Understanding User Cognition: from Everyday Behavior and Spatial Ability to Code Writing and Review

Yu Huang

University of Michigan

Dec 11, 2019

COLLEGE OF ENGINEERING
COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF MICHIGAN

Break Down the Title

- A standard workday of a software developer

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What could go wrong?
What is currently holding us back?

Break Down the Title

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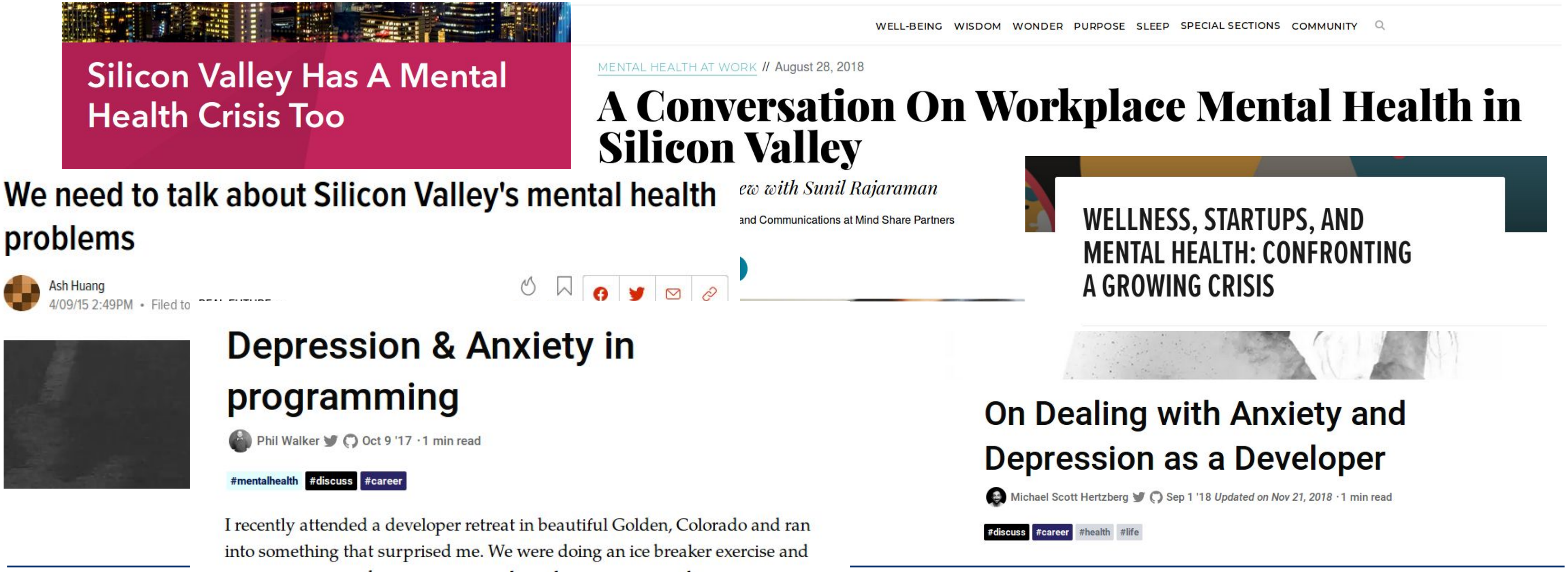

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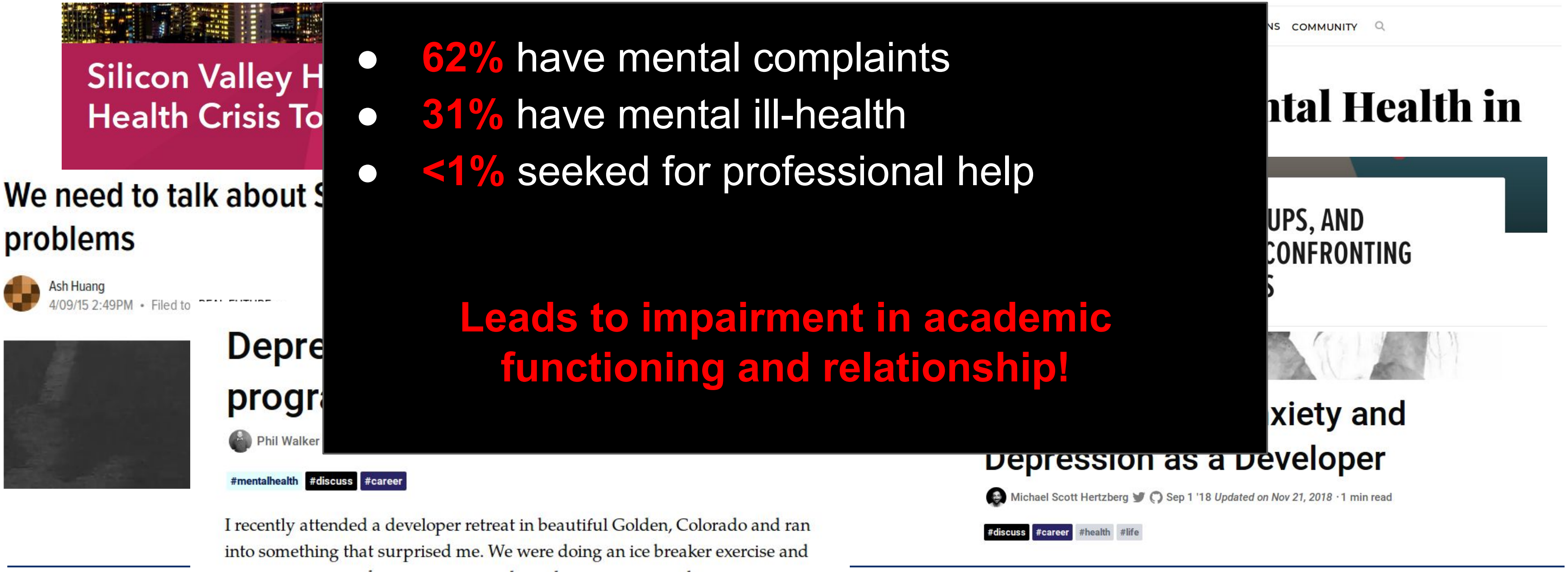

- **62%** have mental complaints
- **31%** have mental ill-health
- **<1%** seeked for professional help

Leads to impairment in academic functioning and relationship!

Break Down the Title

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- **How can we be more effective and efficient in programming? What are the cognitive processes of programming? What affects our decisions in programming?**
  - Traditional research solutions: self-reporting
    - **Unreliable**

International Journal for Quality in Health Care 1999; Volume 11, Number 3: pp. 187–192

Evidence of self-report bias in assessing adherence to guidelines

HAN LOMAS[2] AND DENNIS ROSS-DEGNAN[1]

Self-Reports in Organizational Problems and Prospec

Philip M. Podsakoff
Dennis W. Organ
Indiana University

Self-reports figure prominently in organizational and research, but there are several problems associated w This article identifies six categories of self-reports and d problems as common method variance, the consistency cial desirability. Statistical and post hoc remedies and dural methods for dealing with artifactual bias are prese uated. Recommendations for future research are also offered.

Faking It: Social Desirability Response Bias in Self-report Research

Australian Journal of Advanced Nur
Volume 25 Issue 4 (June/Aug 2008)

van de Mortel, Thea F[1]

Abstract: Objective: The tendency for questionnaires is called socially desirab creating false relationships or obscuring scales can be used to detect, minimise, questionnaire- based research. The air related studies that used questionnaire

Journal of Business and Psychology, Vol. 17, No. 2, Winter 2002 (©2002)

UNDERSTANDING SELF-REPORT BIAS IN ORGANIZATIONAL BEHAVIOR RESEARCH

Stewart I. Donaldson
Claremont Graduate University
Elisa J. Grant-Vallone
California State University, San Marcos

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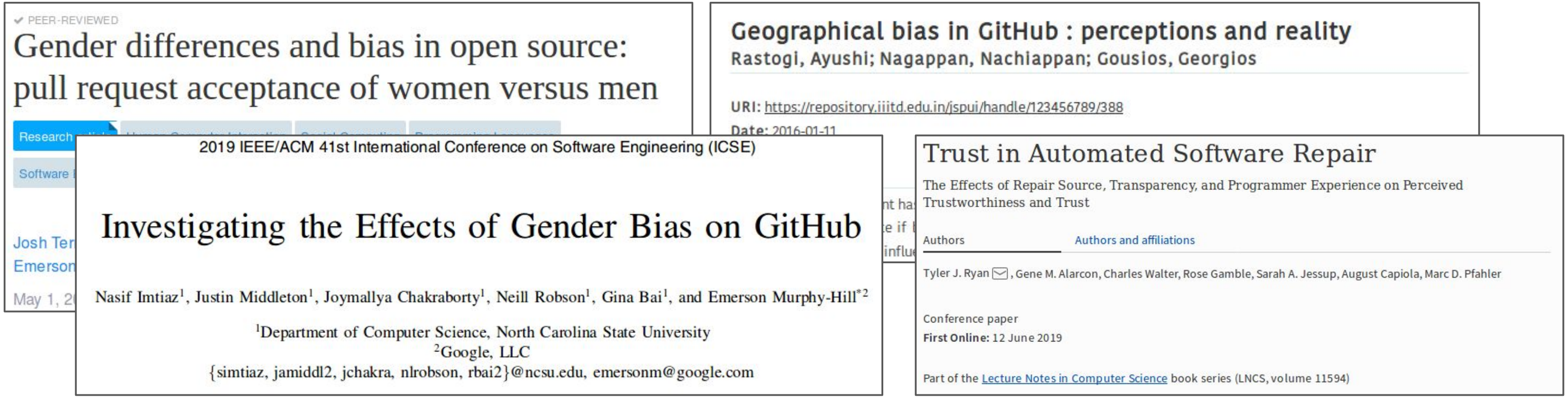
- **How can we be more effective and efficient in programming? What are the cognitive processes of programming? What affects our decisions in programming?**
  - Traditional research solutions: **Unreliable** self-reporting
  - **Observed potential bias** of non-functional factors



PEER-REVIEWED

Gender differences and bias in open source: pull request acceptance of women versus men

Geographical bias in GitHub : perceptions and reality

Rastogi, Ayushi; Nagappan, Nachiappan; Gousios, Georgios

URI: https://repository.iiitd.edu.in/jspui/handle/123456789/388

Date: 2016-01-11

2019 IEEE/ACM 41st International Conference on Software Engineering (ICSE)

Investigating the Effects of Gender Bias on GitHub

Nasif Imtiaz[1], Justin Middleton[1], Joymallya Chakraborty[1], Neill Robson[1], Gina Bai[1], and Emerson Murphy-Hill*[2]

[1]Department of Computer Science, North Carolina State University

[2]Google, LLC

{simtiaz, jamiddl2, jchakra, nlrobson, rbai2}@ncsu.edu, emersonm@google.com

Trust in Automated Software Repair

The Effects of Repair Source, Transparency, and Programmer Experience on Perceived Trustworthiness and Trust

Authors | Authors and affiliations

Tyler J. Ryan, Gene M. Alarcon, Charles Walter, Rose Gamble, Sarah A. Jessup, August Capiola, Marc D. Pfahler

Conference paper

First Online: 12 June 2019

Part of the Lecture Notes in Computer Science book series (LNCS, volume 11594)

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Lack a **foundational understanding**

Desired properties for this proposal

- Bring all the concerns together:

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  - **Objective** measures
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  - **Higher-level** programming tasks
    - Data structures; code writing; code reviews
  - **Generalizability** across different user groups
    - How is productivity mitigated by group difference

Insights

- It is now **possible** to conduct studies that acquire **objective data** to understand the underlying **cognitive processes** of certain tasks
  - Mobile crowdsensing (MCS); medical imaging; eye tracking

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- We can adapt **scientific approaches and concepts** from **other domains** to assist our investigation and understanding of certain tasks
  - Social anxiety; spatial ability; creative writing
- It is now **possible** to study historically-subjective factors by designing rigorous **controlled experiments**
  - Contrast-based experiments

Thesis Statement

It is possible to meaningfully and objectively measure user cognition to understand the mental status, role of spatial ability, fundamental processes and stereotypical associations in certain software engineering activities by combining mobile crowdsensing (MCS), medical imaging, and eye tracking.

Proposal Overview: Four Components

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Monitoring mental health using mobile crowdsensing

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Understanding the neural representation of data structures

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Understanding the neural representation of data structures

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Proposal Overview: Four Components

- Monitoring mental health using mobile crowdsensing
- Understanding the neural representations of data structures
- Comparing prose writing and code writing
- Understanding bias in code reviews

Monitoring Mental Health Using Mobile Crowdsensing (MCS)

- Can we monitor humans' mental health status objectively via their everyday behaviors in a natural setting?

