



MOONSHOT FOR MENTAL HEALTH

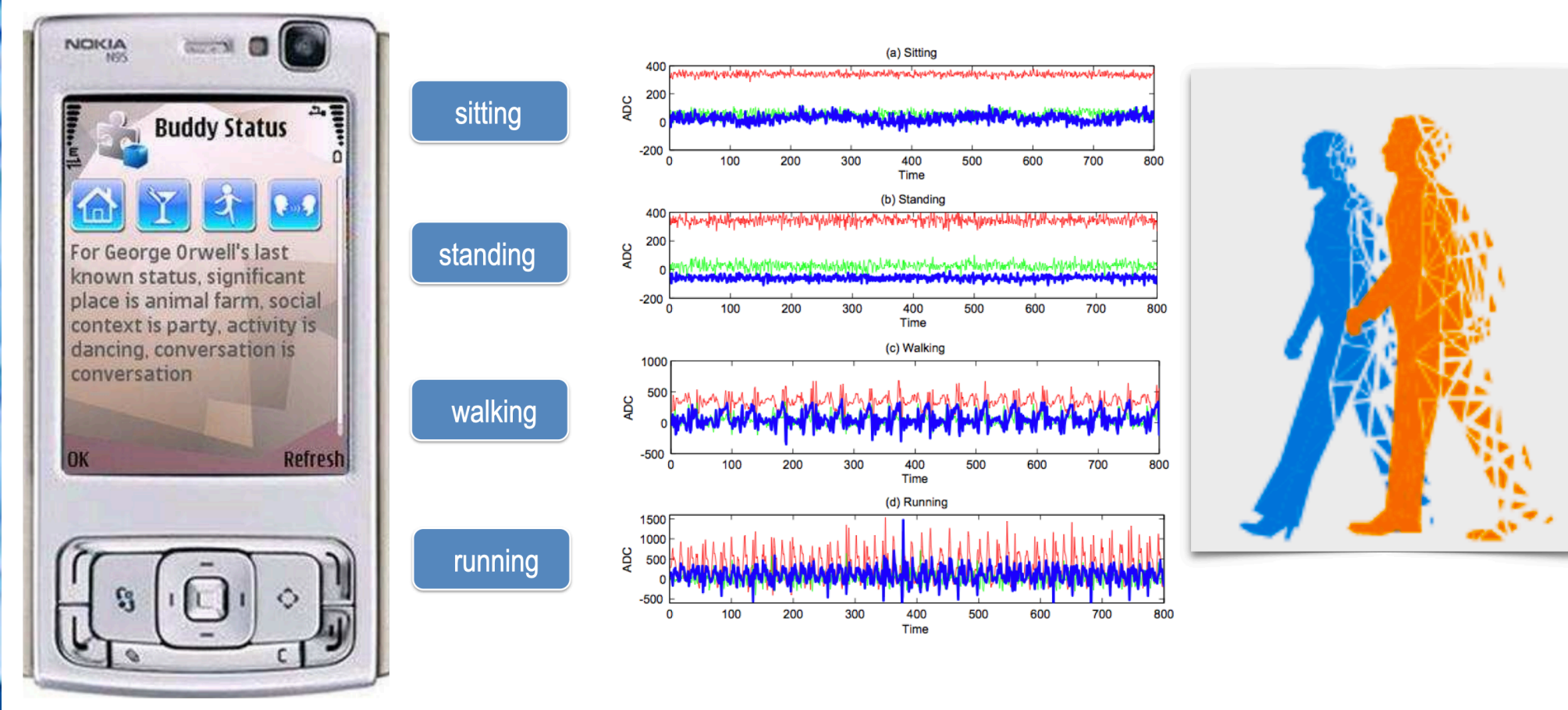
ANDREW CAMPBELL, DARTMOUTH COMPUTER SCIENCE, FAMILY FELLOWS WEEKEND
SATURDAY, FEBRUARY 25, 2023

