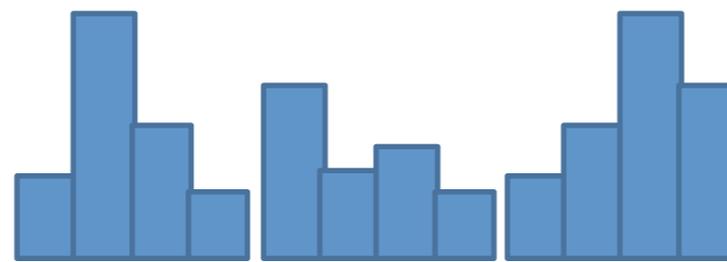


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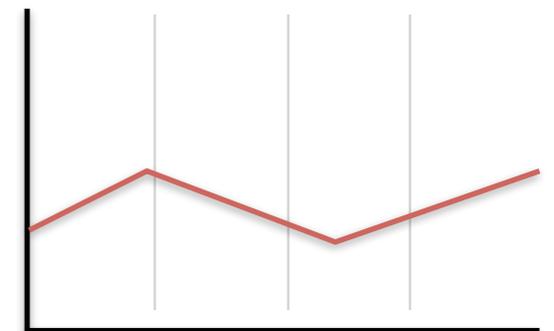
Sept Oct Nov

Since we have a progression of spending patterns over time...



Sept Oct Nov

...we can examine how the resulting distributions change...



...and plot the statistics for each time frame, resulting in a time series which can then be correlated against other time series.

# Pushcart



Pushcart analyzes consumer's online grocery-shopping e-receipts

Coach/clinician can map weekly choices to personal health goals.

No receipt scanning, no apps to install. Once consumer signs up with email address pushcart automatically analyzes purchases week by week

## automated summary to consumer

Pushcart  
May 17, 2014  
Whole Foods Market

### Your Goal

I want to eat more fruits and vegetables (5-7 servings per day)

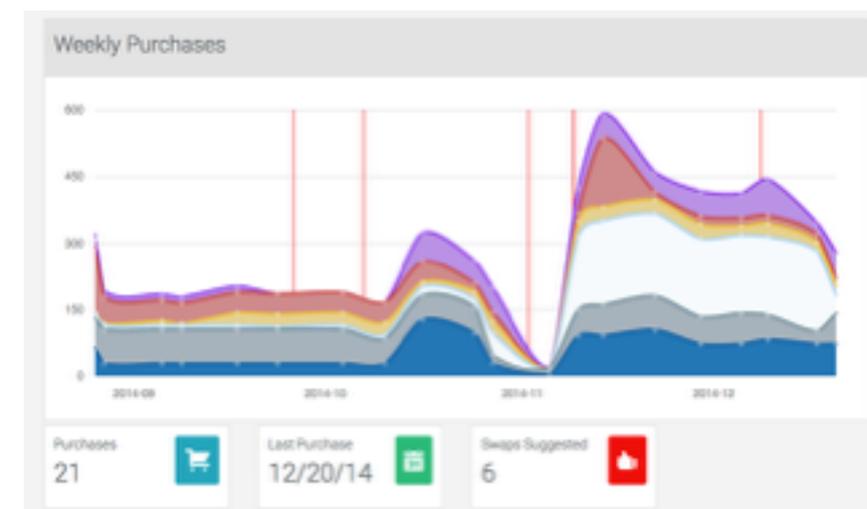
**Your Cart**

30 items      \$147.70

Food Group Breakdown (% of Cart)

Food Group	Percentage	Change
dairy	7.5%	
grains	15%	+7% from last week
veggies	37.5%	
protein (non-dairy)	22.5%	
fruits	10%	-5% from last week
fats	7.5%	
uncategorized	?	

## dashboard for coaches/RDs



## swap suggestions from RD to consumer

Healthy substitution suggestion!

**Pushcart Suggests:**

Next time you buy from Fresh Direct, try replacing your Red Jacket Apple Cider with [Flavored seltzer water](#)

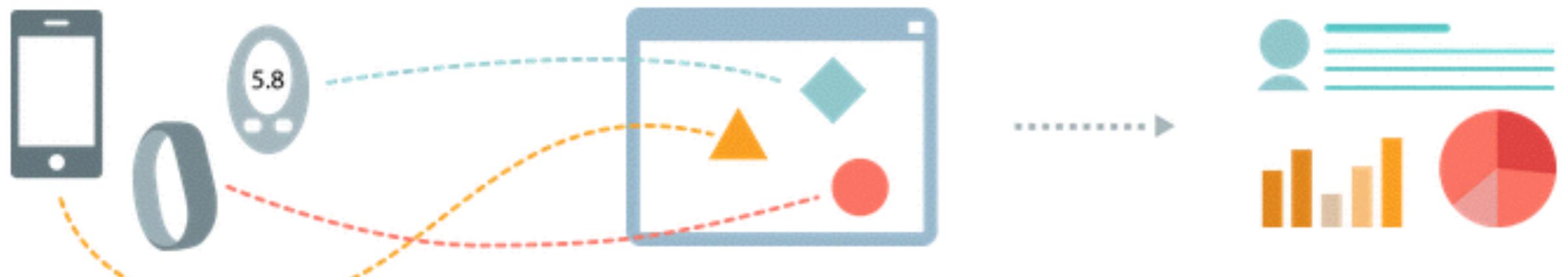
# Critical next steps

- collaborative research studies and data commons ([Sage Bionetworks Bridge and Synapse projects](#))
- standardized clinical representation and aggregate measures ([Open mHealth](#))