Monitoring Mental Health Using Mobile Crowdsensing

- ***Sensus***: Cross-platform, general MCS mobile application for human-subject studies
- ***A MCS-based framework***: understanding the relationship between human behaviors and mental health status

Sensus: Cross-Platform, General MCS

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1. Target **heterogeneous** mobile infrastructures

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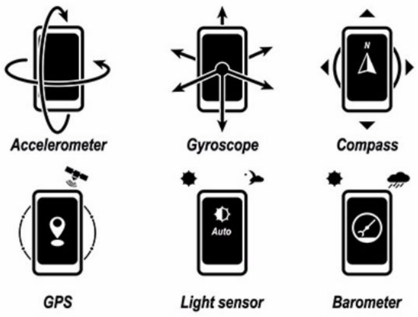
2. Support a **wide range** of MCS-based human studies



Sensus: Cross-Platform, General MCS

1. Target **heterogeneous** mobile infrastructures
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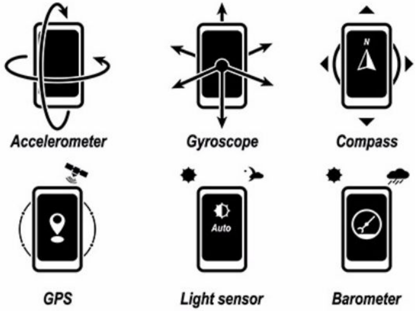
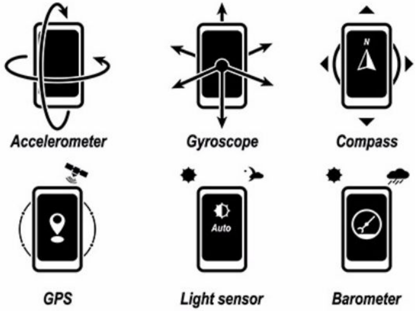
3. **Eliminate** the need for **programming background**



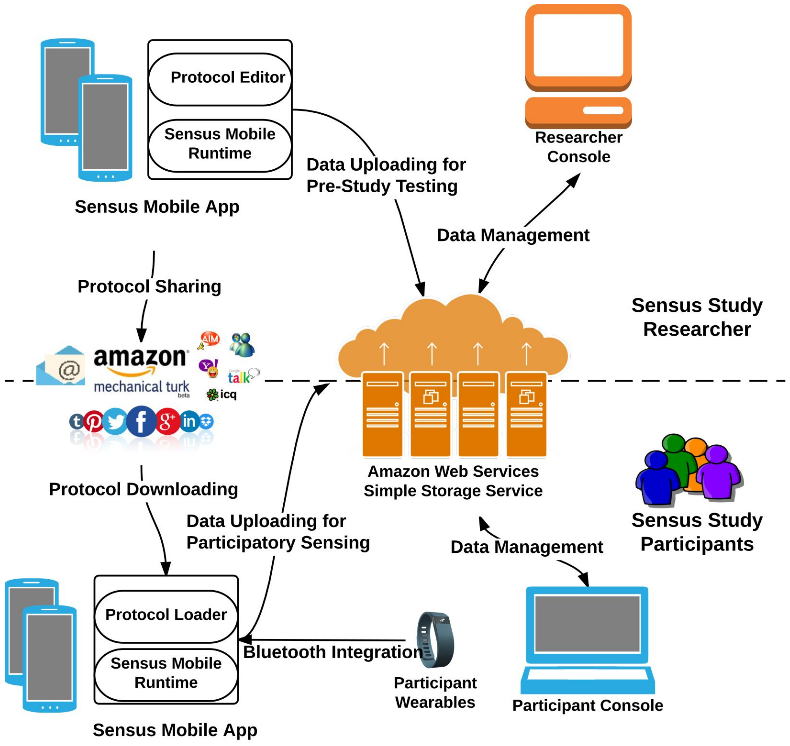
Sensus: Cross-Platform, General MCS

1. Target **heterogeneous** mobile infrastructures
2. Support a **wide range** of MCS-based human studies
3. **Eliminate** the need for **programming background**
4. Rely on **readily-available** mobile devices and cloud storage



Architecture of *Sensus*: High-Level Design

- High-level design of ***Sensus***
  - Cloud storage
    - Amazon AWS S3



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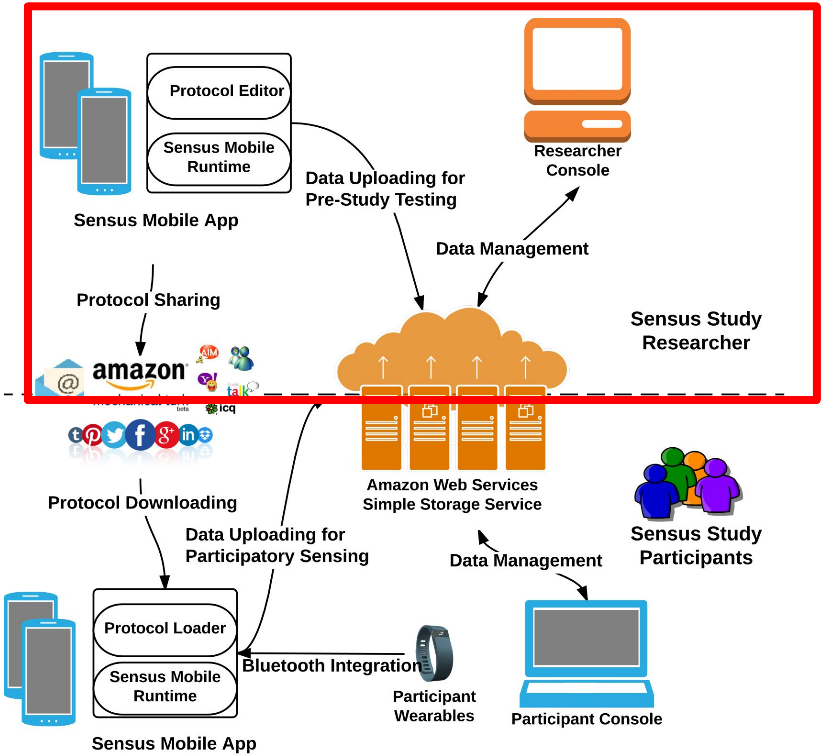

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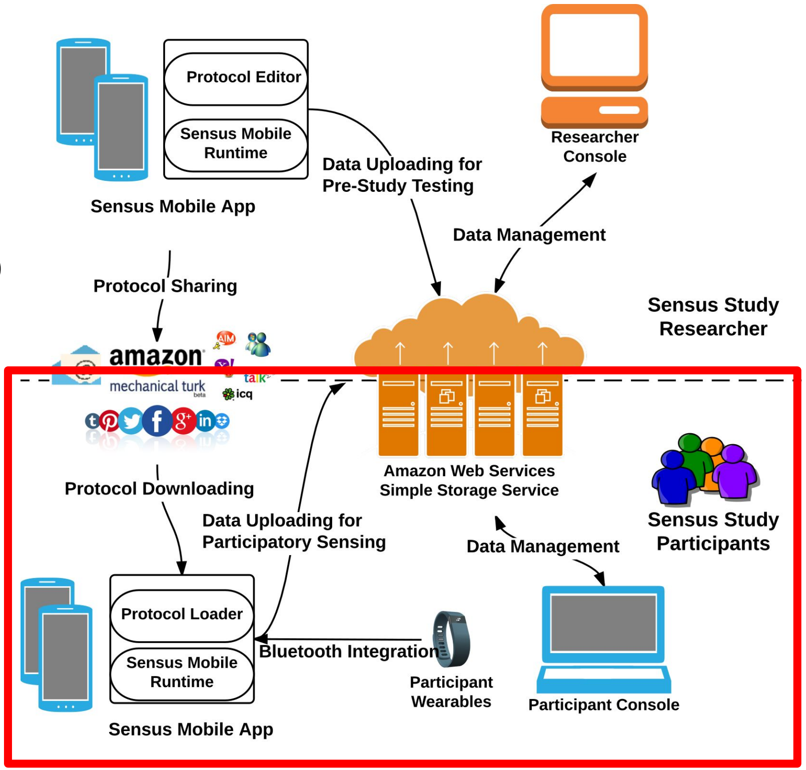
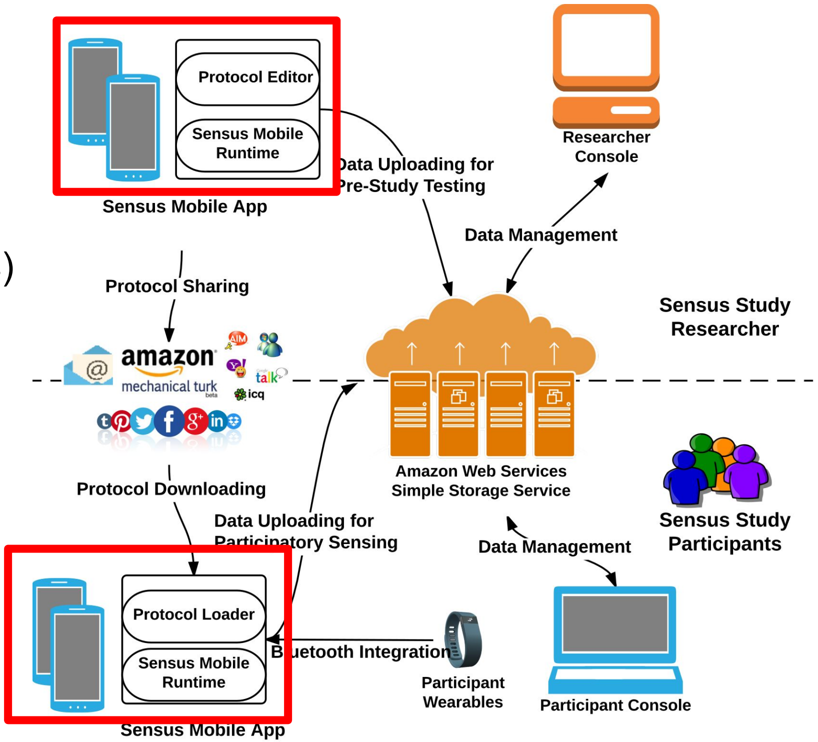


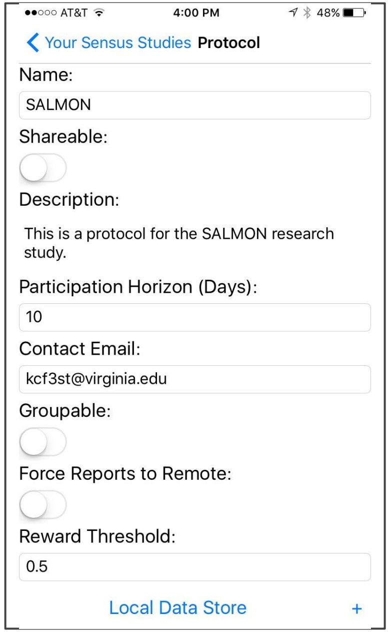
Architecture of *Sensus*: High-Level Design

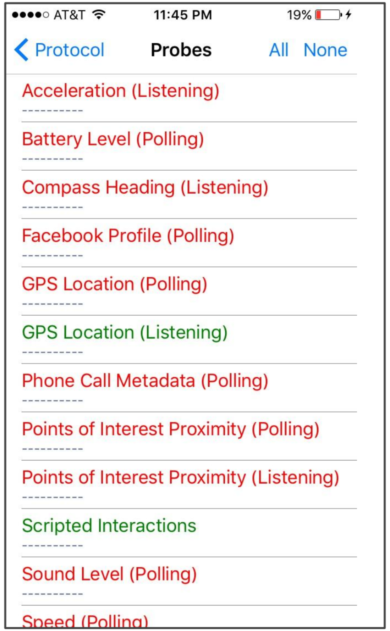
- High-level design of ***Sensus***
  - Cloud storage
    - Amazon AWS S3
  - Users
    - Researchers (study designers)
    - Participants
  - Protocols
    - Sensing plans
      - Probes
      - Surveys
      - Customized scheduling
    - JSON file

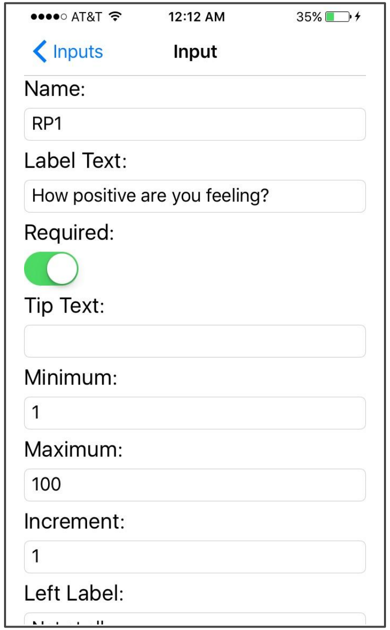


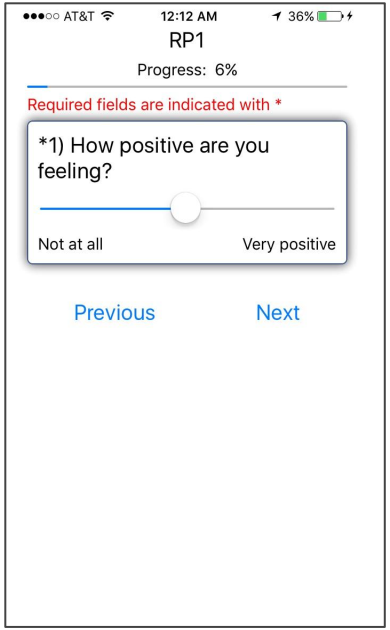
Sensus: An Example Case

- A *Sensus* protocol example (iOS)









Sensus: Metrics

- ***Sensus*** can be used in real-world scalable human-subjects studies
  - Release ***Sensus***
  - Conduct real-world studies using ***Sensus***
- ***Sensus*** is easy for researchers without engineering background to use
  - Interview researchers who used ***Sensus*** but without engineering backgrounds

Sensus: Preliminary Results

- Apple App Store
- Google Play Store: **500+**
- **> 200** subjects in research studies