AI IS THE FUTURE OF MENTAL HEALTH

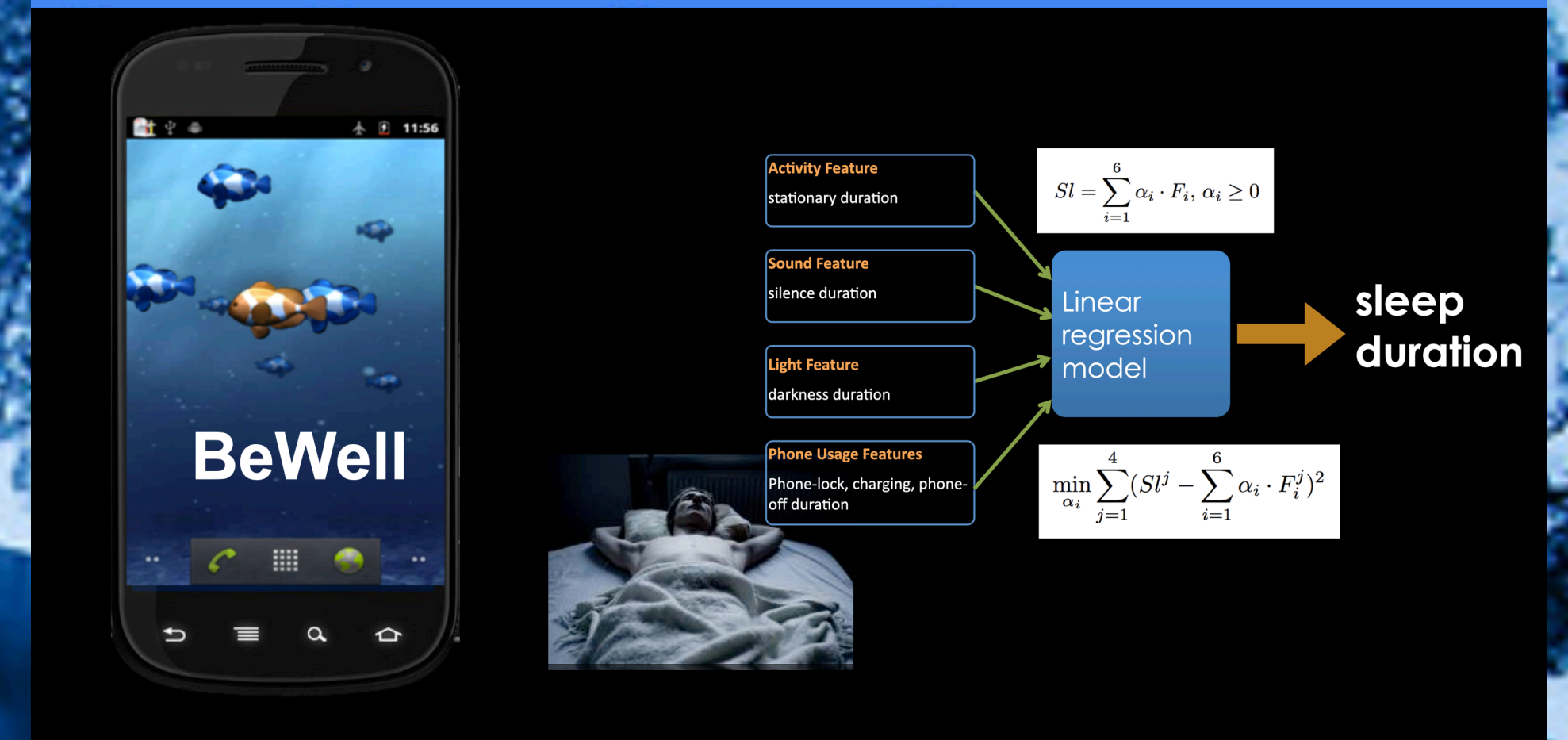


KUUSUMÖ, FINLAND, 2005

2006

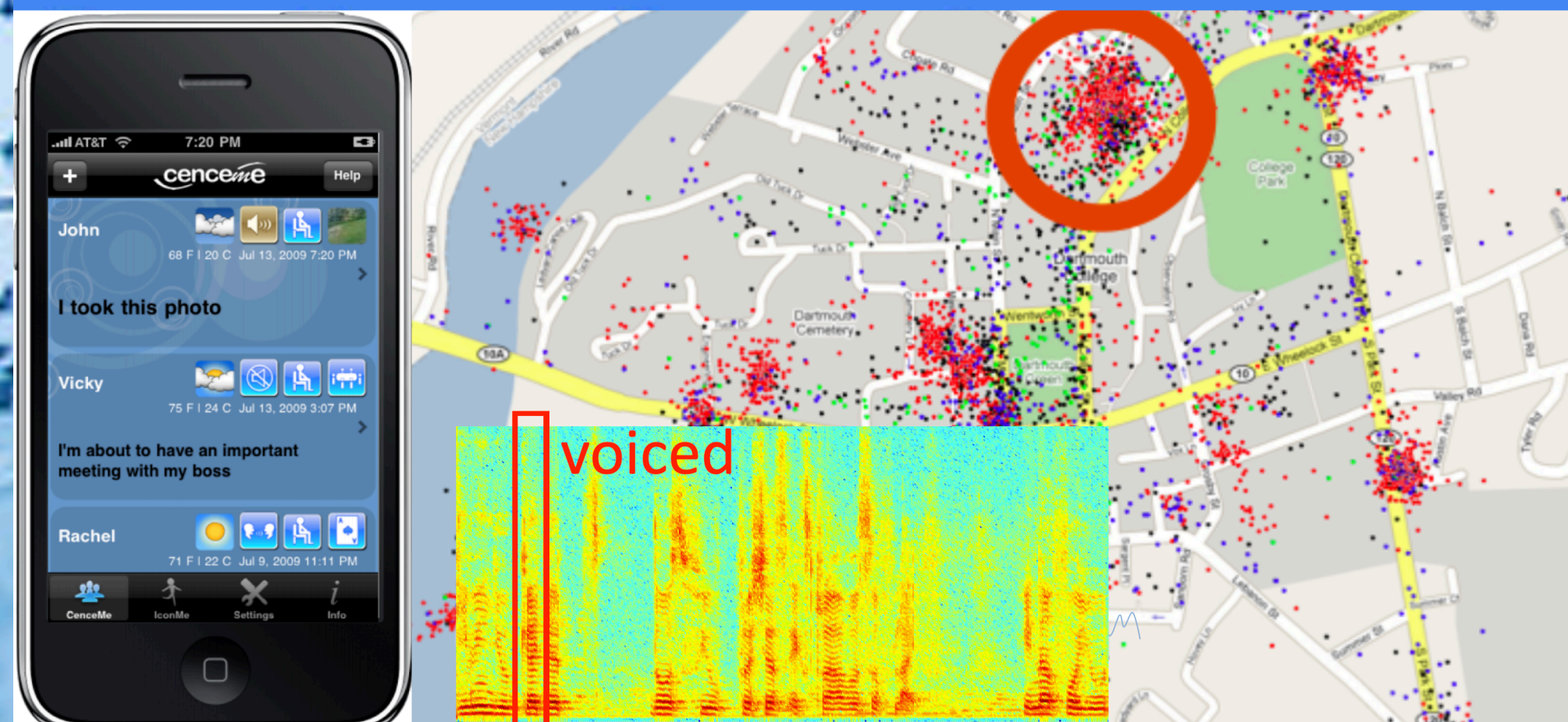


2011

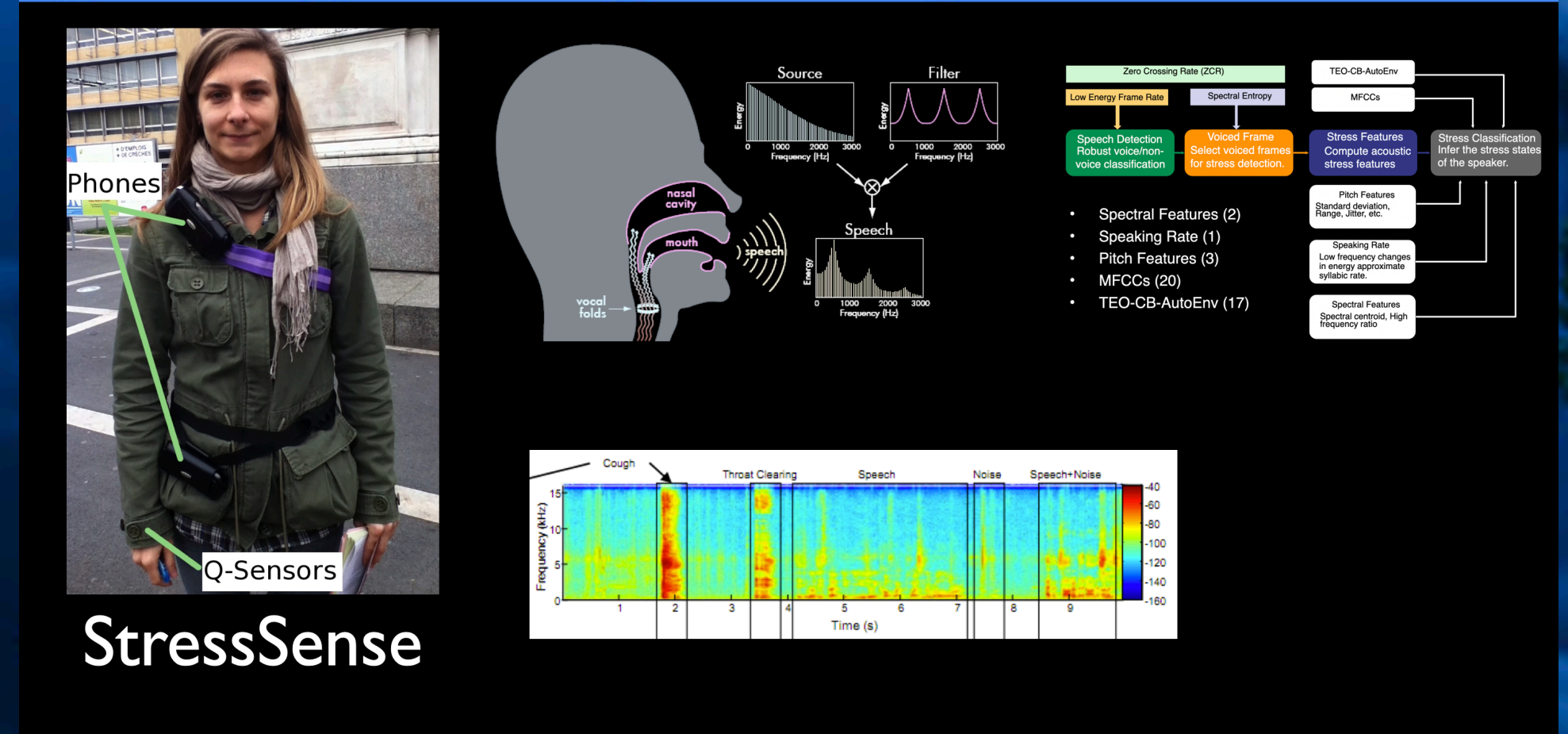


BEHAVIORAL SENSING

2007

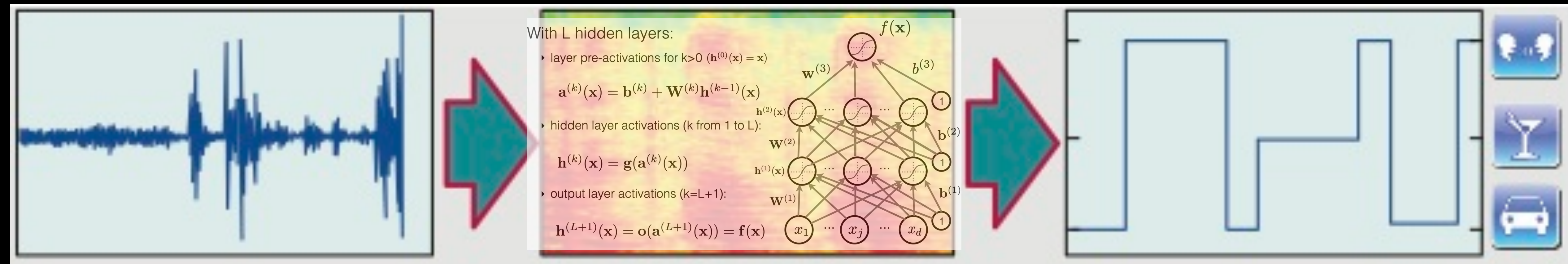


2012





MACHINE LEARNING PIPELINES

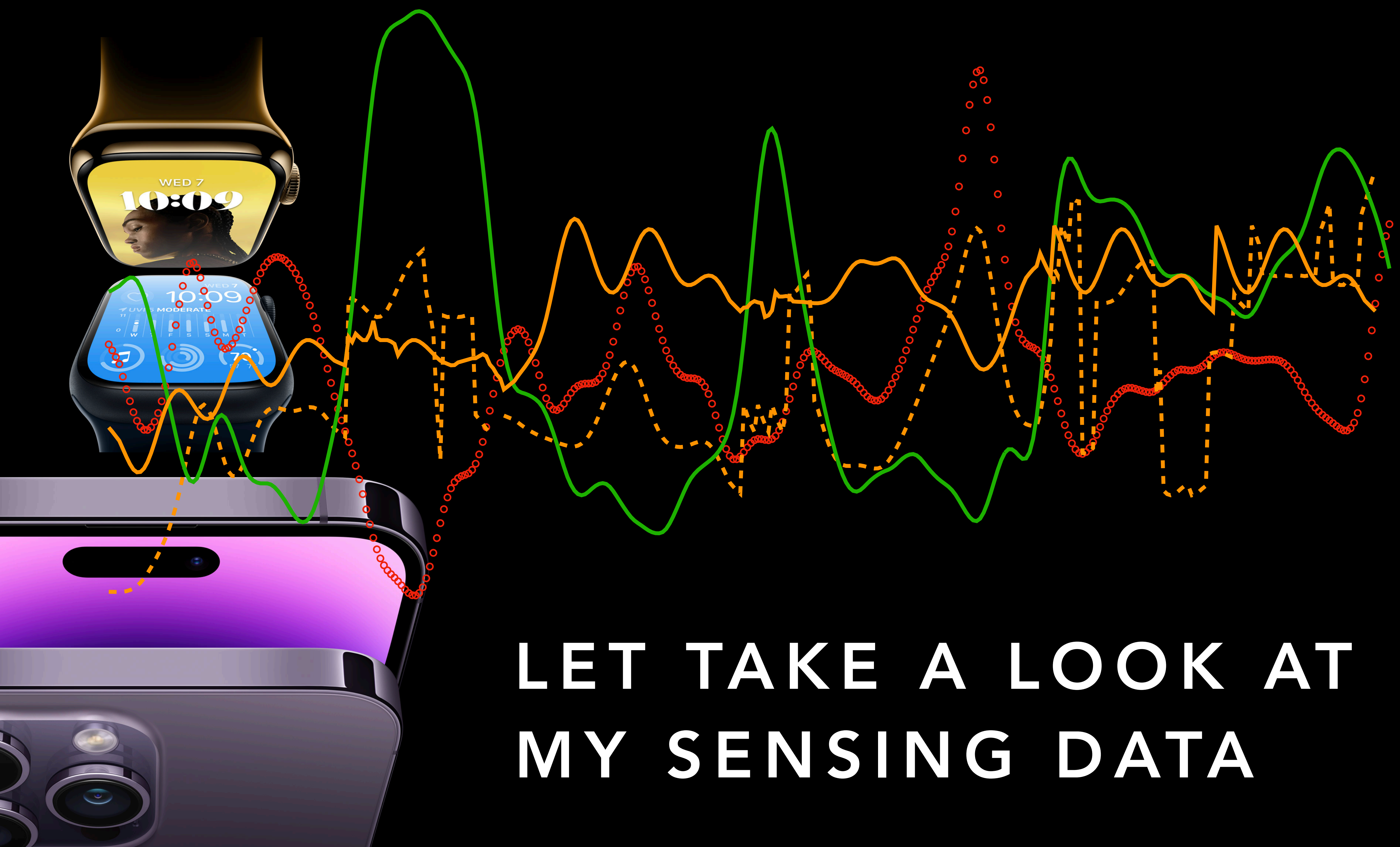


RAW SENSOR
DATA

DEEP NEURAL
NETWORKS

PREDICTION





LET TAKE A LOOK AT
MY SENSING DATA



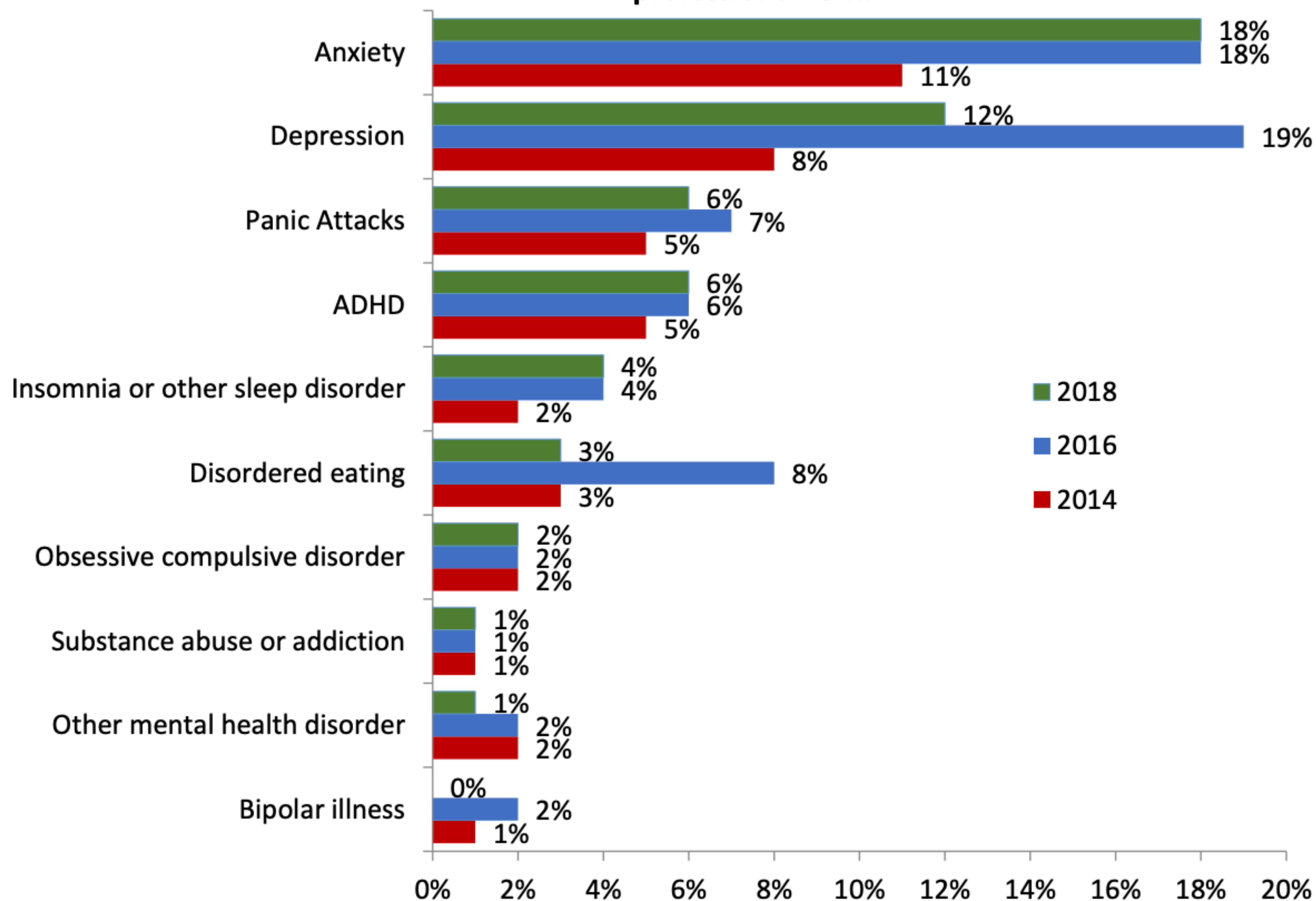


EUREKA MOMENT

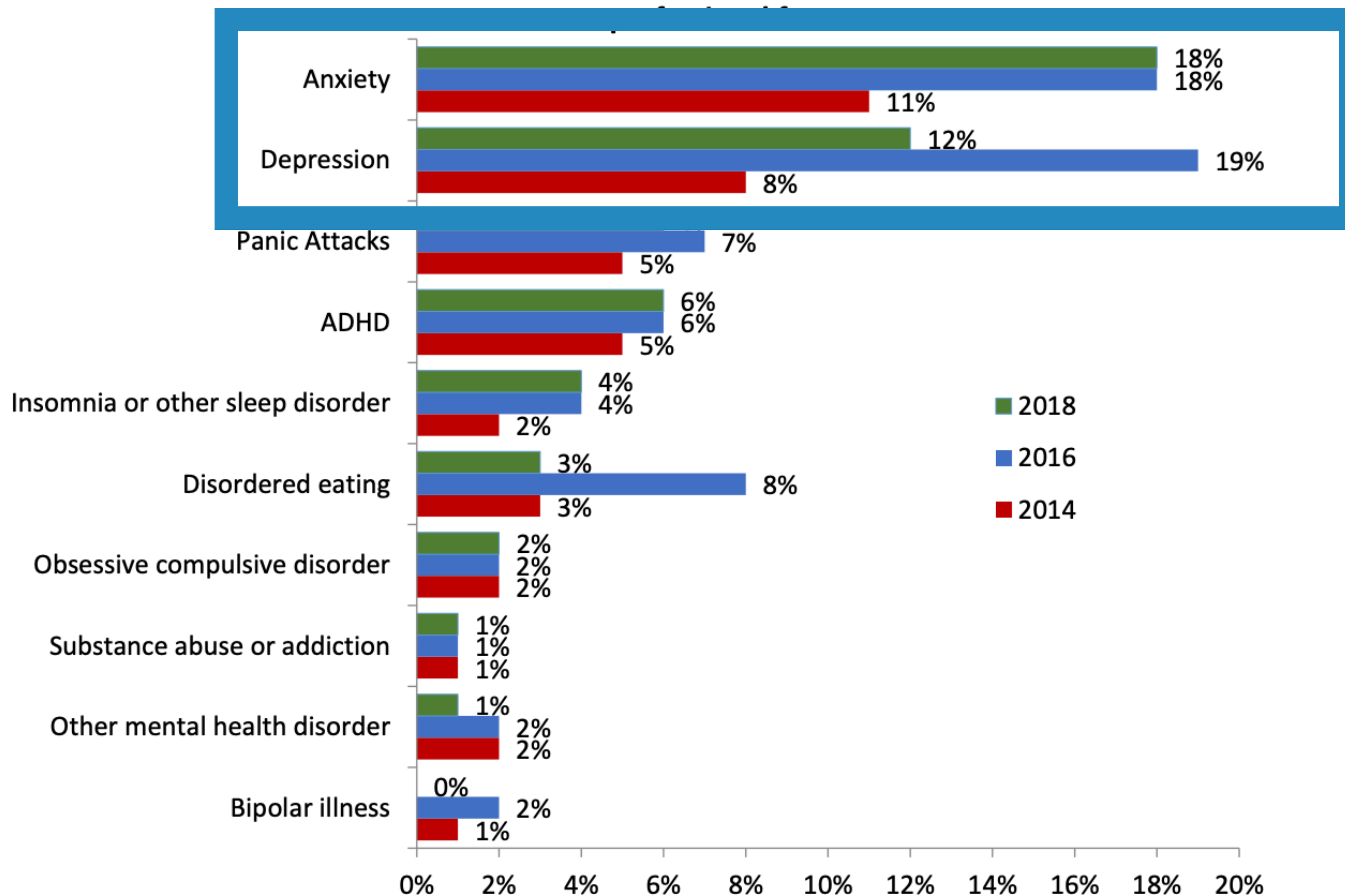


THE STUDENT LIFE STUDY

Within the last 12 months, have you been diagnosed or treated by a professional for...



Within the last 12 months, have you been diagnosed or treated by a



DARTMOUTH 2021: HEALTHY MINDS STUDY

STUDENT SURVEY DATA

▼ Depression

About one in five students (19%) report having been diagnosed with depression at some point in their lives. About one in three students (33%) report moderate to severe depression at the time of survey administration. By comparison, 27% of students in the national HMS sample reported having been diagnosed with depression at some point in their lives and 41% reported moderate or severe depression at the time of survey administration.

▼ Anxiety

About one in four students (26%) report have been diagnosed with anxiety at some point in their lives. Similarly, about one in four students (27%) reported moderate to severe anxiety at the time of the survey administration.³ By comparison, 31% of students in the national HMS sample reported having been diagnosed with anxiety at some point in their lives and 35% reported moderate or severe anxiety at the time of survey administration.³

DARTMOUTH 2021: HEALTHY MINDS STUDY

STUDENT SURVEY DATA

▼ Depression