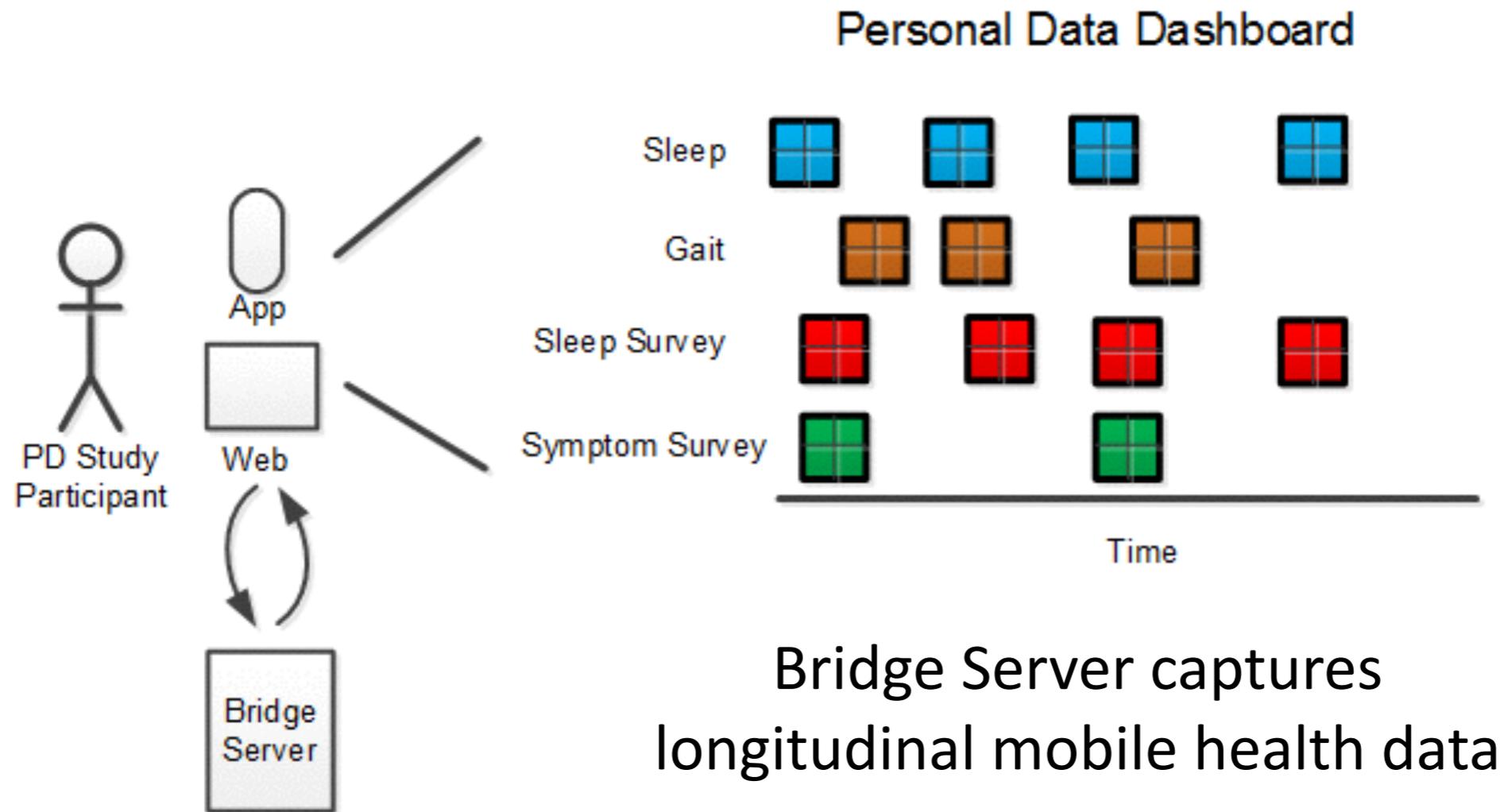
access  
diverse data

clinical  
interpretability and  
interoperability

personalized  
**clinical** insights



# Sage Bionetworks and ResearchKit "Bridge" Citizen Interface Initiative

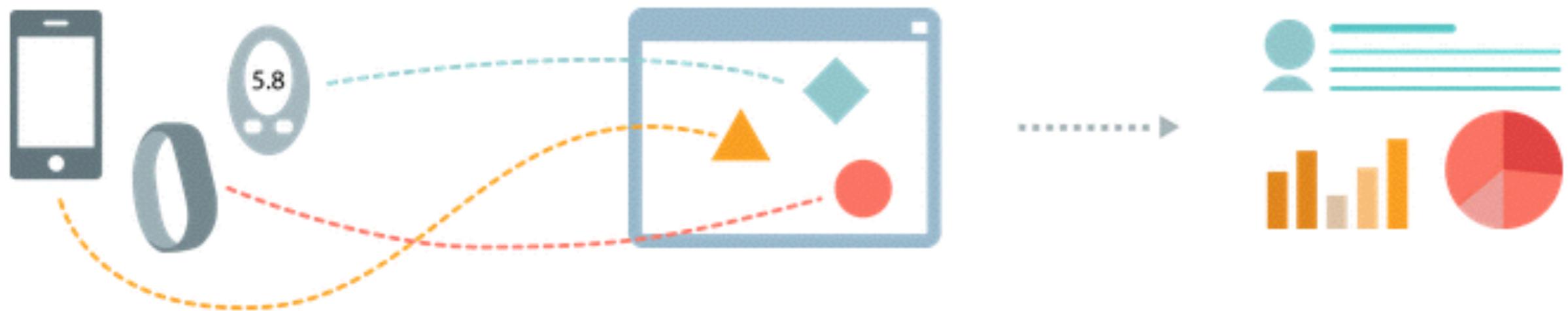


# Open mhealth architecture: community-defined APIs, data schema, to imbue and access digital health data w/ clinical context

access  
diverse data

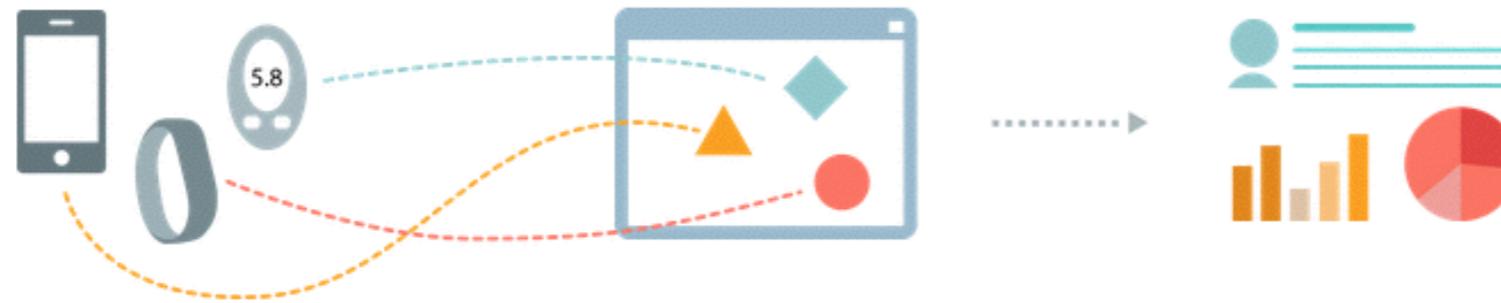
clinical  
interpretability and  
interoperability

personalized  
**clinical** insights



<http://openmhealth.org>

# open mHealth: status



## DSU current features

- Authentication
- Storage
- Filtering
- Data generator and subscriptions

## Shim server:

- Schema support
- Template to create shims to existing APIs
- Unit and integration tests
- Vendor API health status

## Shims to popular apps

- Fitbit
- Jawbone
- Runkeeper
- Withings
- FatSecret
- HealthVault
- Healthkit (library)

## Shims in progress:

- Google Fit
- Misfit
- iHealth
- Moves
- Ginsberg.io



**Join Us**

<https://omhsummit15.eventbrite.com>

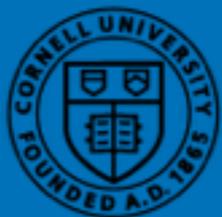
password OMH15

## 2 Year MS in Health Tech @ Jacobs Institute

- Focus on individual and population health
- Technologies and applications for medical monitoring and prediction, chronic disease management, consumer health behavior
- Commercial engagement in course projects and student internships
- Developed in collaboration with leaders from relevant healthcare sectors: Business, Clinical, Research, Entrepreneurial, and with faculty.

**CORNELL  
TECH**

HOME OF THE  
**JACOBS  
INSTITUTE**





# small data lab @ Cornell Tech

Faculty:

**Deborah Estrin, JP Pollak, Daniel Stein**

Technologists-in-Residence:

**Aaron Baum, Michael Carroll, Diana Freed, Lucky Gunasekara**

PhD Students:

**Faisal Alquadoomi, Andy Hsieh, Fabian Okeke, Longqi Yang**

Funding:

**NSF, NIH, AOL, Google, UHG, Pfizer, RWJF, Intel, Cornell Tech**

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