*Sensus development website: https://predictive-technology-laboratory.github.io/sensus/index.html
*For more design details, please refer to our paper: *Haoyi Xiong, Yu Huang, Laura E Barnes, and Matthew S Gerber.* [Sensus: a Cross-Platform, General-Purpose System for Mobile Crowdsensing in Human-Subject Studies.]() *In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, UbiComp '16, pages 415–426.*

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    - A desktop or web-based protocol design tool would be useful

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Monitoring Mental Health Using Mobile Crowdsensing

- **Recall: Can we monitor humans' mental health status objectively via their everyday behaviors in a natural setting?**
  - We already have an MCS mobile application: ***Sensus***

Monitoring Mental Health Using Mobile Crowdsensing

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- **A MCS-based framework**: understanding the relationship between human behaviors and mental health status

A MCS-based Framework: Understanding Behaviors and Mental Health Status

- Fine-grained human behaviors vs. Mental health status
  - Objective measures from ***Sensus***
    - **GPS**: mobility patterns with semantics
    - **Accelerometer (3-axis)**: micro-level motions
    - **Smartphone metadata**: call and text logs

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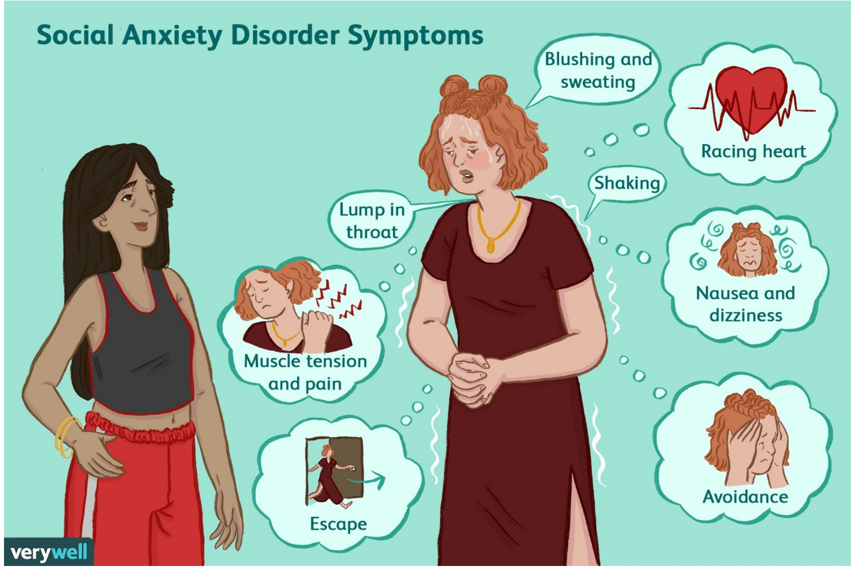
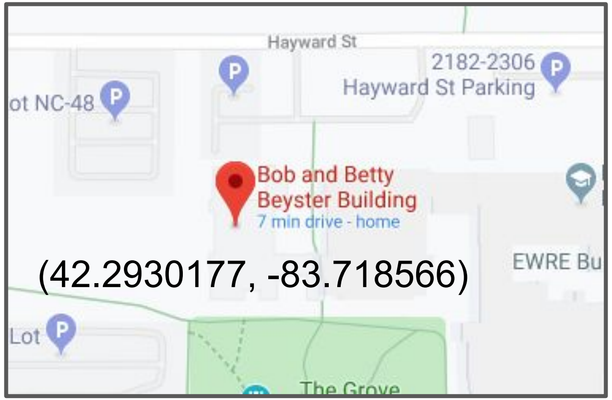
  - Social anxiety levels: SIAS score (0-80)



ACHA American College Health Association
advocacy•education•research

A MCS-based Framework: Understanding Behaviors and Mental Health Status

- Semantics of locations
  - (42.2930177, -83.718566) => School
  - Point of Interest (POI) information obtained from *Foursquare*
  - Clustering spatially and temporally
  - Categories of location semantics

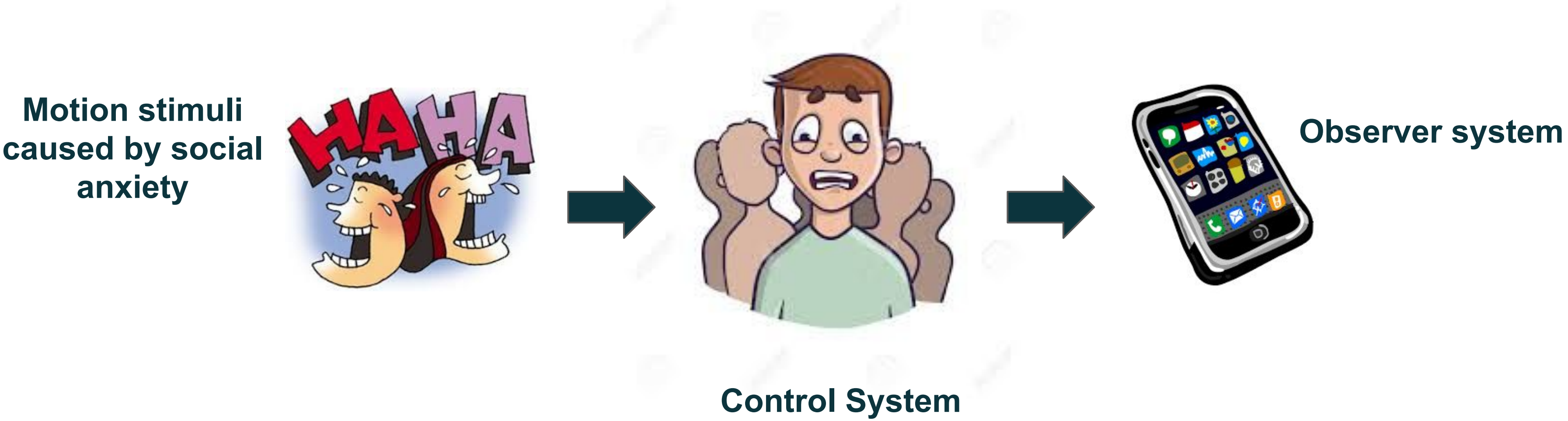


FOURSQUARE

{
Education.
Bob and Betty Beyster Building.
Department of Computer Science and Engineering.
University of Michigan.
}

A MCS-based Framework: Understanding Behaviors and Mental Health Status

- Semantics of locations
- Micro-level behaviors (behavioral dynamics)
    - Linear dynamic system (LDS)



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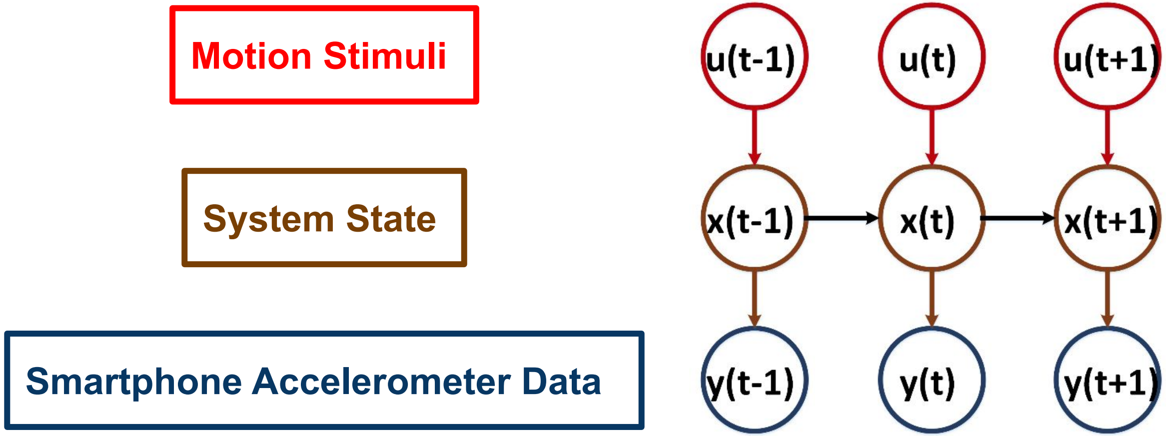

$$\begin{cases} \| u(\bullet) \|_{l0} \leq k \\ |u(t)| \leq 1 \qquad \forall t \\ \Sigma_t \| CA^t B \|_1 \leq \mu \\ x(t+1) = Ax(t) + Bu(t) \\ y(t) = Cx(t) + N \end{cases}$$

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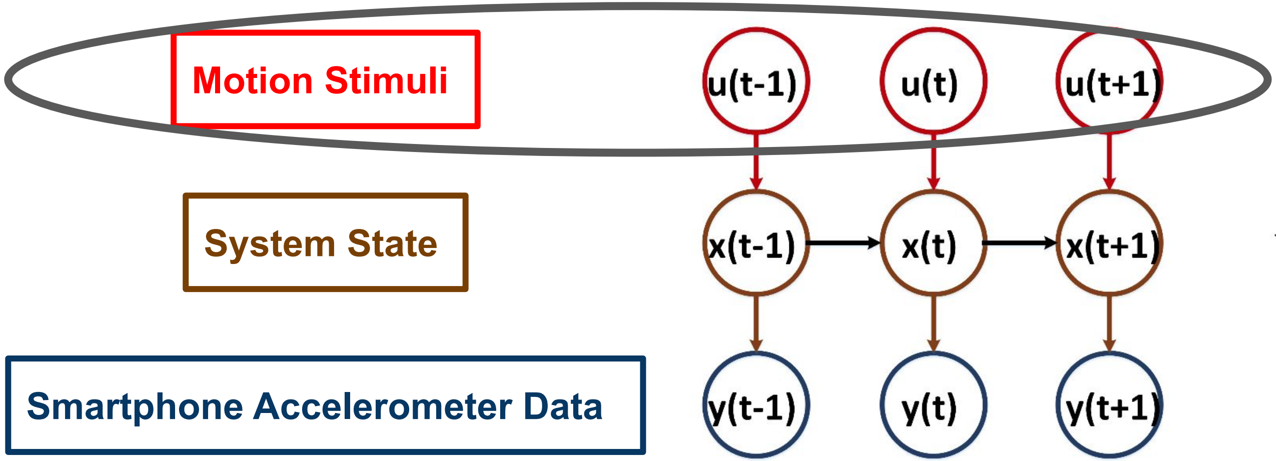

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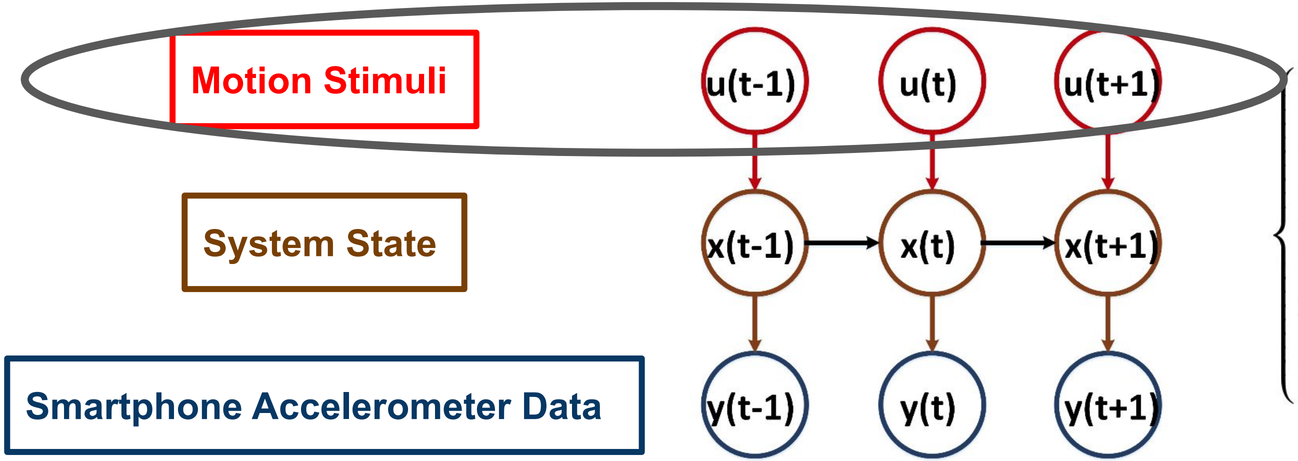