About one in five students (19%) report having been diagnosed with depression at some point in their lives. [About one in three students \(33%\) report moderate to severe depression at the time of survey administration.](#) By comparison, 27% of students in the national HMS sample reported having been diagnosed with depression at some point in their lives and 41% reported moderate or severe depression at the time of survey administration.

▼ Anxiety

About one in four students (26%) report have been diagnosed with anxiety at some point in their lives. [Similarly, about one in four students \(27%\) reported moderate to severe anxiety at the time of the survey administration.](#)³ By comparison, 31% of students in the national HMS sample reported having been diagnosed with anxiety at some point in their lives and 35% reported moderate or severe anxiety at the time of survey administration.³

NATIONAL TRENDS 2021

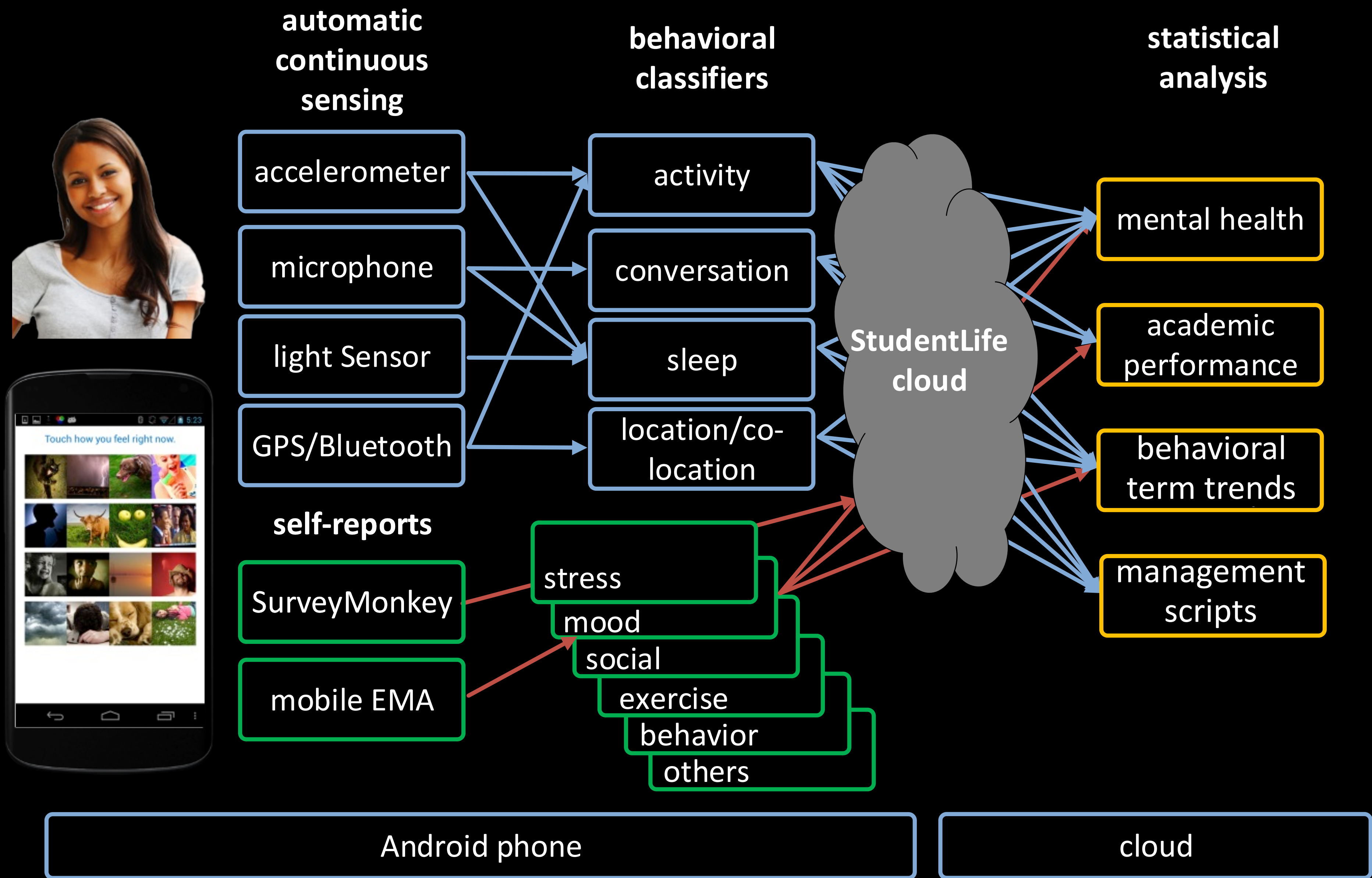
DEPRESSION

ANXIETY

SUICIDALITY



STUDENTLIFE



SELF-REPORTS

STATE SELF-ESTEEM

RIGHT NOW, I worry about what other people think of me.

RIGHT NOW, I am pleased with my appearance.

RIGHT NOW, I feel as smart as others.

RIGHT NOW, Overall, I feel good about myself.

PHQ-4: THE FOUR-ITEM PATIENT HEALTH QUESTIONNAIRE FOR ANXIETY AND DEPRESSION

Over the last two weeks, how often have you been bothered by the following problems?

	Not at all	Several days	More than half the days	Nearly every day
Feeling nervous, anxious or on edge	0	1	2	3
Not being able to stop or control worrying	0	1	2	3
Feeling down, depressed or hopeless	0	1	2	3
Little interest or pleasure in doing things	0	1	2	3
TOTAL S				

Survey

Patient Health Questionnaire

1 of 9 – Over the past week, how often have you been bothered by any of the following problems: Little interest or pleasure in doing things?

☐ Not at all

☒ Several Days

☐ More than half the days

☐ Nearly every day

NEXT

Stress

Right now, I am...