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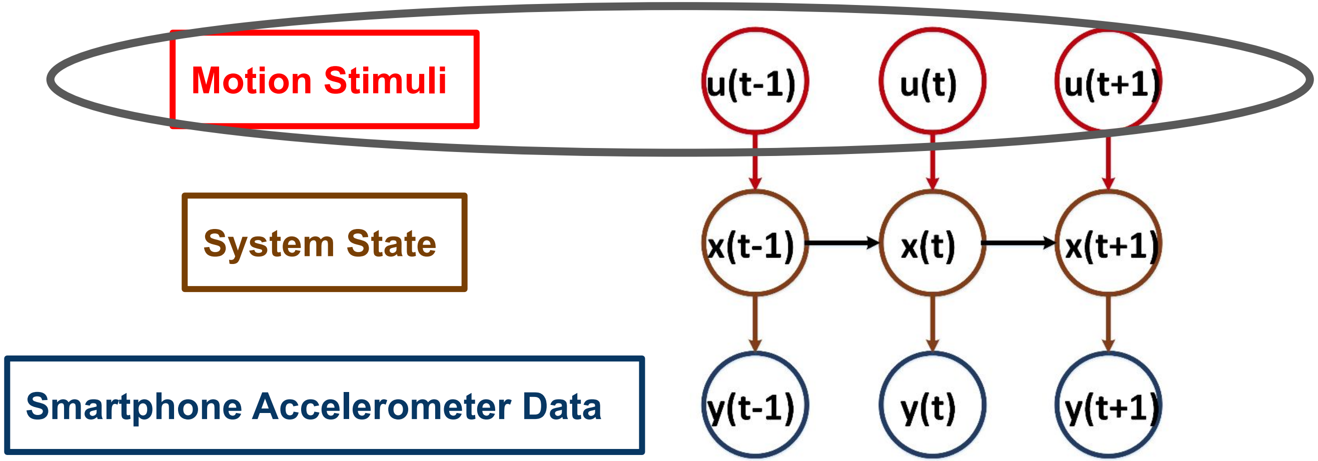
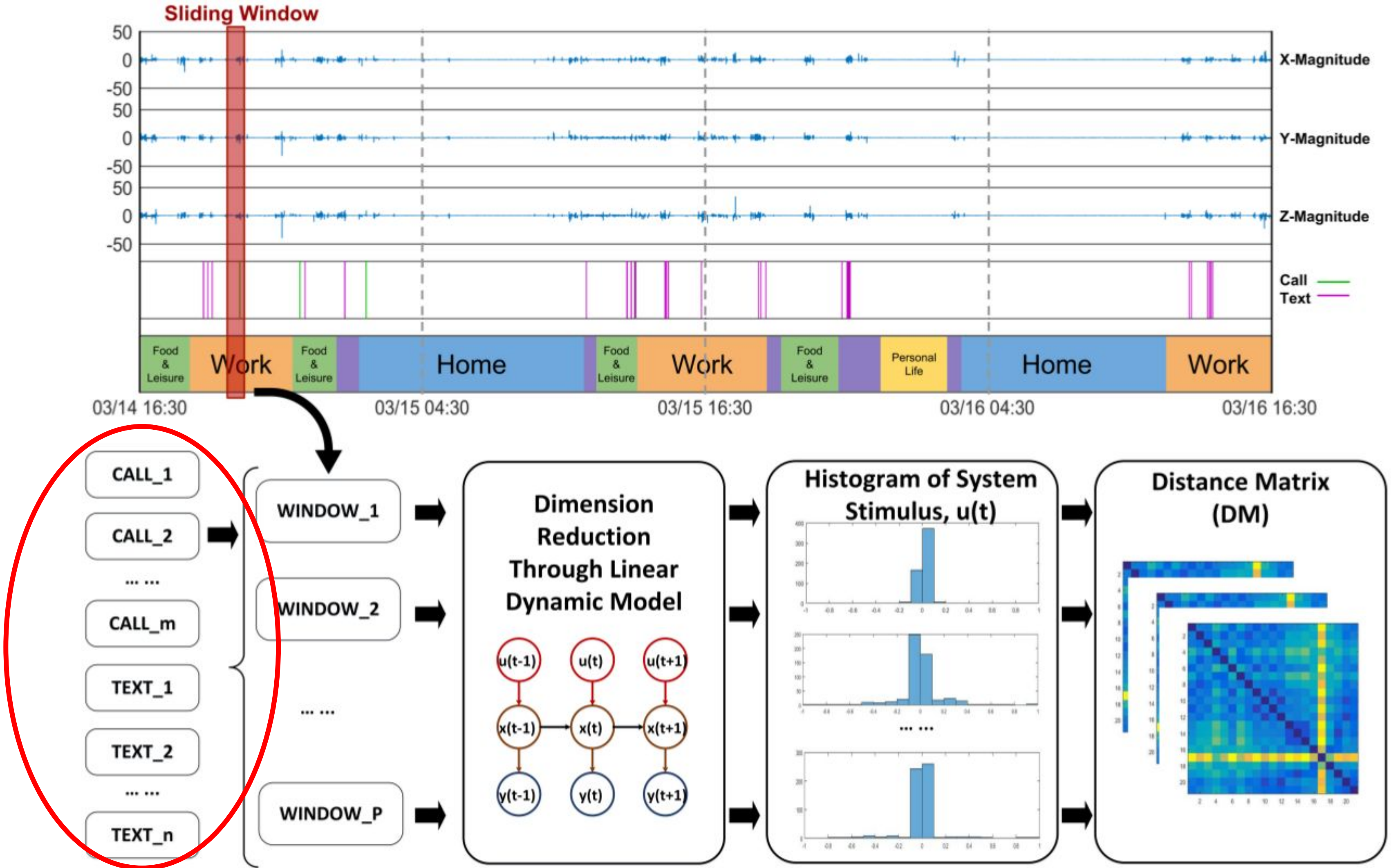