A little stressed

A little stressed

Definitely stressed

Stressed out

Feeling good

Feeling great

Save Resp

SOCIAL LEVEL

Have you spent most of your time alone or

Almost always alone

Mostly alone, a little time with others

Equal amounts of time alone and with

Mostly with others, a little time alone

Almost always with others



LET'S LOOK AT BEHAVIORAL
TRENDS ACROSS SPRING TERM

LOCATION IS MUCH MORE MEANINGFUL

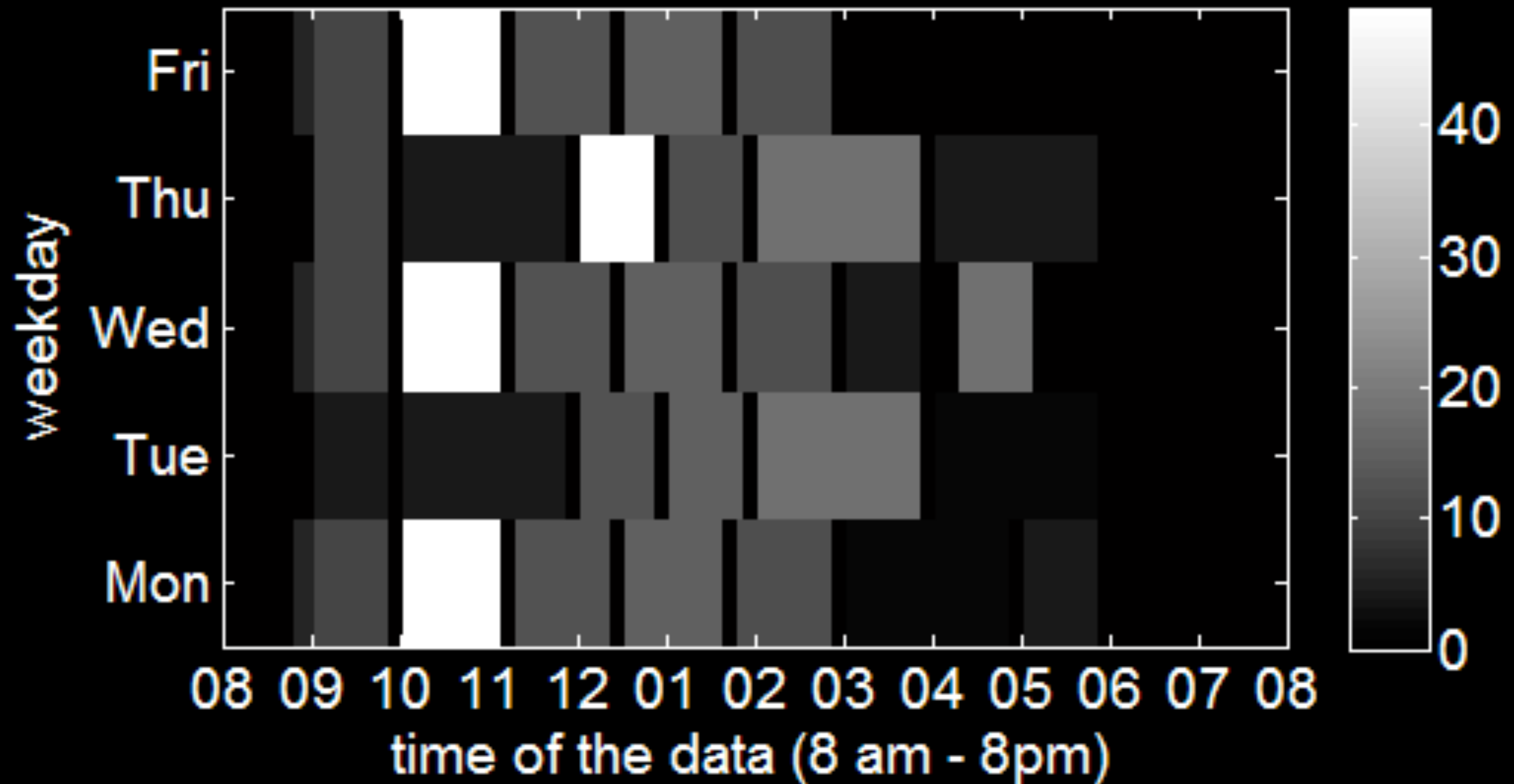


WEEKLY CLASS TIMETABLE

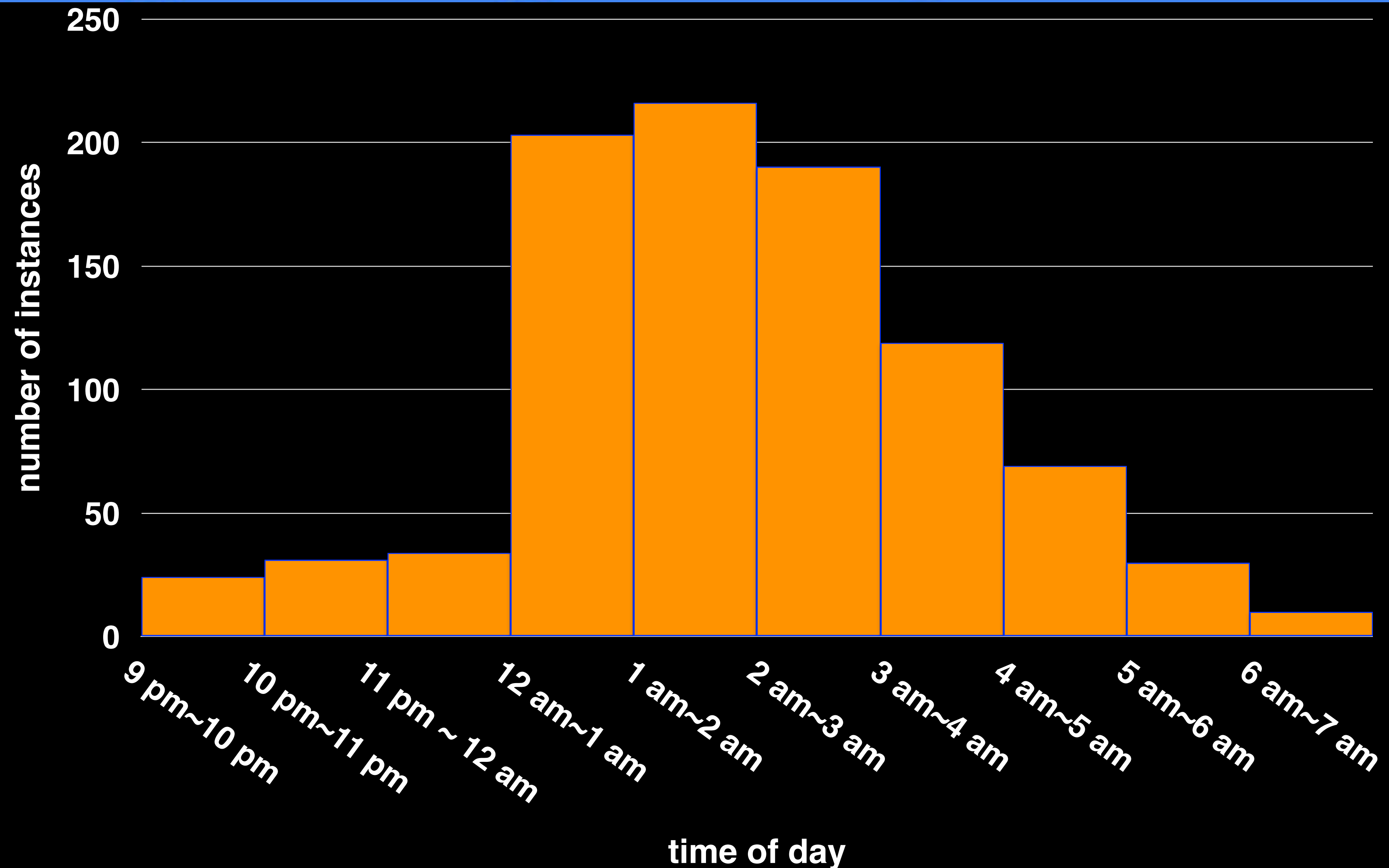
Class Schedule Fall 2022

Monday	Tuesday	Wednesday	Thursday	Friday
7:458S8:35 7:308L7:458:35	7:458S8:35 7:308L7:458:35	7:458SX8:35 7:308L7:458:35	7:458S8:35 7:458LX8:35	7:458S8:35 7:458L7:458:35
9:059S9:55 8:509L9:059:55	9:059S9:55 8:509L9:059:55	9:059SX9:55 8:509L9:059:55	9:059S9:55 9:059LX9:55	9:059S9:55 8:509L9:059:55
10:101011:15 10:1010A11:15	10:101011:15 10:1010A11:15	10:101011:15 10:101011:15	10:101011:15 10:1010A11:15	10:101011:15 10:101011:15
11:301112:35 11:301112:35	11:301112:35 11:301112:35	11:301112:35 11:301112:35	11:301112:35 11:301112:35	11:301112:35 11:301112:35
12:50121:55 12:50121:55	12:50121:55 12:50121:55	12:50121:55 12:50121:55	12:50121:55 12:50121:55	12:50121:55 12:50121:55
2:1023:15 2:1022:253:15	2:1023:15 2:1022:253:15	2:1023:15 2:1022:253:15	2:1023:15 2:1022:253:15	2:1023:15 2:1022:253:15
3:303A5:20 3:303A4:155:20	3:303A5:20 3:303A4:155:20	3:303A5:20 3:303A4:155:20	3:303A5:20 3:303A4:155:20	3:303A5:20 3:303A4:155:20
5:303AX6:20 5:303AX6:20	5:303AX6:20 5:303AX6:20	5:303AX6:20 5:303AX6:20	5:303AX6:20 5:303AX6:20	5:303AX6:20 5:303AX6:20
6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20
6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20	6:306A8:20 6:306A7:208:20