Dimension Reduction

$Y_{(3xT)} \Rightarrow U_{(1xT)}$

A MCS-based Framework: Understanding Behaviors and Mental Health Status

- The architecture of the MCS-based framework


Sliding Window
X-Magnitude
Y-Magnitude
Z-Magnitude
Call
Text
Food & Leisure
Work
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Personal Life
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03/15 16:30
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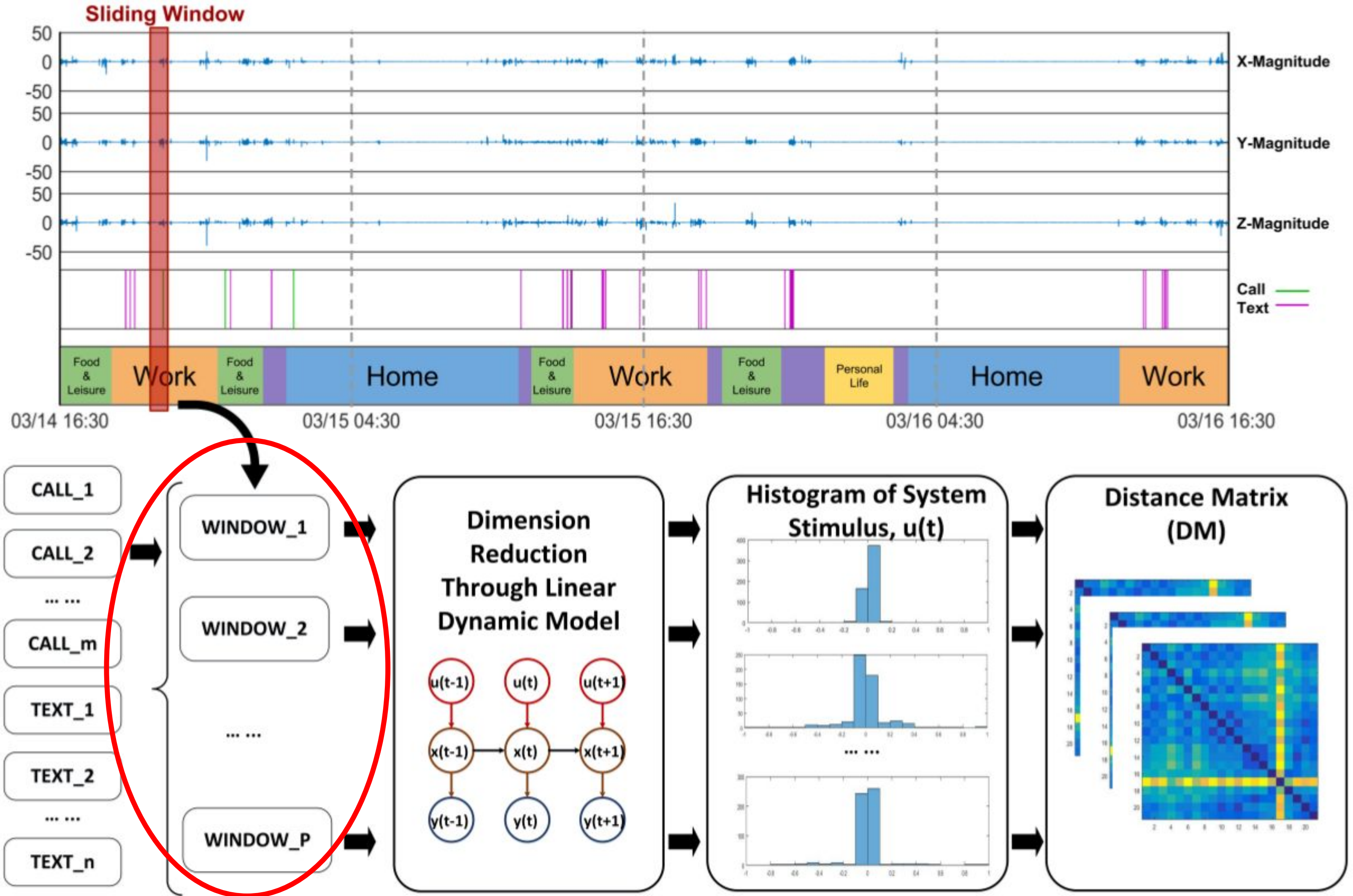
CALL_2
CALL_m
TEXT_1
TEXT_2
TEXT_n
WINDOW_1
WINDOW_2
WINDOW_P
Dimension Reduction Through Linear Dynamic Model
u(t-1)
u(t)
u(t+1)
x(t-1)
x(t)
x(t+1)
y(t-1)
y(t)
y(t+1)
Histogram of System Stimulus, u(t)
Distance Matrix (DM)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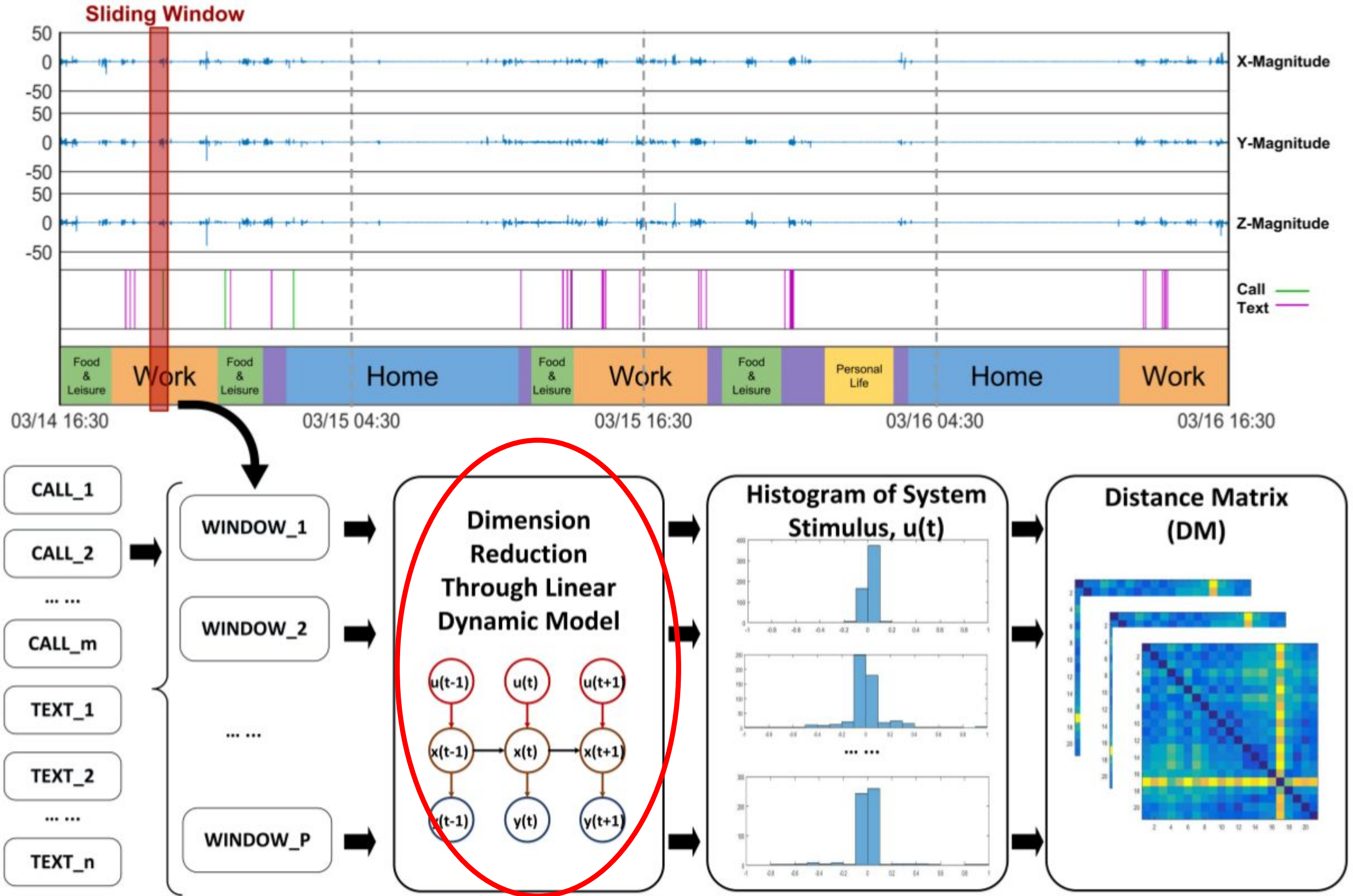
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WINDOW_P
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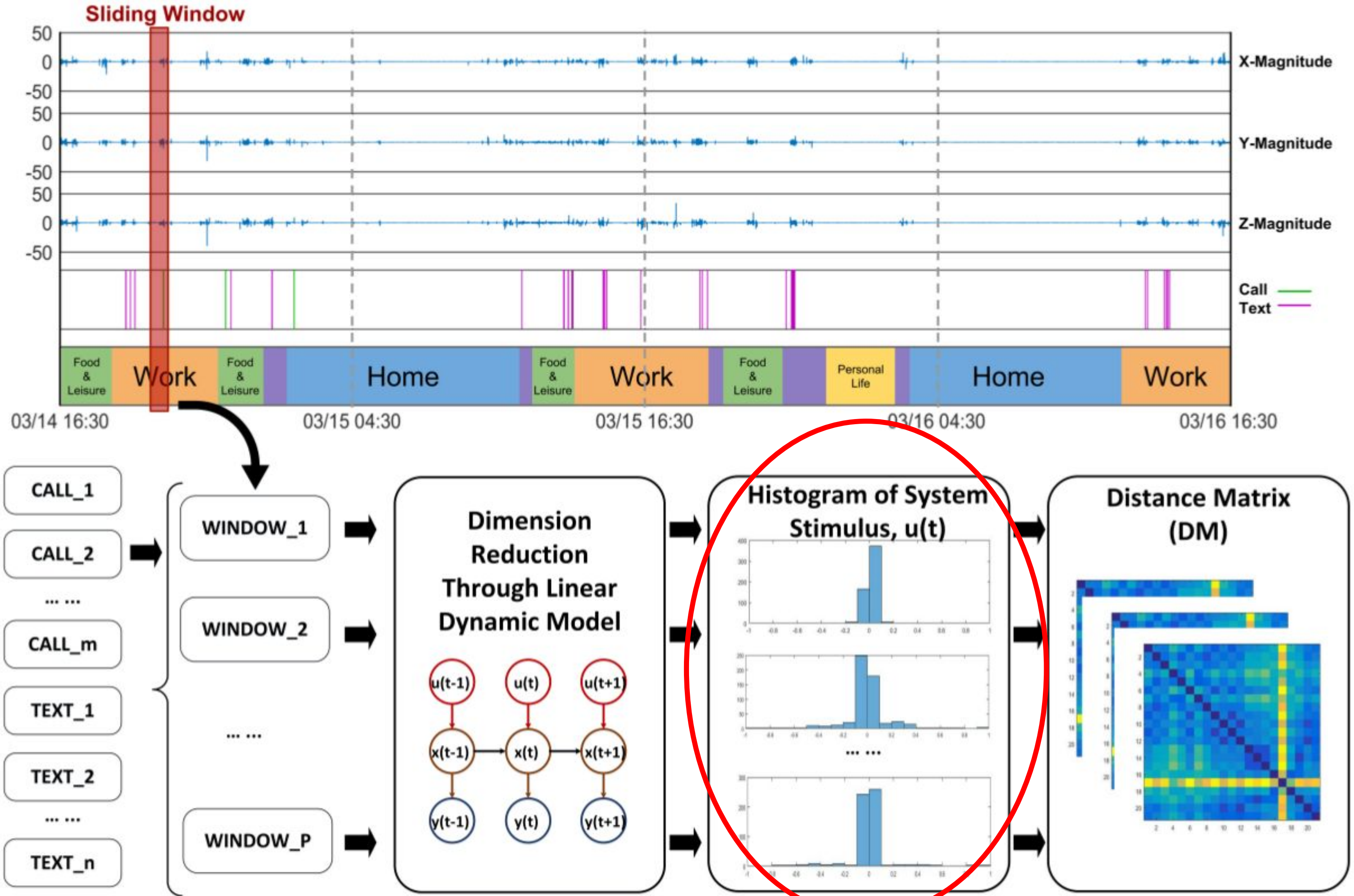
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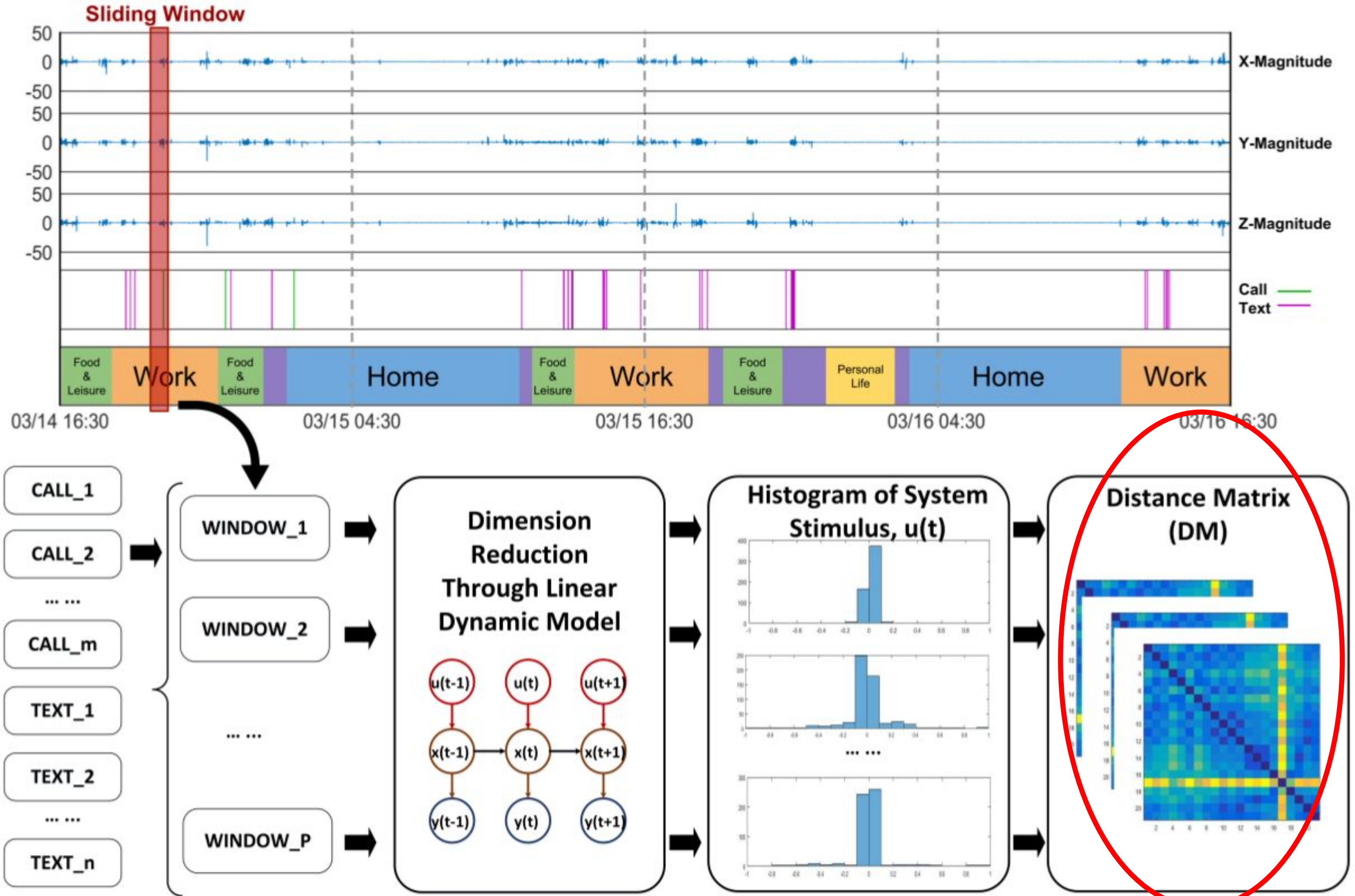
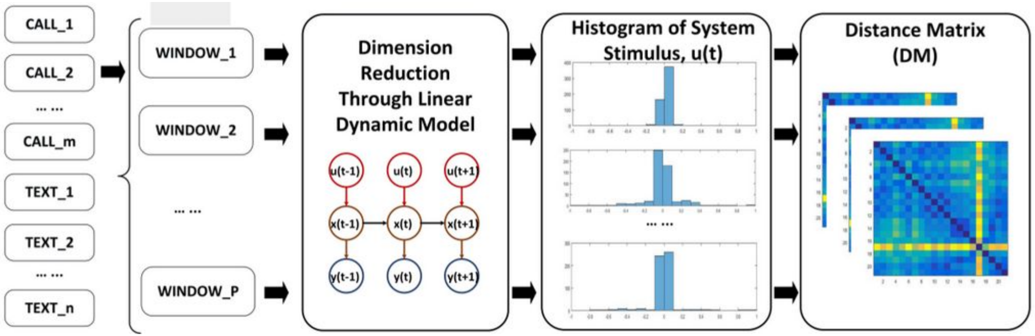
WINDOW_1
WINDOW_2
... ...
WINDOW_P
Dimension Reduction Through Linear Dynamic Model
u(t-1)
u(t)
u(t+1)
x(t-1)
x(t)
x(t+1)
y(t-1)
y(t)
y(t+1)
Histogram of System Stimulus, u(t)
... ...
Distance Matrix (DM)


Sliding Window
X-Magnitude
Y-Magnitude
Z-Magnitude
Call
Text
Food & Leisure
Work
Home
Personal Life
03/14 16:30
03/15 04:30
03/15 16:30
03/16 04:30
03/16 16:30
CALL_1
CALL_2
... ...
CALL_m
TEXT_1
TEXT_2
... ...
TEXT_n
WINDOW_1
WINDOW_2
... ...
WINDOW_P
Dimension Reduction Through Linear Dynamic Model
u(t-1)
u(t)
u(t+1)
x(t-1)
x(t)
x(t+1)
y(t-1)
y(t)
y(t+1)
Histogram of System Stimulus, u(t)
Distance Matrix (DM)

A MCS-based Framework: Understanding Behaviors and Mental Health Status

- Feature extraction



Term	Definition
Call_Proportion	The proportions of phone calls at different locations
Text_Proportion	The proportions of text messages at different locations
$\overline{FAC_1}$	The average of the mean values of all distance matrices ($DM(i)$) belonging to a subject
$\overline{FAC_2}$	The average of the standard deviations of all distance matrices ($DM(i)$) belonging to a subject
MC	The metric for a phone call event
MT	The metric for a text message event

A MCS-based Framework: Metrics

- In real-world human-subjects studies, we can objectively measure humans’ behaviors in a natural setting
- From the objectively collected data, we can extract meaningful features
- We can find features that have a significant correlation with mental health status ($p<0.05$)

A MCS-based Framework: Preliminary Results

- Human study of 52 participants
  - ***Sensus***
  - Duration: 14 days
  - SIAS: mean = 35.02, std = 12.10
- Correlations between behavioral dynamics and social anxiety levels under different social contexts

	Call (MC)		Text (MT)	
Matrix feature	Pearson r	p-value	Pearson r	p-value
$\overline{FAC_1}$	**0.2867**	**0.0457**	0.1961	0.1634
$\overline{FAC_2}$	**0.3041**	**0.0336**	0.2342	0.0946

A MCS-based Framework: Preliminary Results

- Correlations between behavioral dynamics and social anxiety levels under different social contexts

	Call_Proportion				Text_Proportion			
Location	Pearson r	p-value	$\bar{x}$	σ	Pearson r	p-value	$\bar{x}$	σ
Work	-0.1806	0.2142	0.0935	0.1074	-0.2511	0.0725	0.1441	0.1040
Home	**0.3983**	**0.0045**	0.3868	0.2484	**0.4059**	**0.0028**	0.3989	0.2128
Food & leisure	-0.2342	0.1053	0.1188	0.1551	-0.0882	0.5340	0.1412	0.1423
Personal life	0.1234	0.3982	0.0138	0.0346	**-0.2917**	**0.0359**	0.0166	0.0228
Transition	-0.0715	0.6141	0.3200	0.1812	-0.0707	0.6045	0.2381	0.1153

*Refer to the paper for more details: *Jiaqi Gong, Yu Huang, Philip I Chow, Karl Fua, Matthew Gerber, Bethany Teachman, Laura Barnes.* Understanding Behavioral Dynamics of Social Anxiety Among College Students Through Smartphone Sensors.*Information Fusion, 49:57–68, September 2019*.

Monitoring Mental Health Using Mobile Crowdsensing

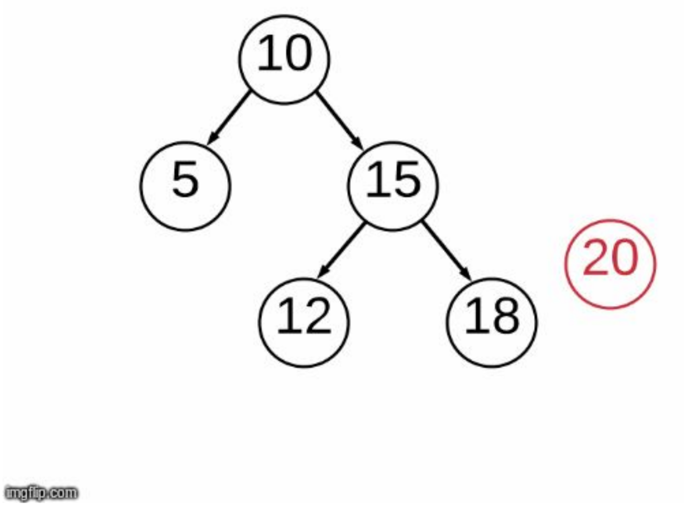
- **Recall: Can we monitor humans' mental health status objectively via their everyday behaviors in a natural setting?**

Yes, we can.