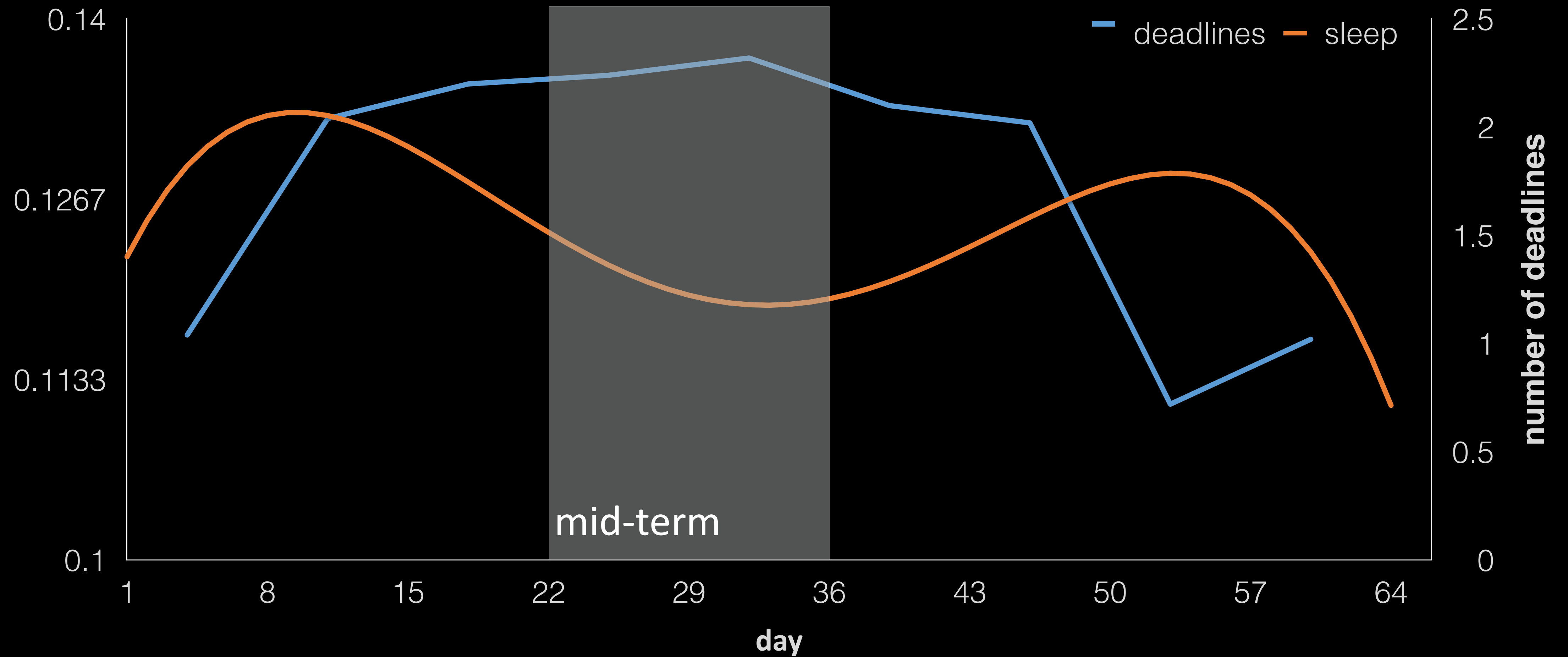
TERM CLASS ATTENDANCE



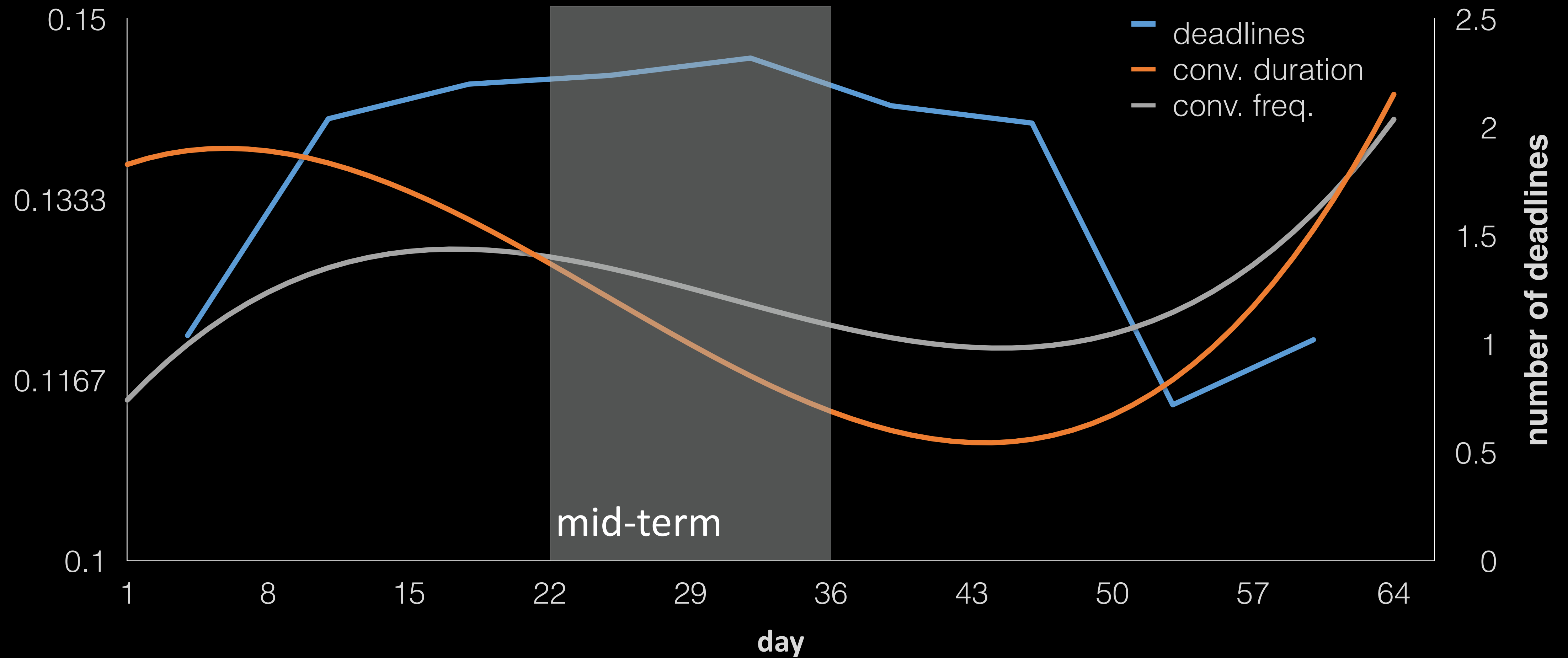
BEDTIME



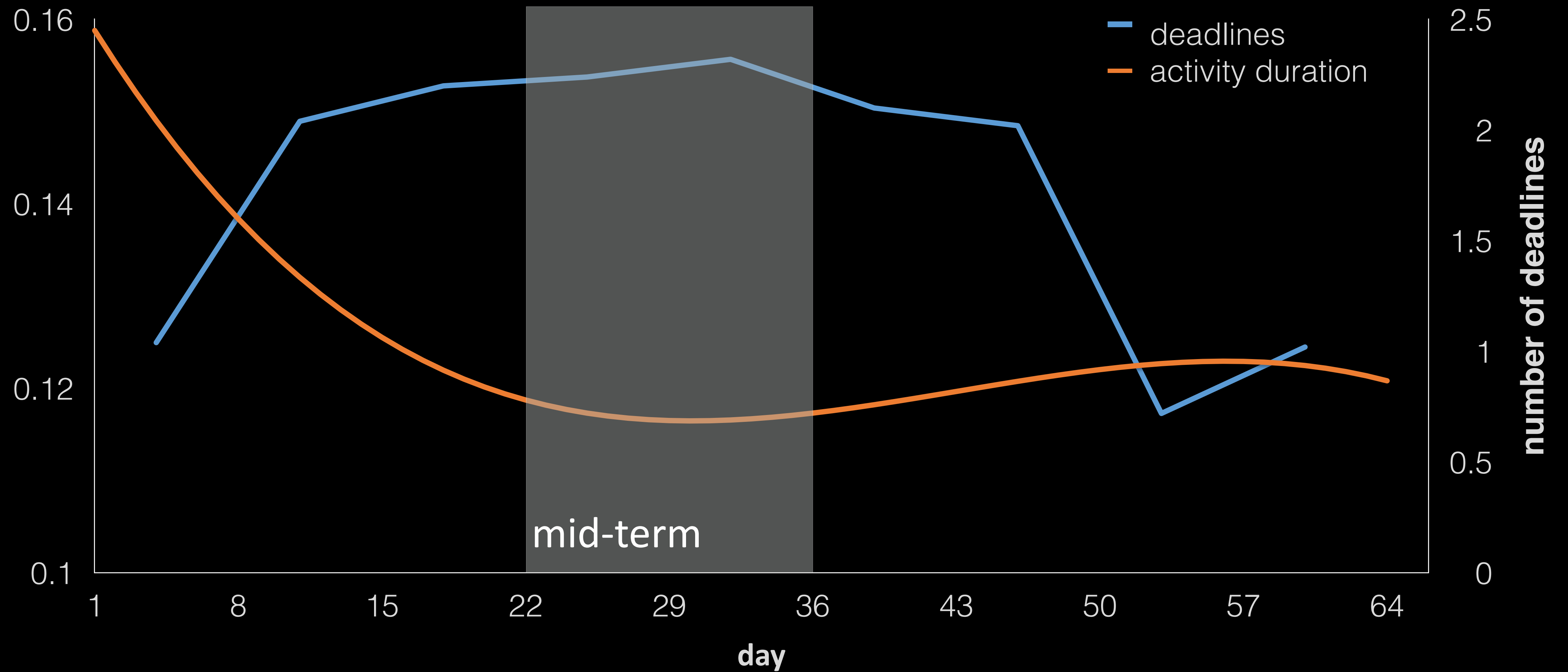
SLEEP



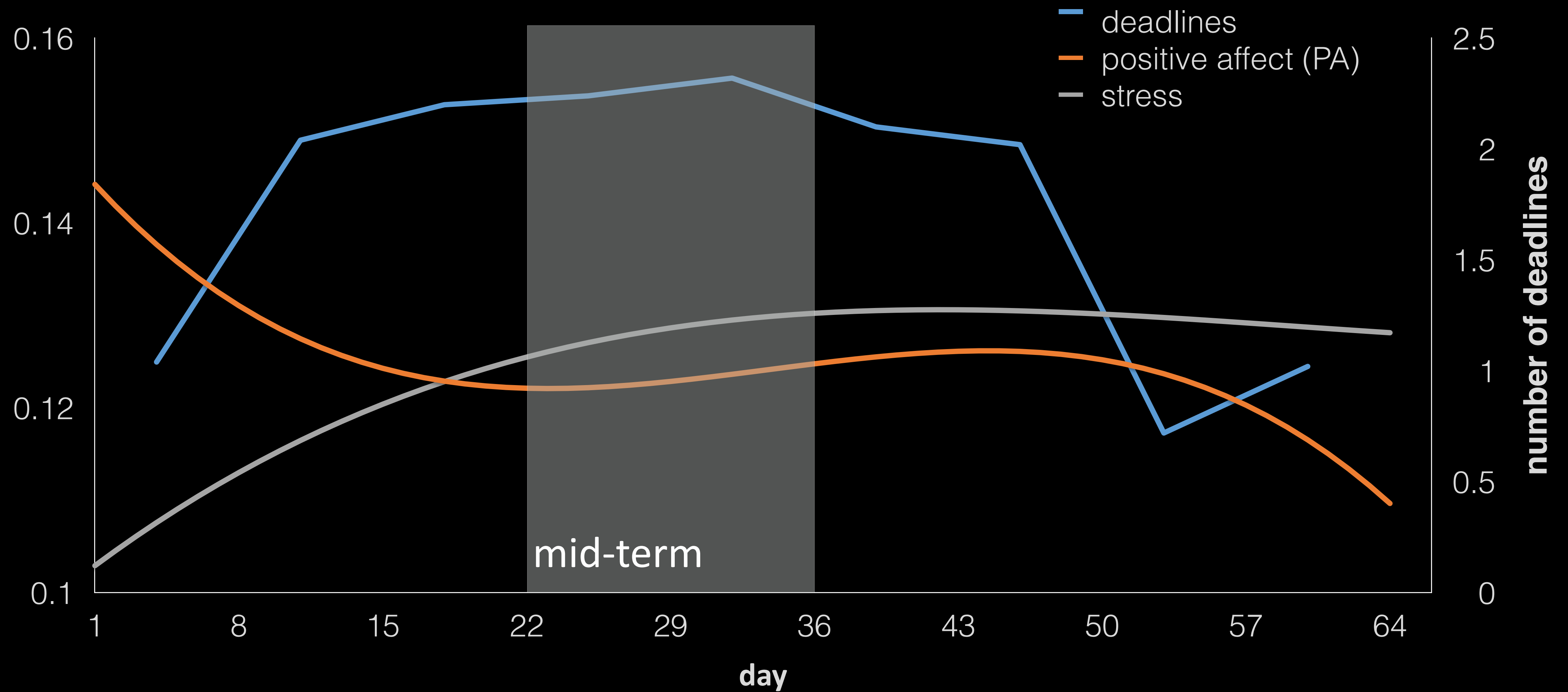
FACE-TO-FACE CONVERSATION



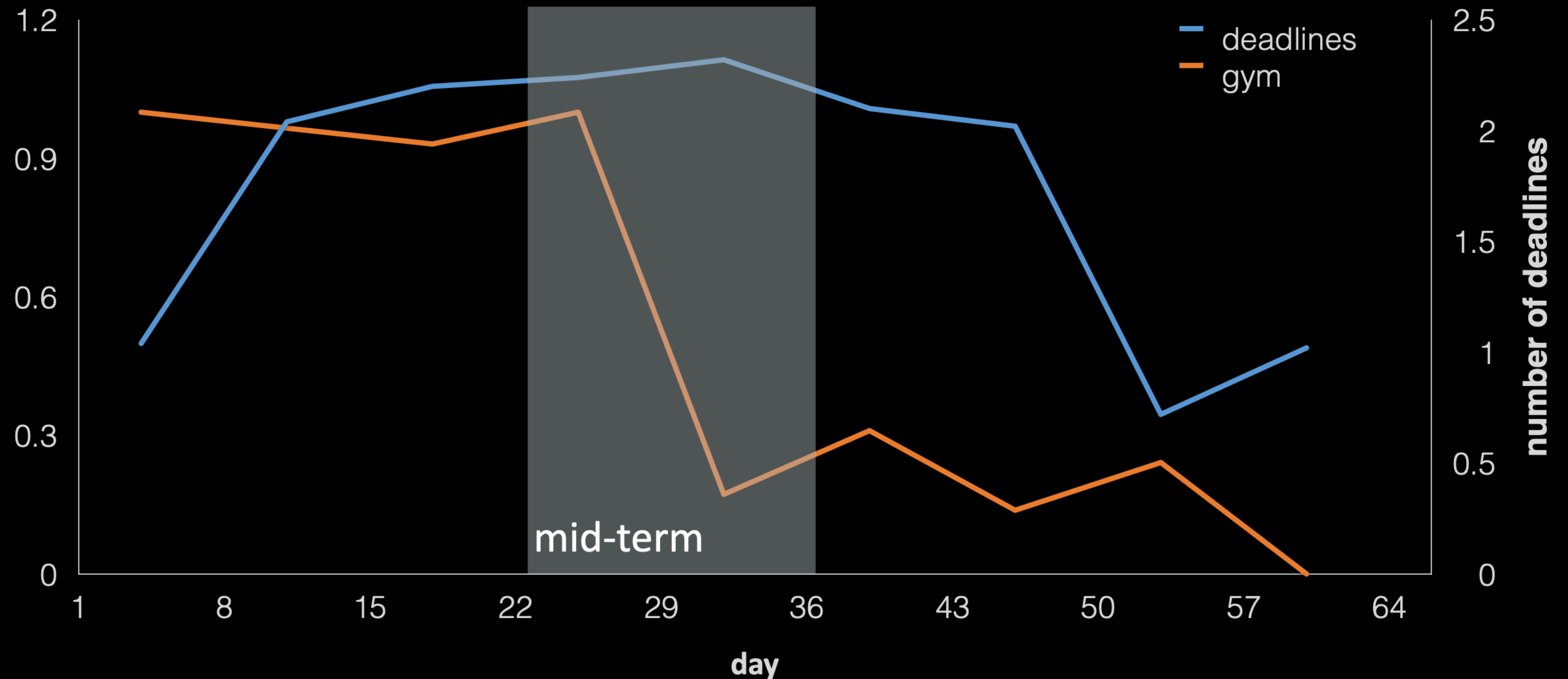
MOVING AROUND CAMPUS



STRESS AND AFFECT

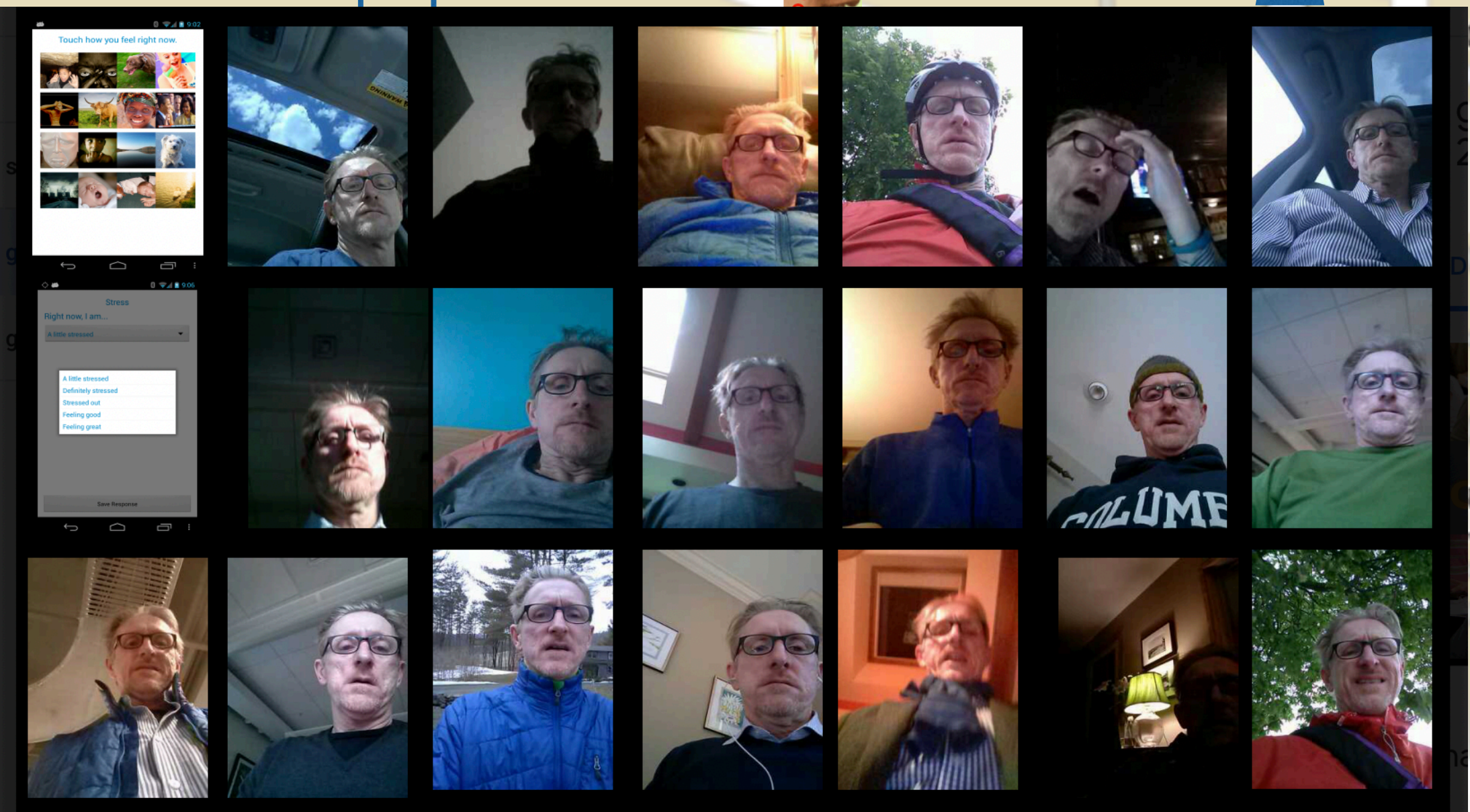
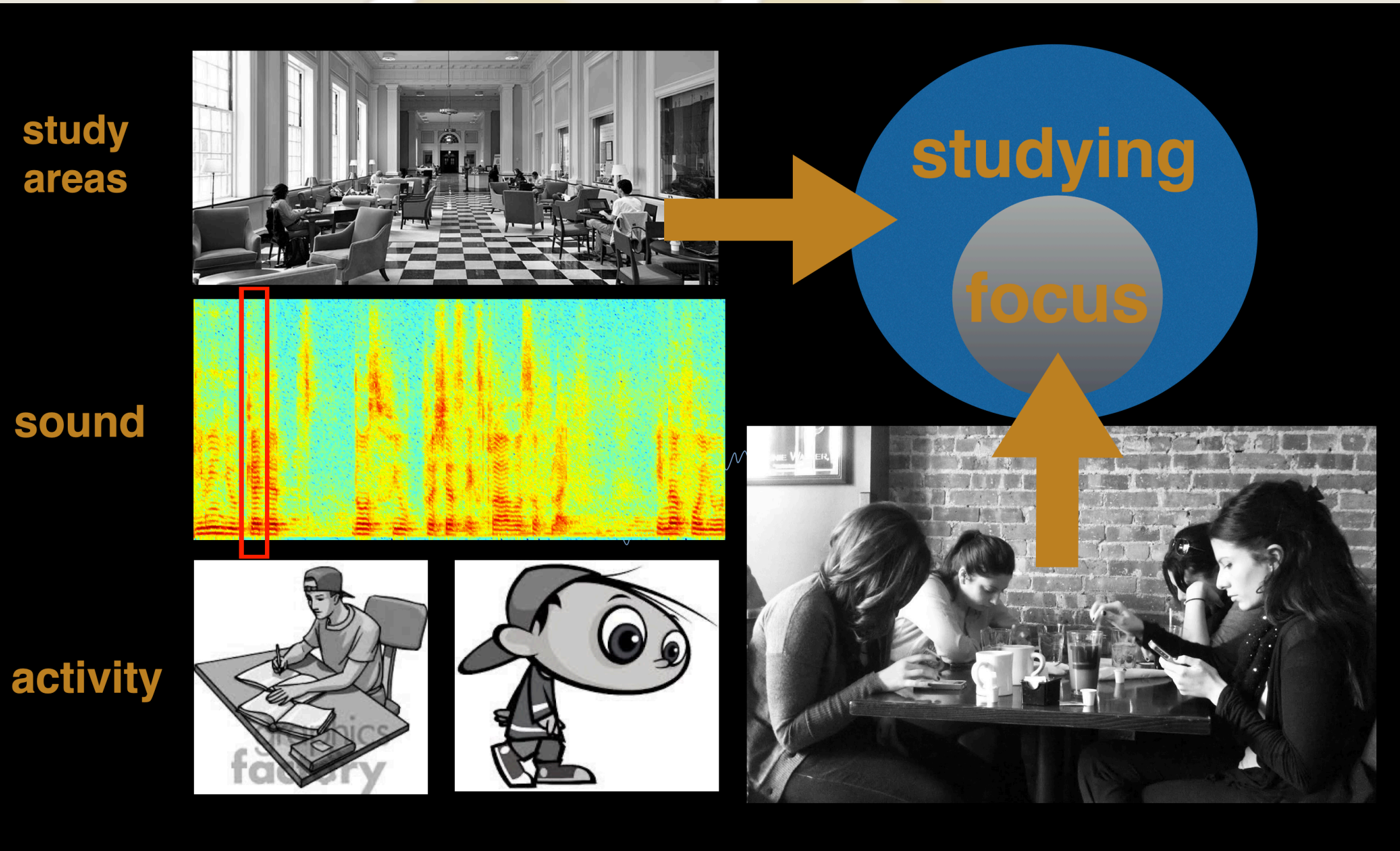


VISITS TO THE GYM





GPA





UBICOMP '15, SEPTEMBER 7–11, 2015, OSAKA, JAPAN

SmartGPA: How Smartphones Can Assess and Predict Academic Performance of College Students

Rui Wang, Gabriella Harari[†]
Peilin Hao, Xia Zhou, and Andrew T. Campbell
Dartmouth College, The University of Texas at Austin[†],
{ruiwang, hao, xia, campbell}@cs.dartmouth.edu,
gabriella.harari@utexas.edu

ABSTRACT

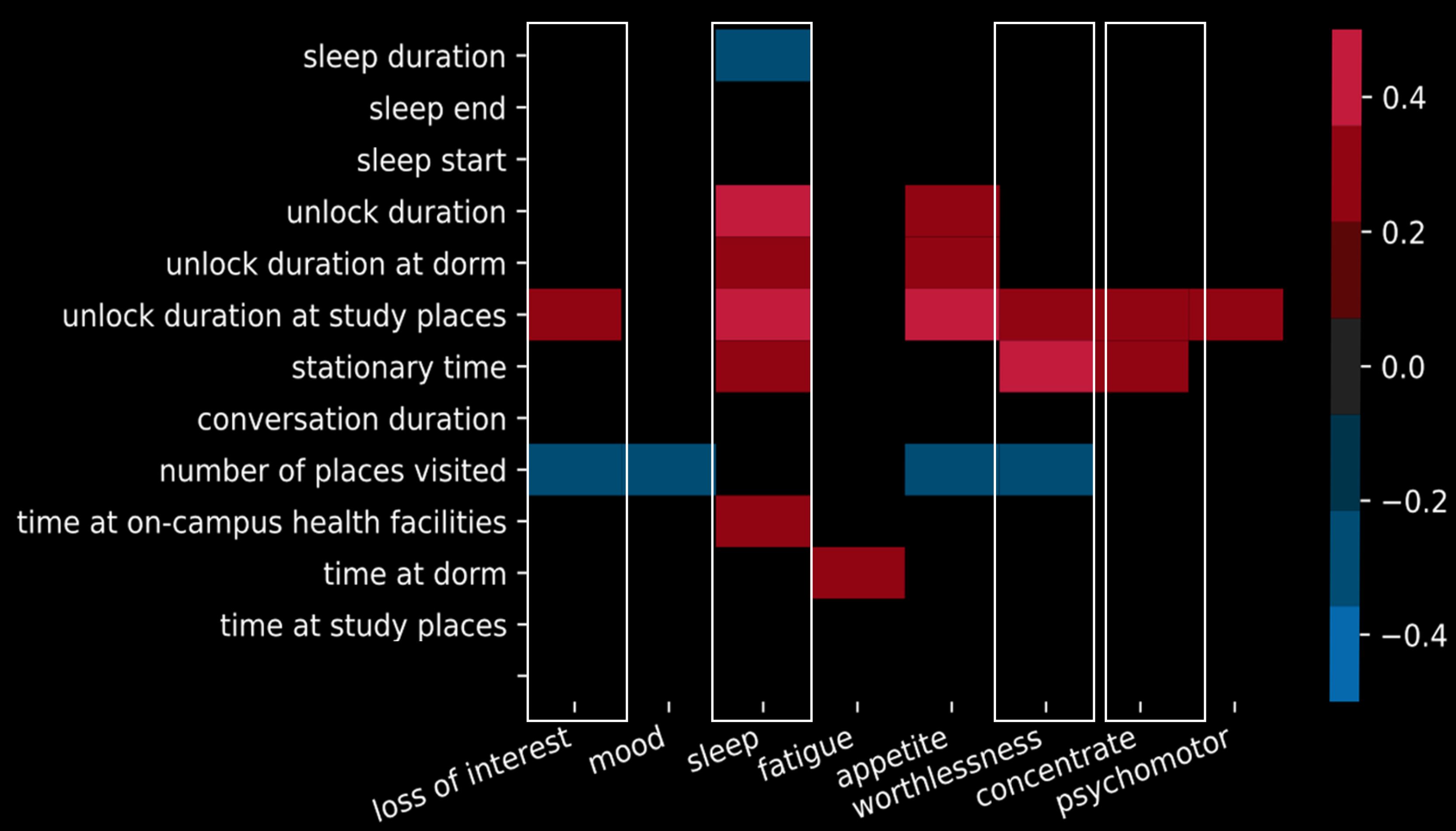
Many cognitive, behavioral, and environmental factors impact student learning during college. The *SmartGPA study* uses passive sensing data and self-reports from students' smartphones to understand individual behavioral differences between high and low performers during a single 10-week term. We propose new methods for better understanding study (e.g., study duration) and social (e.g., partying) behavior of a group of undergraduates. We show that there are a number of important behavioral factors automatically inferred from smartphones that significantly correlate with term and cumulative GPA, including time series analysis of activity, conversational interaction, mobility, class attendance, studying, and partying. We propose a simple model based on linear regression with lasso regularization that can accurately predict cumulative GPA. The predicted GPA strongly correlates with the ground truth from students' transcripts ($r = 0.81$ and $p < 0.001$) and predicts GPA within ± 0.179 of the reported number. Our analysis opens the way for novel

friends and families, and trying to stay active and physically and mentally healthy during the ebb and flow of the term's workload and commitments. As a result, succeeding in a demanding educational environment is challenging.

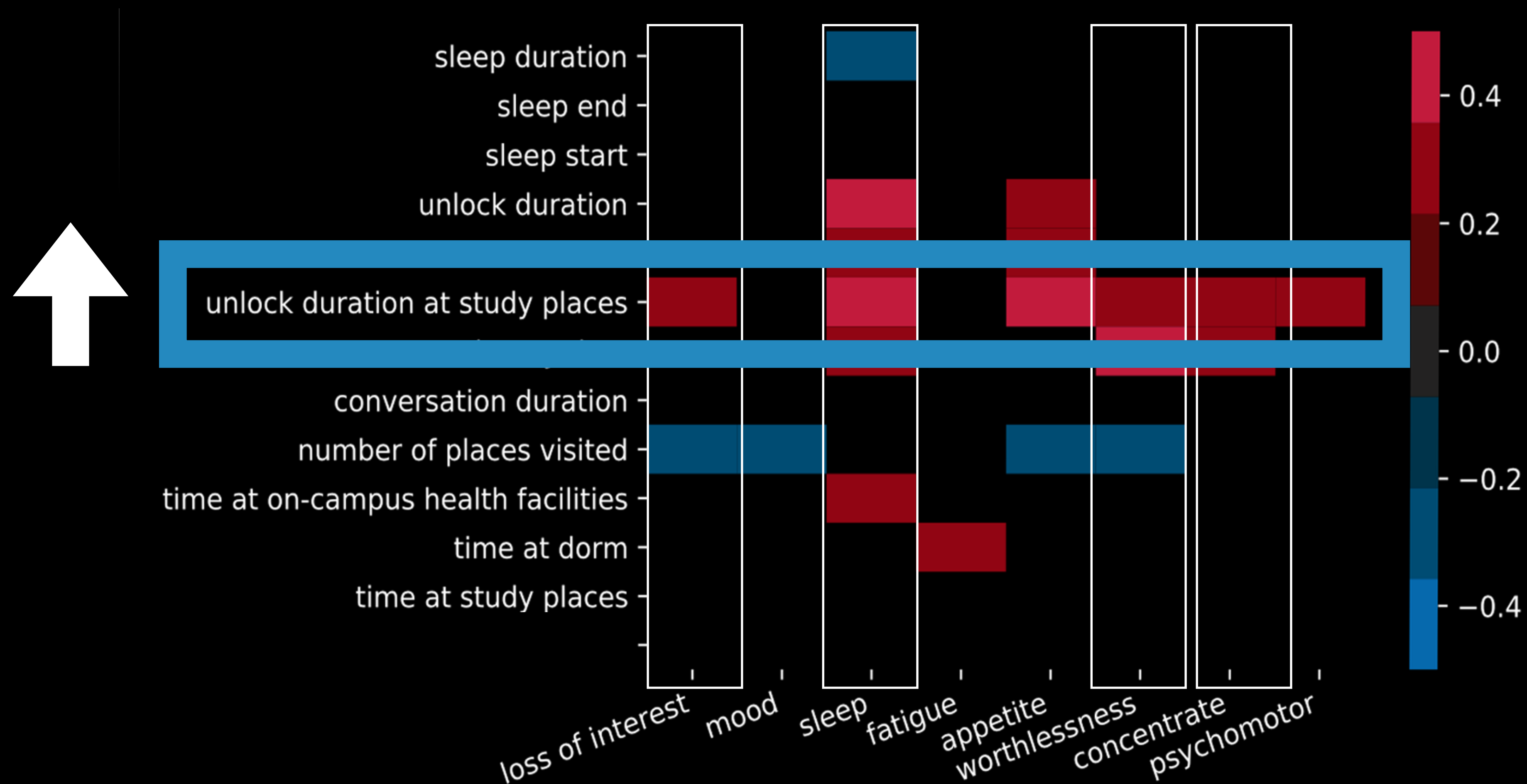
When we think of “academic performance” we usually associate it with educational outcomes best represented by a student's cumulative GPA. This measure typically captures a continuous assessment of a student's academic achievement in terms of results from assignments, quizzes, tests, midterms, and final examinations as they move through their college years. Academic performance is linked to a student's intellectual curiosity and ability (e.g., as measured by IQ), their drive and motivation, the educational environment, health, prior test results (e.g., SATs), and personality traits (e.g., conscientiousness). There is no general agreement, however, on why students with similar academic capability at the same institution do better or worse than one another. It seems likely that students' everyday behavioral patterns (e.g., study habits,



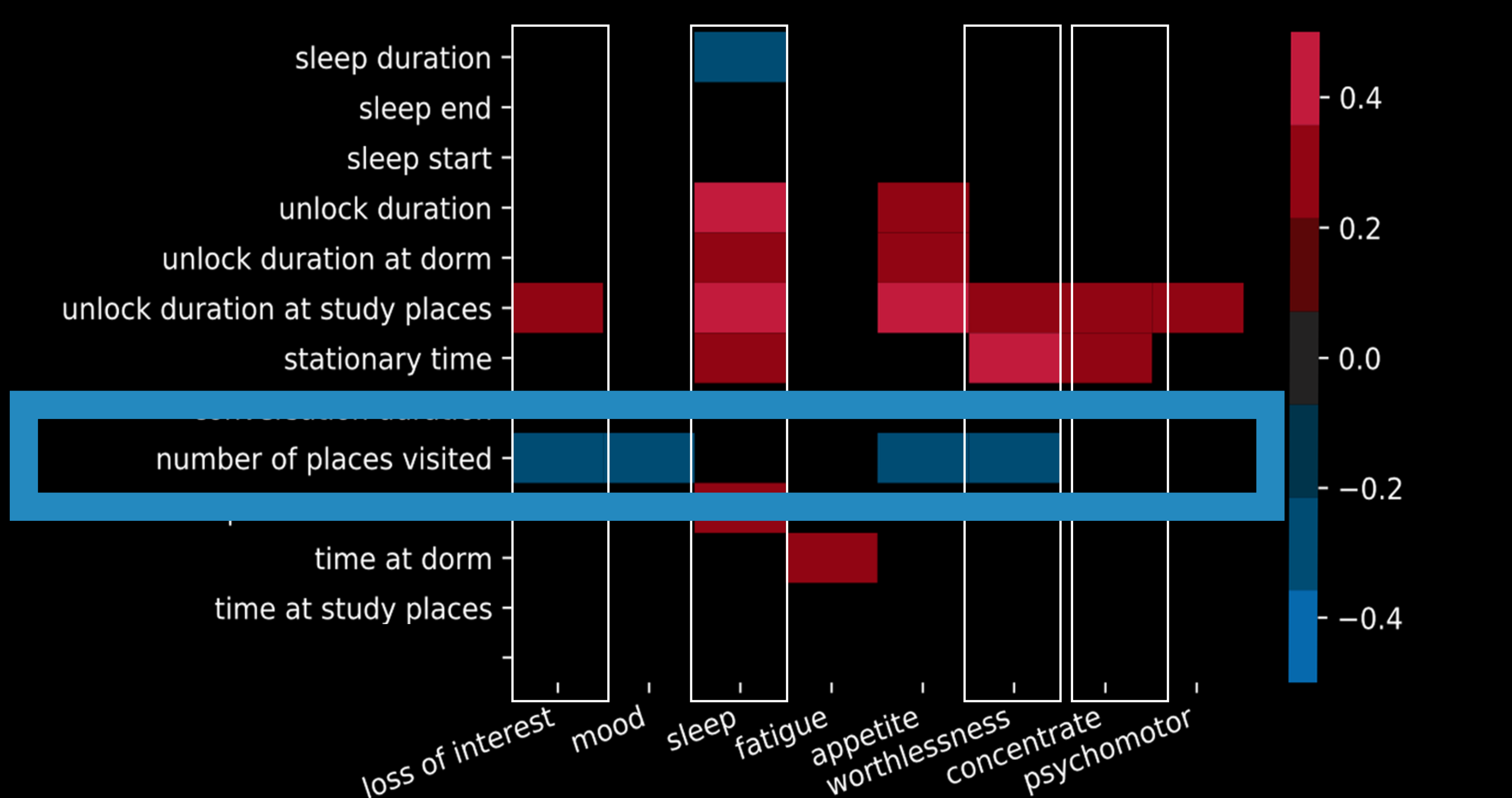
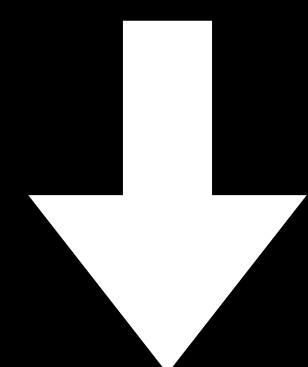
STUDENTLIFE 2.0