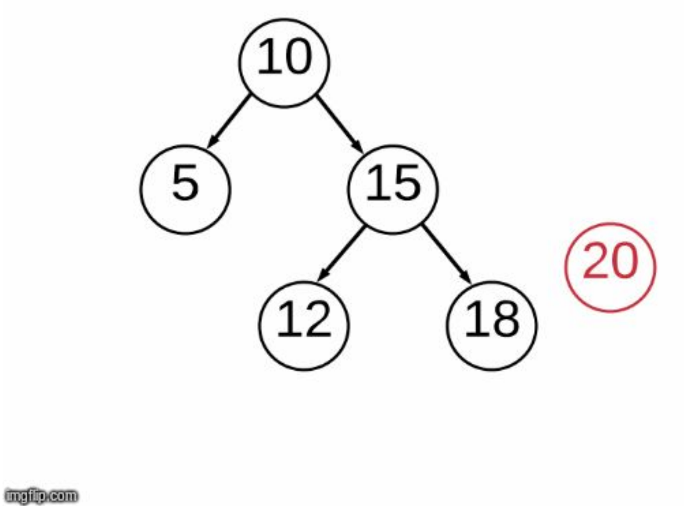
Proposal Overview: Four Components

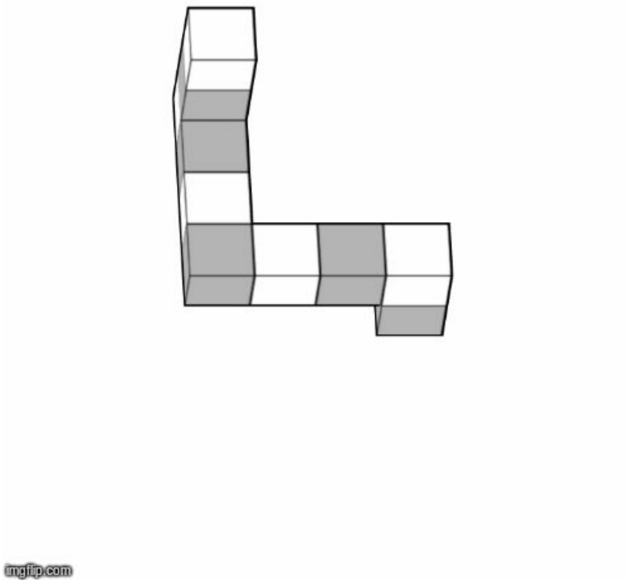
- Monitoring mental health using mobile crowdsensing
- Understanding the neural representations of data structures
- Comparing prose writing and code writing
- Understanding bias in code reviews

- **How do human brains represent data structures? Is it more like text or more like 3D objects?**



- **How do human brains represent data structures? Is it more like text or more like 3D objects?**





- Spatial ability: Mental rotations
  - The determination of spatial relationships between objects and the mental manipulation of spatially presented information
  - **Measured by mental rotation tasks**: 3D objects
  - Related to success in STEM

Understanding the Neural Representations of Data Structure Manipulations

- **fMRI** vs. **fNIRS**
  - Measure brain activities by calculating the blood-oxygen level dependent (BOLD) signal
- **F**unctional **M**agnetic **R**esonance **I**maging
  - Magnets
  - Strong penetration power
  - Lying down in a magnetic tube: cannot move
- **F**unctional **N**ear-**I**nfra**R**ed **S**pectroscopy
  - Light
  - Weak penetration power
  - Wearing a specially-designed cap: more freedom of movement

Understanding the Neural Representations of Data Structure Manipulations

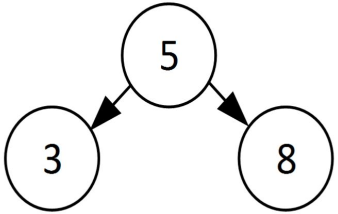
- Experimental design: 2 tasks
  - Data structure manipulations
    - List/Array operations
    - Tree operations
  - Mental rotations: 3D objects

What is the minimum number of swaps required to make the given array sorted?

Indices	0	1	2	3	4	5
nums	0	6	7	4	8	10

A. 1 B. 2

Which of the candidate insertion sequences will produce the given BST?

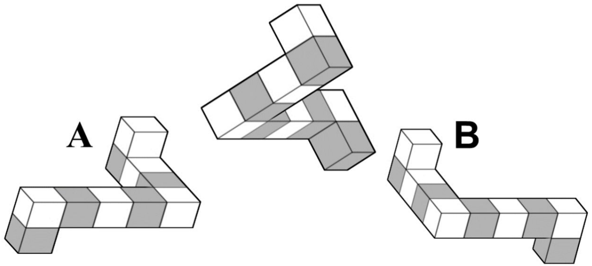


A. 5, 3, 8 B. 8, 3, 5

Understanding the Neural Representations of Data Structure Manipulations

- Experimental design: 2 tasks
  - Data structure manipulations
    - List/Array operations
    - Tree operations
  - Mental rotations: 3D objects

Which object is the same as the original object, aside from its orientation?



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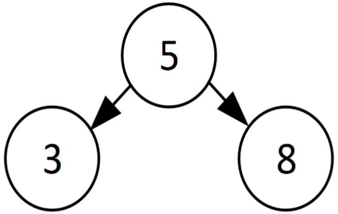
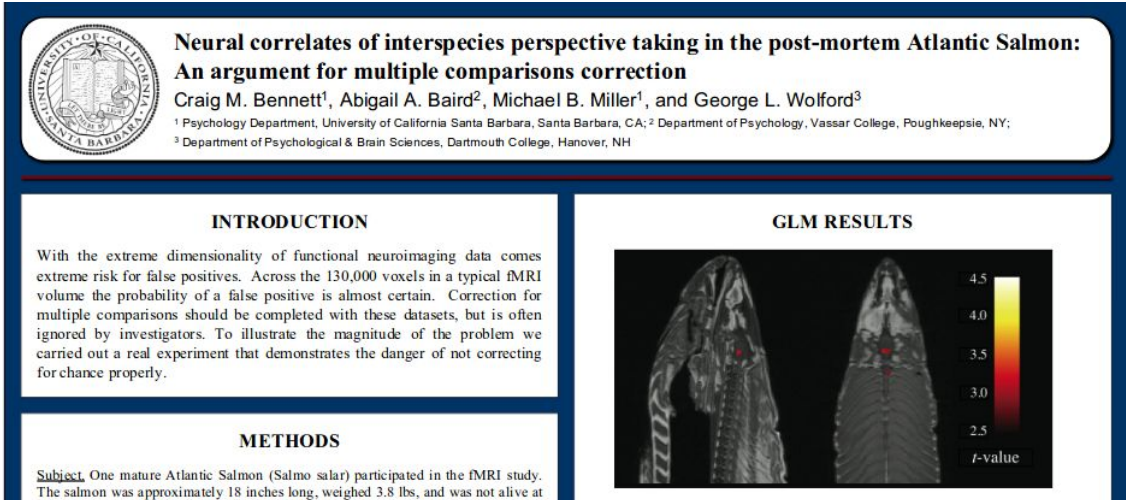


A. 5, 3, 8   B. 8, 3, 5

- Data analysis: we need to be careful
    - Spurious correlations due to multiple comparison



Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction

Craig M. Bennett[1], Abigail A. Baird[2], Michael B. Miller[1], and George L. Wolford[3]

[1] Psychology Department, University of California Santa Barbara, Santa Barbara, CA; [2] Department of Psychology, Vassar College, Poughkeepsie, NY; [3] Department of Psychological & Brain Sciences, Dartmouth College, Hanover, NH

INTRODUCTION

With the extreme dimensionality of functional neuroimaging data comes extreme risk for false positives. Across the 130,000 voxels in a typical fMRI volume the probability of a false positive is almost certain. Correction for multiple comparisons should be completed with these datasets, but is often ignored by investigators. To illustrate the magnitude of the problem we carried out a real experiment that demonstrates the danger of not correcting for chance properly.

METHODS

Subject. One mature Atlantic Salmon (Salmo salar) participated in the fMRI study. The salmon was approximately 18 inches long, weighed 3.8 lbs, and was not alive at

GLM RESULTS

- Data analysis: we need to be careful
- fMRI and fNIRS use the same high-level 3-step analysis approach
  - False discovery rate correction for multiple comparisons (FDR)

- Data analysis: we need to be careful
- fMRI and fNIRS use the same high-level 3-step analysis approach
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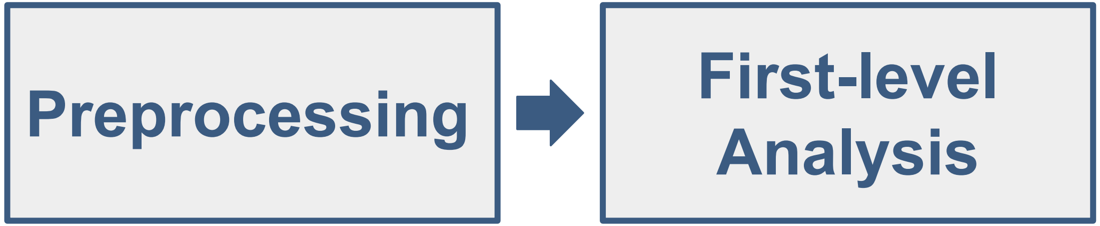
Preprocessing

- Data analysis: we need to be careful
- fMRI and fNIRS use the same high-level 3-step analysis approach
  - False discovery rate correction for multiple comparisons (FDR)



- Data analysis: we need to be careful
- fMRI and fNIRS use the same high-level 3-step analysis approach
  - False discovery rate correction for multiple comparisons (FDR)

Preprocessing → **First-level Analysis** → **Contrast & Group-level analysis**

Neural Representations of Data Structures: Metrics

- Following the best practices in medical imaging, we can find significant relationship between data structure manipulations and spatial ability ($p<0.01$).
- We can find significant relationships regarding the difficulty levels of tasks.

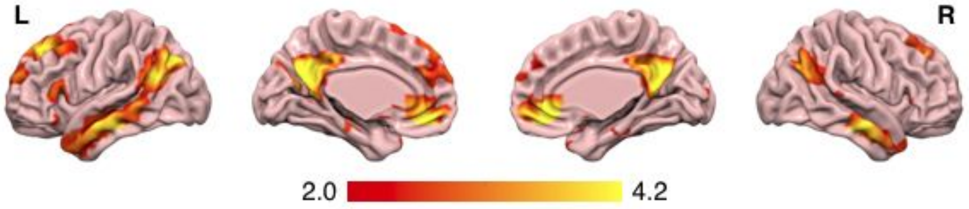
Neural Representations of Data Structures: Preliminary Results

- Experiment setup and data
  - 76 participants: 70 valid
    - fMRI: 30
    - fNIRS: 40
    - Two hours for each participant: 90 stimuli, qualitative post-survey

De-identified data is public: https://web.eecs.umich.edu/weimerw/fmri.html

Neural Representations of Data Structures: Preliminary Results

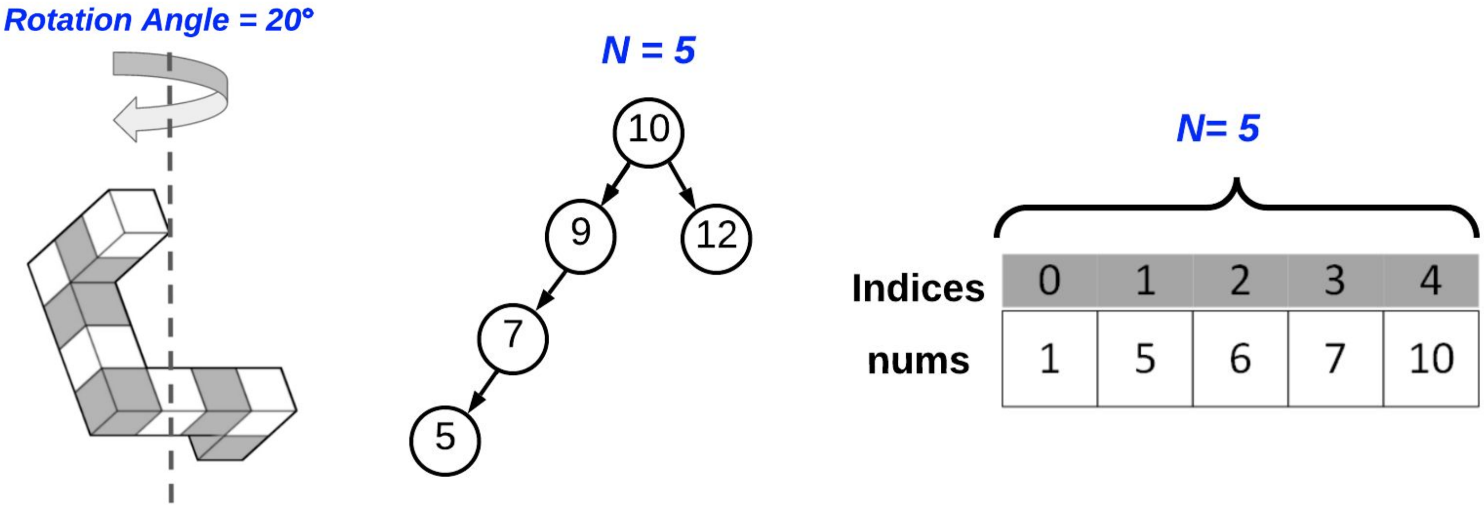
- Data structure manipulations involve spatial ability
  - fMRI: more similarities than differences ($p<0.01$)
  - fNIRS: activation in the same brain regions ($p<0.01$)



Mental Rotation vs. Tree

Neural Representations of Data Structures: Preliminary Results

- The brain works even harder for more difficult data structure tasks
  - Difficulty measurement
    - Mental rotations: angle of rotation
    - Data structure: size

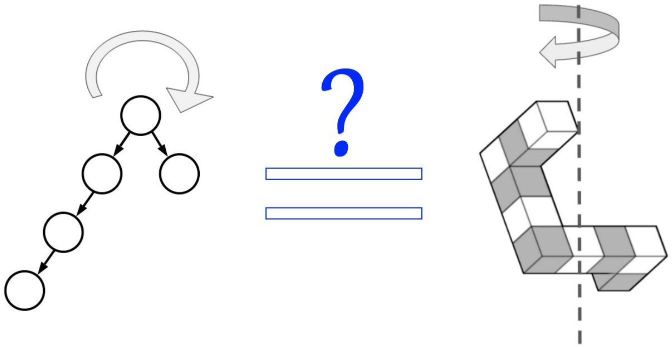


Neural Representations of Data Structures: Preliminary Results

- The brain works even harder for more difficult data structure tasks
  - Difficulty measurement
    - Mental rotations: angle of rotation
    - Data structure: size
  - fMRI: the rate of extra work in your brain is higher for data structure tasks than it is for mental rotation tasks
  - fNIRS: no significant findings for the effect of task difficulty

Neural Representations of Data Structures: Preliminary Results

- How Do **Self-reporting** and Neuroimaging Compare?
  - Self-reporting may not be reliable
  - Medical imaging found mental rotation and data structure tasks are very similar
  - 70% of human participants believe there is no connection!



- **Recall: How do human brains represent data structures? Is it more like text or more like 3D objects?**

Data structure manipulations and mental rotations (spatial ability) involve very similar brain regions.

Proposal Overview: Four Components

Monitoring mental health using mobile crowdsensing

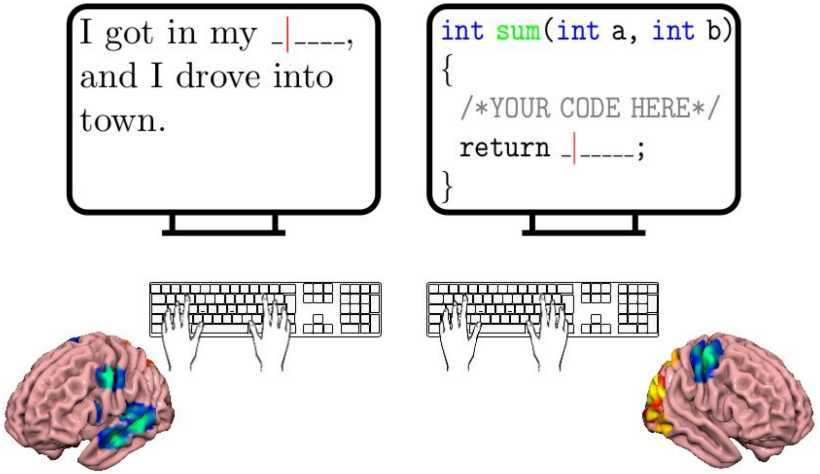
Understanding the neural representations of data structures

Comparing prose writing and code writing

Understanding bias in code reviews

Comparing Code Writing and Prose Writing

- **Are code writing and prose writing similar neural activities? Do I have to be good at English writing to become a good software developer?**

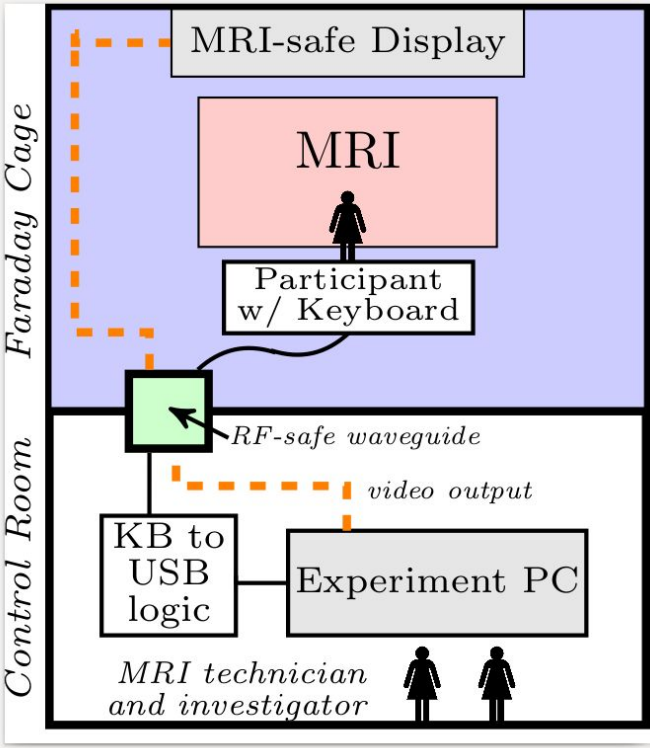


Comparing Code Writing and Prose Writing

- fMRI: penetration power
- Challenges
  - fMRI-safe bespoke keyboard
    - QWERTY keyboard
    - Allow typing and editing
  - Design writing stimuli
    - Prose writing
    - Code writing

Comparing Code Writing and Prose Writing

- fMRI: penetration power
- Challenge: fMRI-safe bespoke keyboard
  - QWERTY keyboard
  - Allow typing and editing



Comparing Code Writing and Prose Writing

- Challenge: Stimuli design
  - Two categories of tasks for **code writing** and **prose writing**
  - Fill in the blank (FITB)

```
/*Complete the sentence
 * such that the sentence
 * makes sense*/
Brian was so fond of
his dog that their
brief ______ left him
not just saddened, but
in a state of sorrow.
```

Prose - FITB

```
/*Complete the definition of
 * the function such that it
 * receives an integer parameter
 * and returns the absolute
 * value of the parameter.*/
int absoluteValue(int num1)
{
    /* YOUR CODE HERE */

    return absoluteValue;
}
```

Code - FITB

Comparing Code Writing and Prose Writing

- Challenge: Stimuli design
  - Two categories of tasks for **code writing** and **prose writing**
  - Fill in the blank (FITB)
  - Long response (LR)

What would happen if everyone lived in space? (e.g., What type of houses would they live in? What type of clothing would they wear?)

Prose - LR

Implement a function is_sorted that accepts a vector of integer values and returns true if it is non-decreasing, and false otherwise

Code - LR

Comparing Code Writing and Prose Writing

- Experimental design: 2 categories of tasks for **code writing** and **prose writing**
  - Code writing tasks: [Turing's Craft]
  - Prose writing tasks: **SAT**

Code Writing vs. Prose Writing: Metrics

- We can have a bespoke QWERTY keyboard that can safely work in fMRI machine
- We can find significant relationship between code writing and prose writing ($p<0.01$)
  - General relationship
  - Relationship between different types of tasks (i.e., FITB and LR)

Code Writing vs. Prose Writing: Preliminary Results

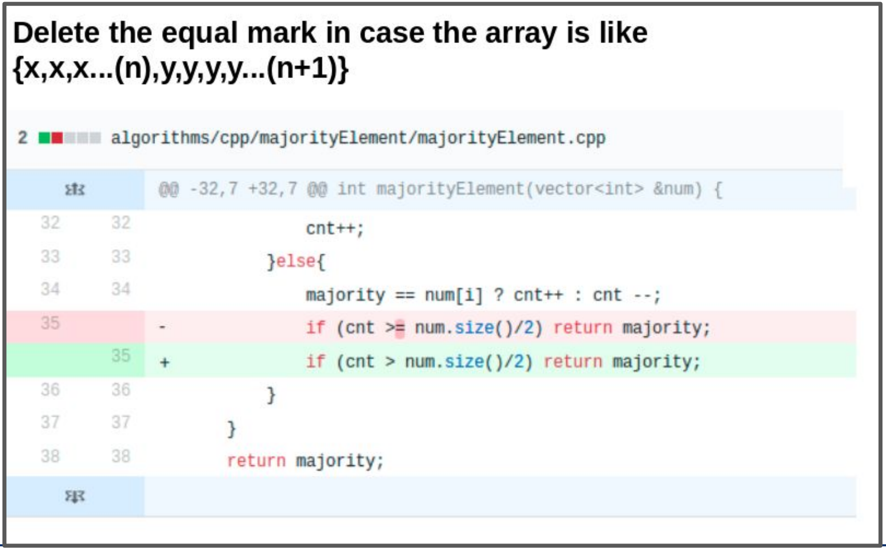
- **IRB approved**
- Bespoke keyboard
  - **Finished** deployment and **passed safety tests**
- Data collection is **done**
  - 30 participants
    - Two hours for each participant: 52 stimuli
    - For both code writing and prose writing:
      - FITB: 17
      - LR: 9

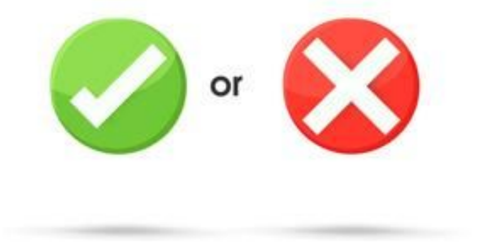
Proposal Overview: Four Components

- Monitoring mental health using mobile crowdsensing
- Understanding the neural representations of data structures
- Comparing prose writing and code writing
- **Understanding bias in code reviews**

Understanding Bias in Code Reviews

- Code reviews
  - The systematic inspection, analysis, evaluation, and revision of code.
  - The latent defect discovery rate of formal code review can be 60%-65%.





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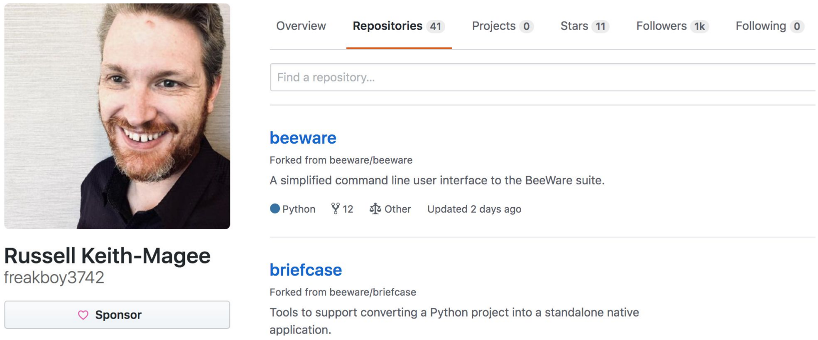
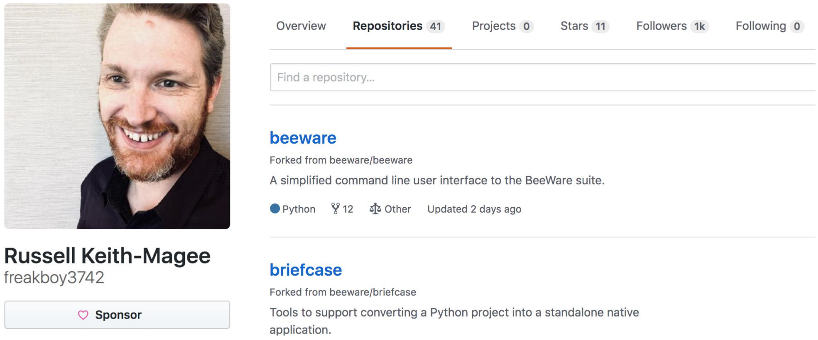


Understanding Bias in Code Reviews

- Code reviews
  - The systematic inspection, analysis, evaluation, and revision of code.
  - The latent defect discovery rate of formal code review can be 60%-65%.
- Bias in code reviews
  - Code source
    - Gender



Understanding Bias in Code Reviews

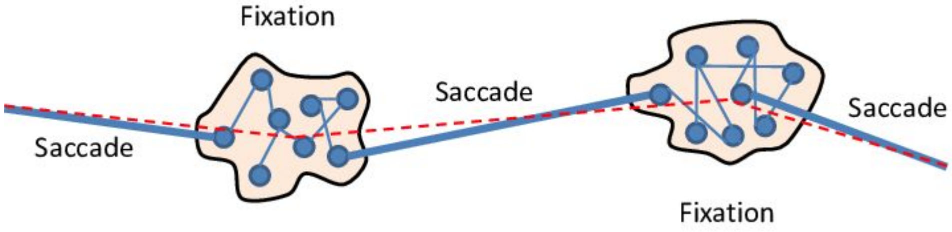
- Code reviews
  - The systematic inspection, analysis, evaluation, and revision of code.
  - The latent defect discovery rate of formal code review can be 60%-65%.
- Bias in code reviews
  - Code source
    - Gender
    - Automated software repair tools

Understanding Bias in Code Reviews

- How does author information affect software developers' decision making in code reviews?
- Do software developers have gender bias in code reviews?
- Do software developers have bias against machine-generated code patches?

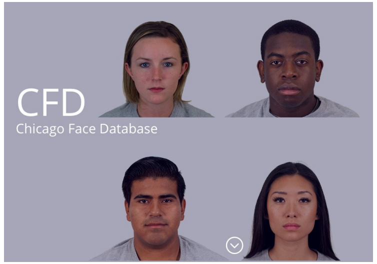
Understanding Bias in Code Reviews

- Neural activities in code reviews: fMRI
- Visual focus in code reviews: eye tracking
  - Fixations and saccades
  - Attention over different Area of Interests (AOI)
    - Comment
    - Code changes
    - Author information



Understanding Bias in Code Reviews

- Stimuli design
  - Pull requests from real world open source C and C++ projects (e.g., GitHub)
  - **Relabel** the author information
    - Pictures from **Chicago Face Database**
      - Controlling age, race, attractiveness and facial expressions
    - Avatar picture to represent automated software repair tools



Understanding Bias in Code Reviews

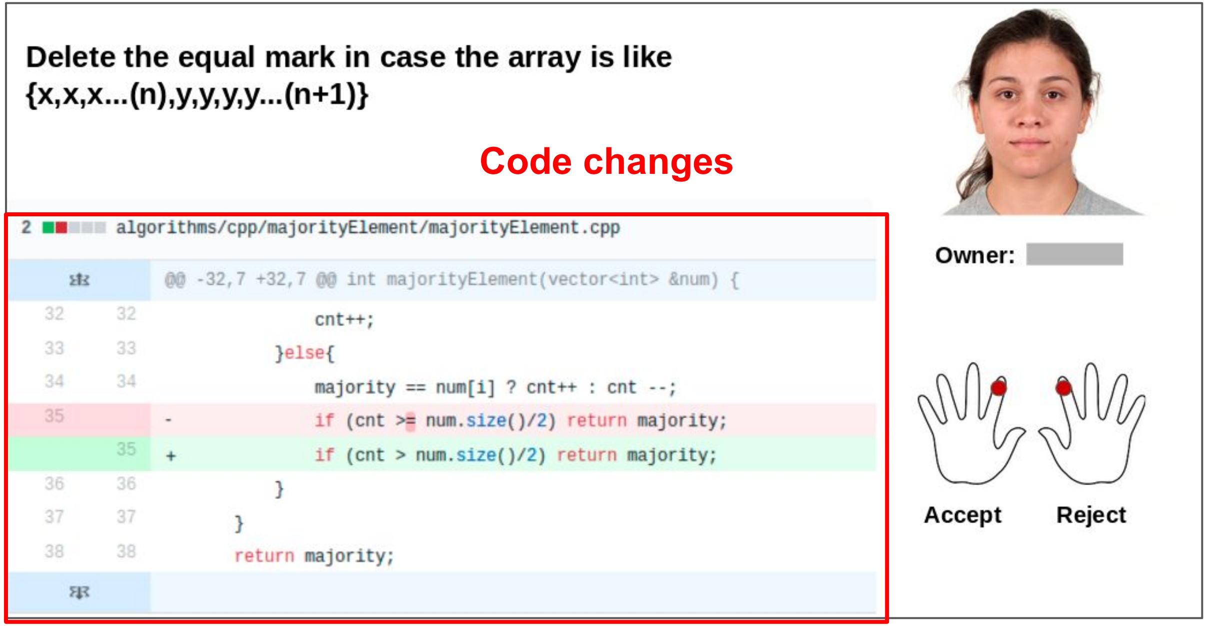
- Stimuli design
  - Pull requests from real world open source projects (C and C++) (e.g., GitHub)
  - **Relabel** the author information
    - Pictures from **Chicago Face Database**
      - Controlling age, race, attractiveness and facial expressions
    - Avatar picture to represent automated software repair tools
  - We will not tell the participants about the relabeling and the purpose of investigating the author bias in code reviews.
    - Avoid social desirability bias

Understanding Bias in Code Reviews

- Stimuli design
  - Simulating a real-world code review interface

Understanding Bias in Code Reviews

- Stimuli design
  - Simulating a real-world code review interface



Understanding Bias in Code Reviews

- Stimuli design
  - Simulating a real-world code review interface

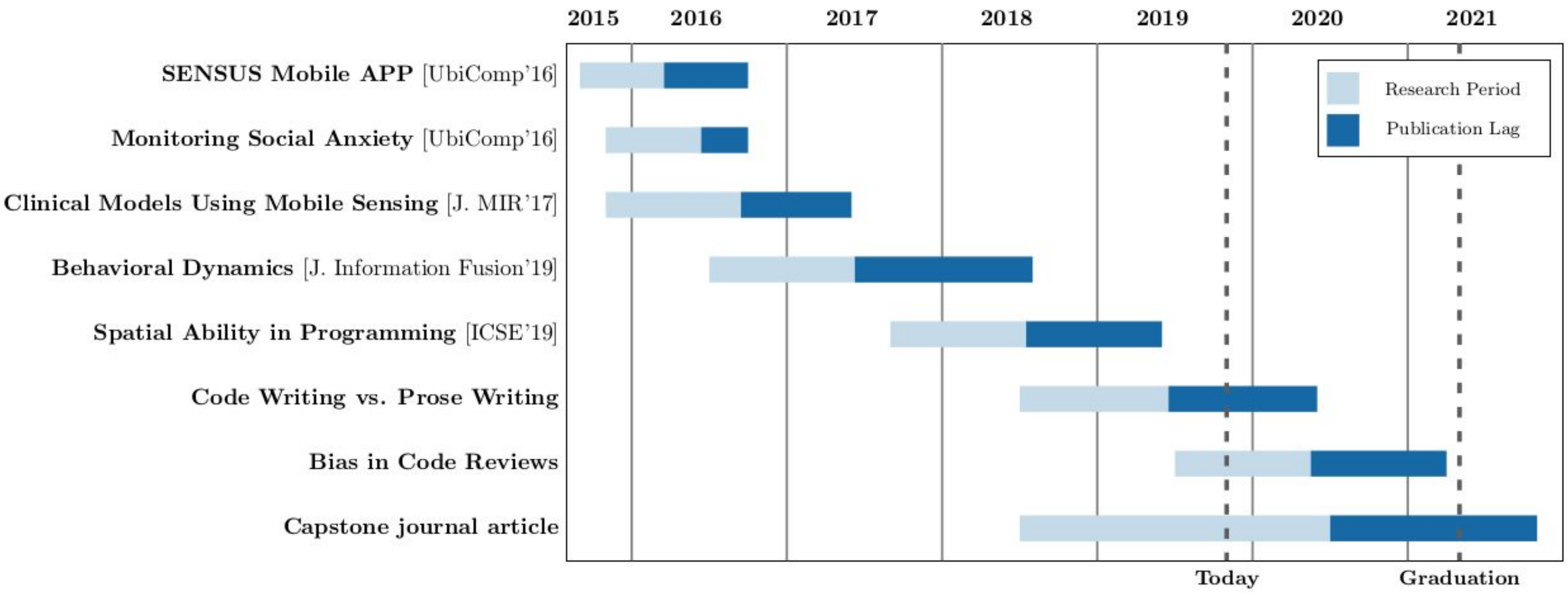
Bias in Code Reviews: Metrics

- We are able to involve author deception in the stimuli design (IRB permission)
- We are able to recruit approximately gender-balanced group of participants
- We are able to obtain significant relationship between the brain activities of code reviews with different author information ($p<0.01$)
- We are able to observe significant similarities or differences of the visual focus and strategies for code reviews with different author information ($p<0.01$)

Bias in Code Reviews: Preliminary Results

- **Stimuli design is done**
  - Two sets of stimuli: 60 stimuli each
    - Randomly assign author pictures into three groups
      - 20 men
      - 20 women
      - 20 machine
    - Relabel each set with different code-author combinations
      - Control code quality
- **IRB approved**
- The fMRI lab has a **built-in eye tracker**
- fMRI lab pilot grant to support this study

Ph.D. Timeline



Publications: Supporting this Proposal

1. **Distilling Neural Representations of Data Structure Manipulation using fMRI and fNIRS**. Yu Huang, Xinyu Liu, Ryan Krueger, Tyler Santander, Xiaosu Hu, Kevin Leach, Westley Weimer. *41st ACM/IEEE International Conference on Software Engineering (ICSE 2019). **Distinguished Paper Award***
2. **Understanding Behavioral Dynamics of Social Anxiety Among College Students Through Smartphone Sensors.** Jiaqi Gong, Yu Huang, Philip I Chow, Karl Fua, Matthew Gerber, Bethany Teachman, Laura Barnes. *Information Fusion, 49:57–68, September 2019.*
3. **Discovery of Behavioral Markers of Social Anxiety From Smartphone Sensor Data.** Yu Huang, Jiaqi Gong, Mark Rucker, Philip Chow, Karl Fua, Matthew S. Gerber, Bethany Teachman, and Laura E. Barnes. *The 1st Workshop on Digital Biomarkers, DigitalBiomarkers '17, pages 9–14, New York, NY, USA, ACM.*
4. **Using Mobile Sensing to Test Clinical Models of Depression, Social Anxiety, State Affect, and Social Isolation Among College Students.** Philip I. Chow, Karl Fua, Yu Huang, Wesley Bonelli, Haoyi Xiong, Laura E. Barnes, and Bethany Teachman. *J Med Internet Res, 19(3):e62, Mar 2017.*
5. **Assessing Social Anxiety Using GPS Trajectories and Point-of-Interest Data.** Yu Huang, Haoyi Xiong, Kevin Leach, Yuyan Zhang, Philip Chow, Karl Fua, Bethany A Teachman, and Laura E Barnes. *In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, UbiComp '16, pages 898–903.*
6. **Sensus: a Cross-Platform, General-Purpose System for Mobile Crowdsensing in Human-Subject Studies.** Haoyi Xiong, Yu Huang, Laura E Barnes, and Matthew S Gerber. *In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, UbiComp* '16, pages 415–426.
7. **Demons: an Integrated Framework for Examining Associations Between Physiology and Selfreported affect Tied to Depressive Symptoms.** Philip Chow, Wesley Bonelli, Yu Huang, Karl Fua, Bethany A Teachman, and Laura E Barnes. *In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct, pages 1139–1143.*

Publications: Others

8. **Physiological Changes Over the Course of Cognitive Bias Modification for Social Anxiety**. Mehdi Boukhechba, Jiaqi Gong, Kamran Kowsari, Mawulolo K Ameko, Karl Fua, Philip I Chow, Yu Huang, Bethany A Teachman, and Laura E Barnes. *Biomedical & Health Informatics (BHI), 2018 IEEE EMBS International Conference on, pages 422–425.*
9. **I Did OK, But Did I Like It? Using Ecological Momentary Assessment to Examine Perceptions of Social Interactions Associated with Severity of Social Anxiety and Depression.** Emily C Geyer, Karl C Fua, Katharine E Daniel, Philip I Chow, Wes Bonelli, Yu Huang, Laura E Barnes, and Bethany A Teachman. *Behavior therapy, 49(6):866–880, 2018* .
10. **Monitoring Social Anxiety From Mobility and Communication Patterns.** Mehdi Boukhechba, Yu Huang, Philip Chow, Karl Fua, Bethany A. Teachman, and Laura E.Barnes. *The ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers, UbiComp '17, pages 749–753.*
11. **Daehr: A Discriminant Analysis Framework for Electronic Health Record Data and an Application to Early Detection of Mental Health Disorders.** Haoyi Xiong, Jinghe Zhang, Yu Huang, Kevin Leach, and Laura E. Barnes. *ACM Trans. Intell. Syst. Technol., 8(3):47:1–47:21, February 2017.*
12. **A Design and Theoretical Analysis of a 145 mV to 1.2 V Single-Ended Level Converter Circuit for Ultra-Low Power Low Voltage ICs.** Yu Huang, Aatmesh Shrivastava, Laura E Barnes, and Benton H Calhoun. *Journal of Low Power Electronics and Applications, 6(3):11, 2016*.
13. **M-SEQ: Early Detection of Anxiety and Depression via Temporal Orders of Diagnoses in Electronic Health Data.** Jinghe Zhang, Haoyi Xiong, Yu Huang, Hao Wu, Kevin Leach, and Laura Barnes. *In Proceedings of the 2015 IEEE International Conference on Big Data (BigData 2015), September 2015*.
14. **A 145 mV to 1.2 V Single Ended Level Converter Circuit for Ultra-Low Power Low Voltage ICs.** Yu Huang, Aatmesh Shrivastava, and Benton H Calhoun. *In SOI-3D-Subthreshold Microelectronics Technology Unified Conference (S3S), 2015 IEEE, pages 1–3*.

Publications: Others

15. **Optimizing Energy Efficient Low Swing Interconnect for Sub-Threshold FPGAs.** He Qi, Oluseyi Ayorinde, Yu Huang, and Benton Calhoun. *In Field Programmable Logic and Applications (FPL), 2015 25th International Conference on, pages 1–4. IEEE, 2015*.
16. **Using Island-Style Bi-directional Intra-CLB Routing in Low-Power FPGAs.** Oluseyi Ayorinde, He Qi, Yu Huang, and Benton H Calhoun. *In Field Programmable Logic and Applications (FPL), 2015 25th International Conference on, pages 1–7. IEEE, 2015*.

Broader Impact

- All the medical imaging and behavioral data will be de-identified and released publicly
- ***Sensus*** has been released and can be used in a wide range of human-subject studies
- Our research findings can help psychologists monitor mental health status and help computer science educators develop efficient training strategies
- Our studies provide guidelines for future study design and implementation in the community

Proposal Summary: Four Components

- Monitoring mental health using mobile crowdsensing
  - Sensus: Cross-platform, general MCS mobile application for human-subject studies
  - Understanding human behaviors and mental health status via MCS
- Understanding the neural representation of data structures
- Comparing prose writing and code writing
- Understanding bias in code reviews