p-value < 0.05



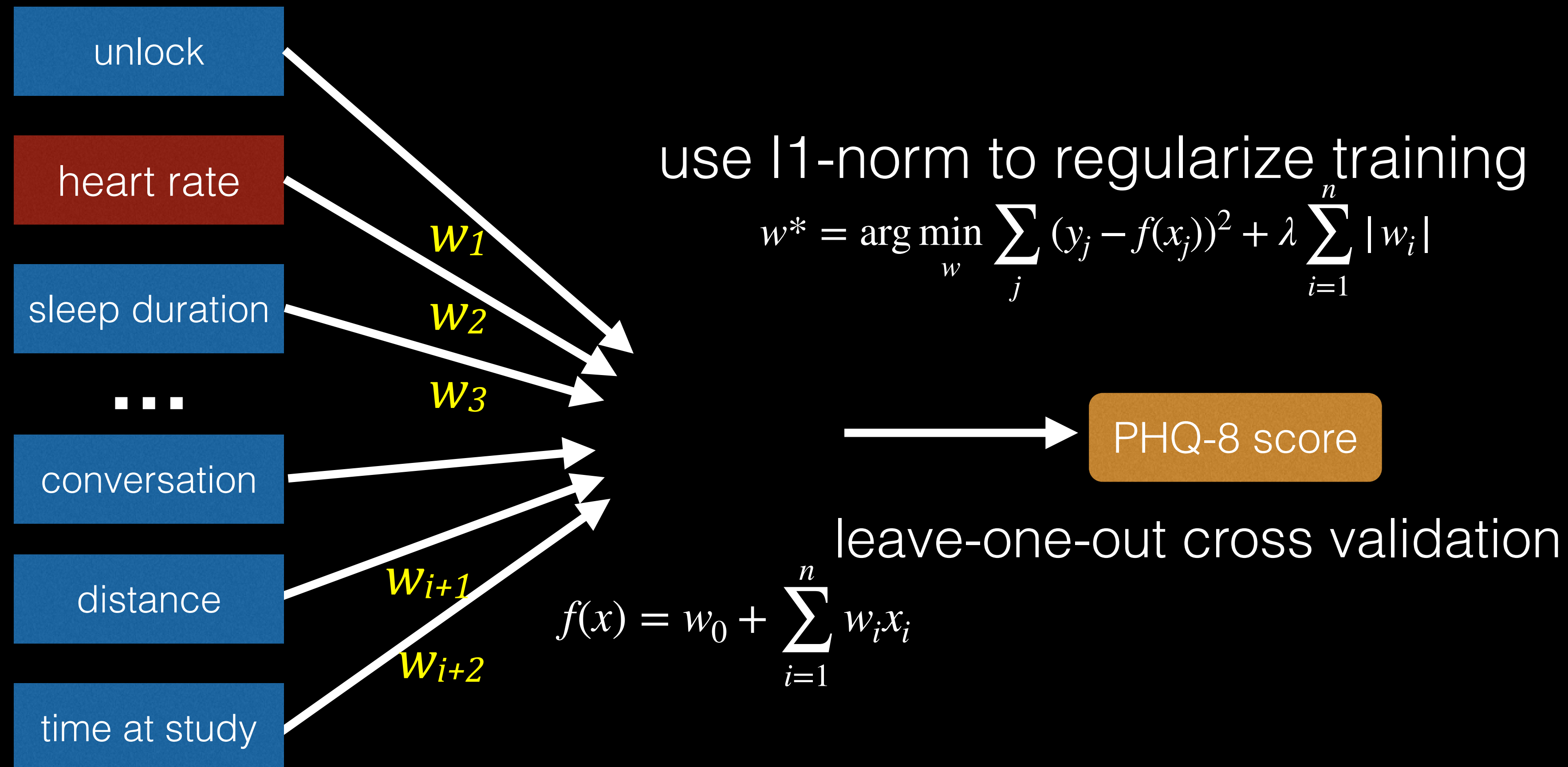
p-value < 0.05



p-value < 0.05

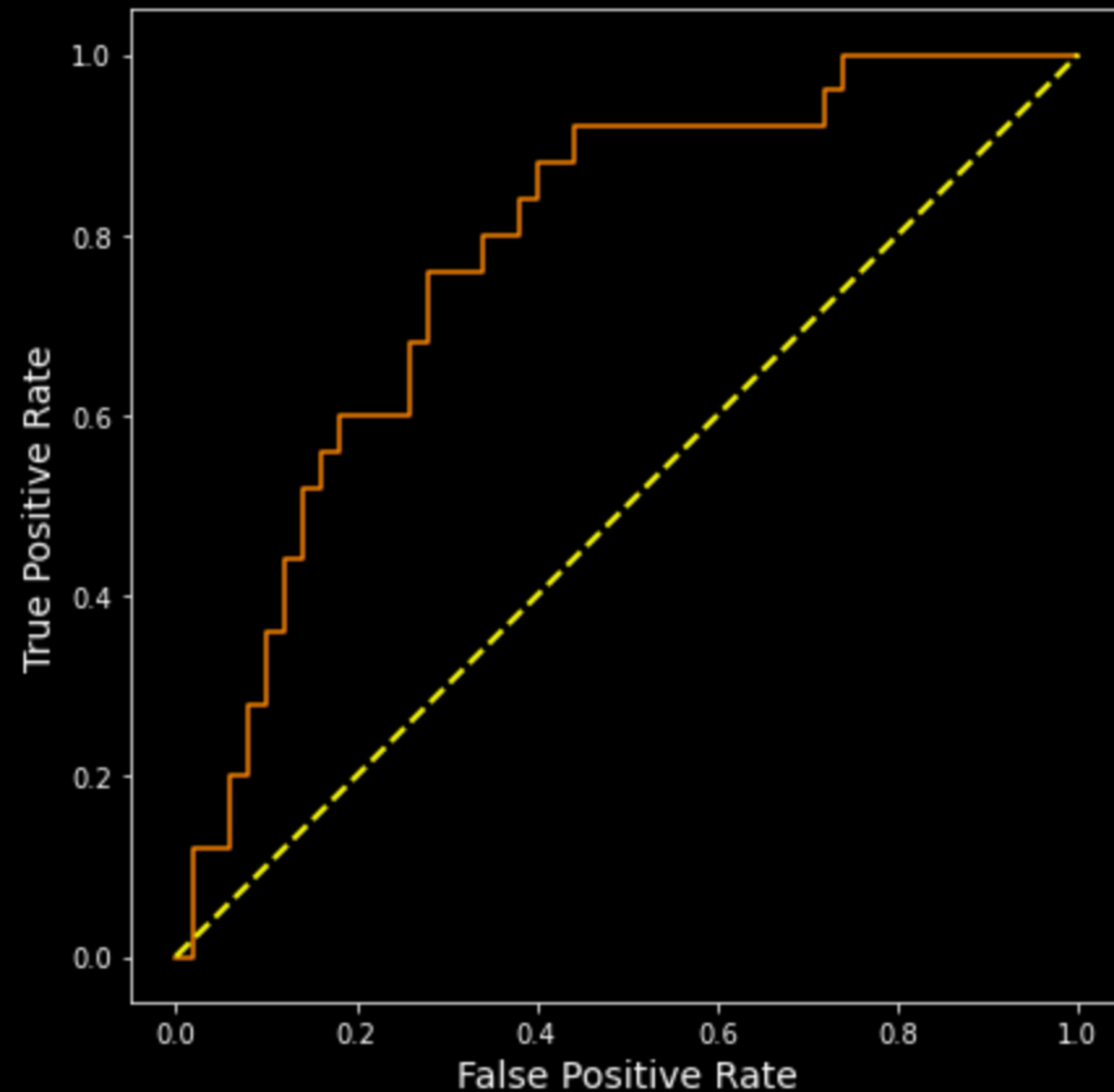
PHONE USAGE AND LOCATION MATTER

PREDICTING DEPRESSION BY TERM

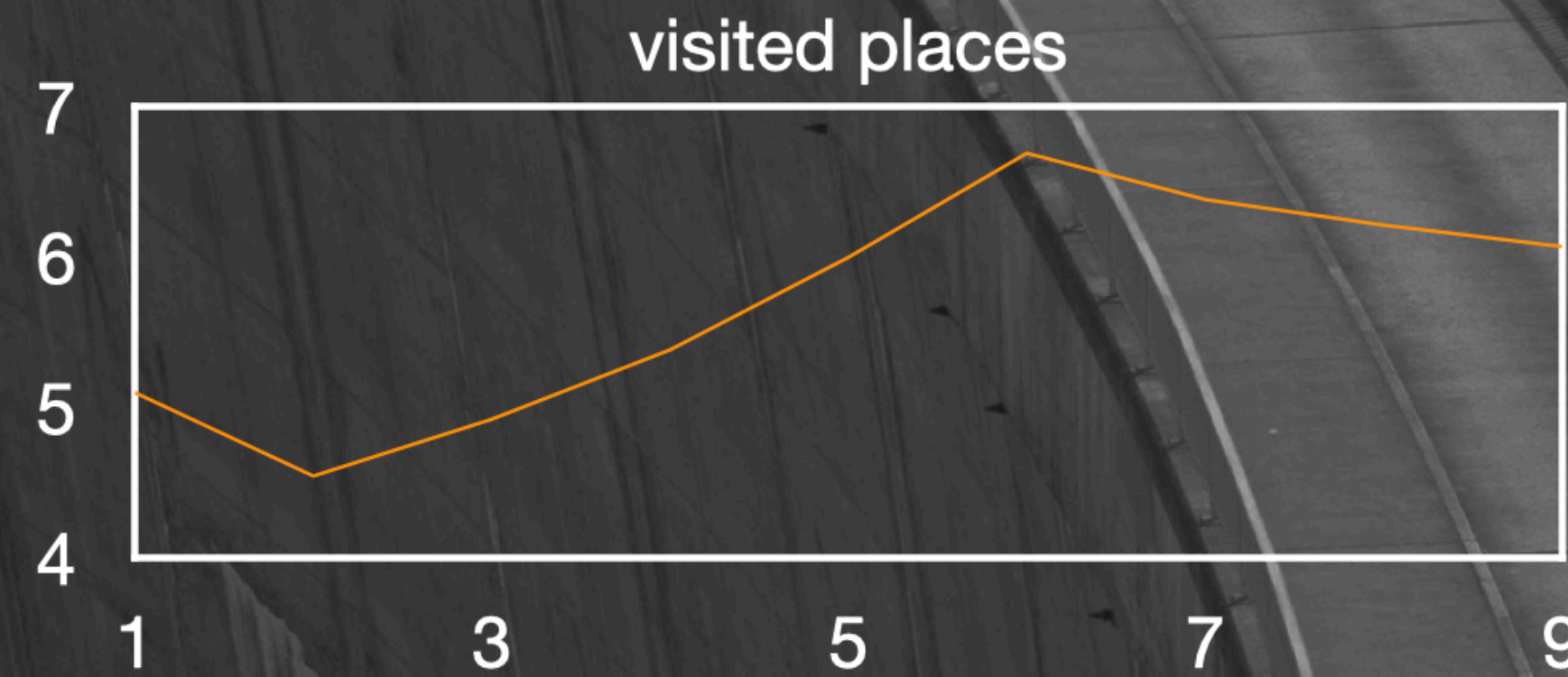
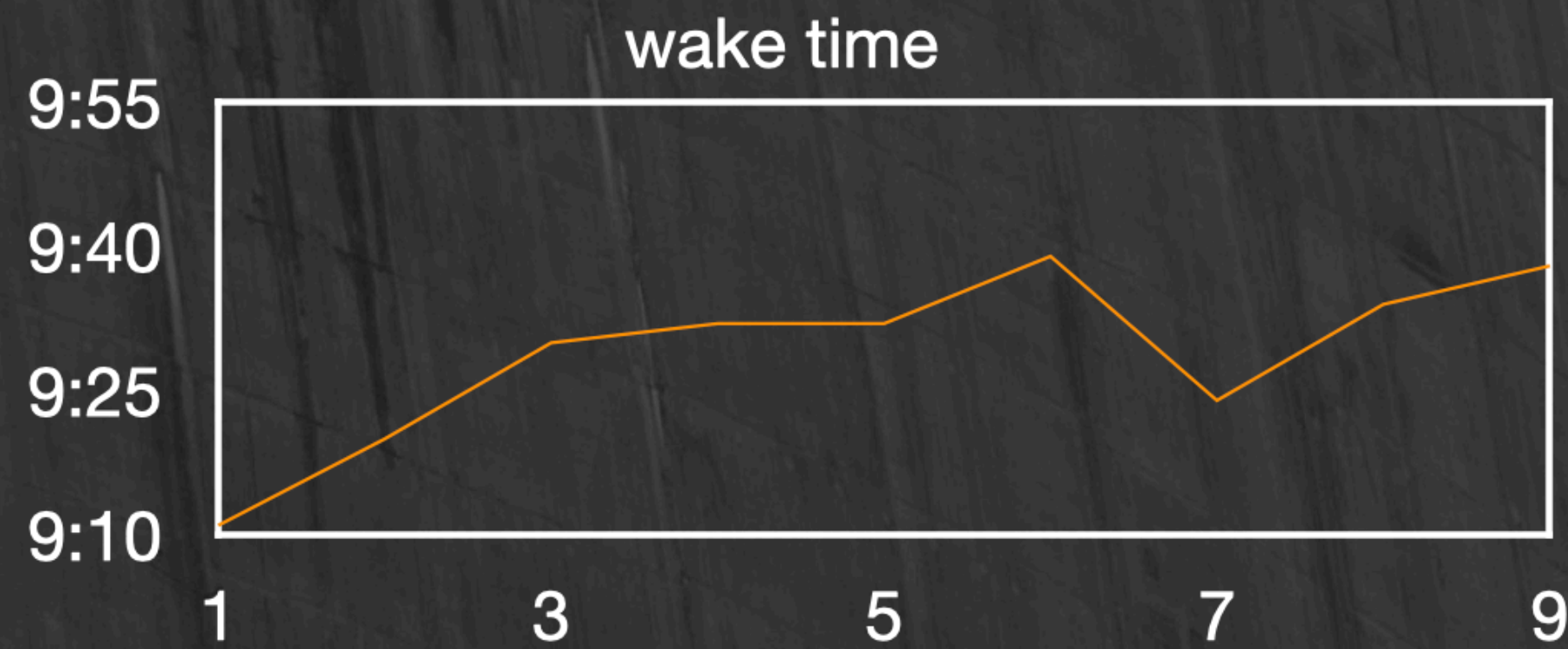
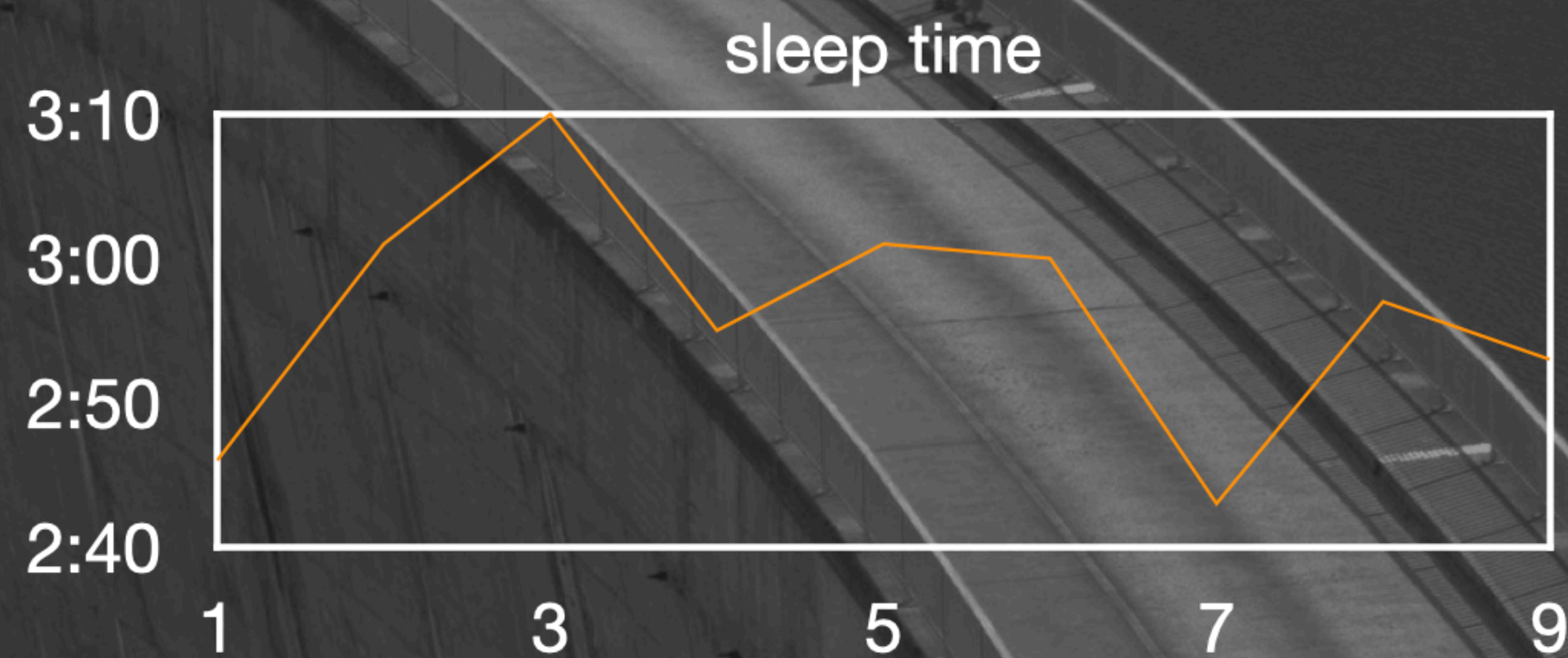
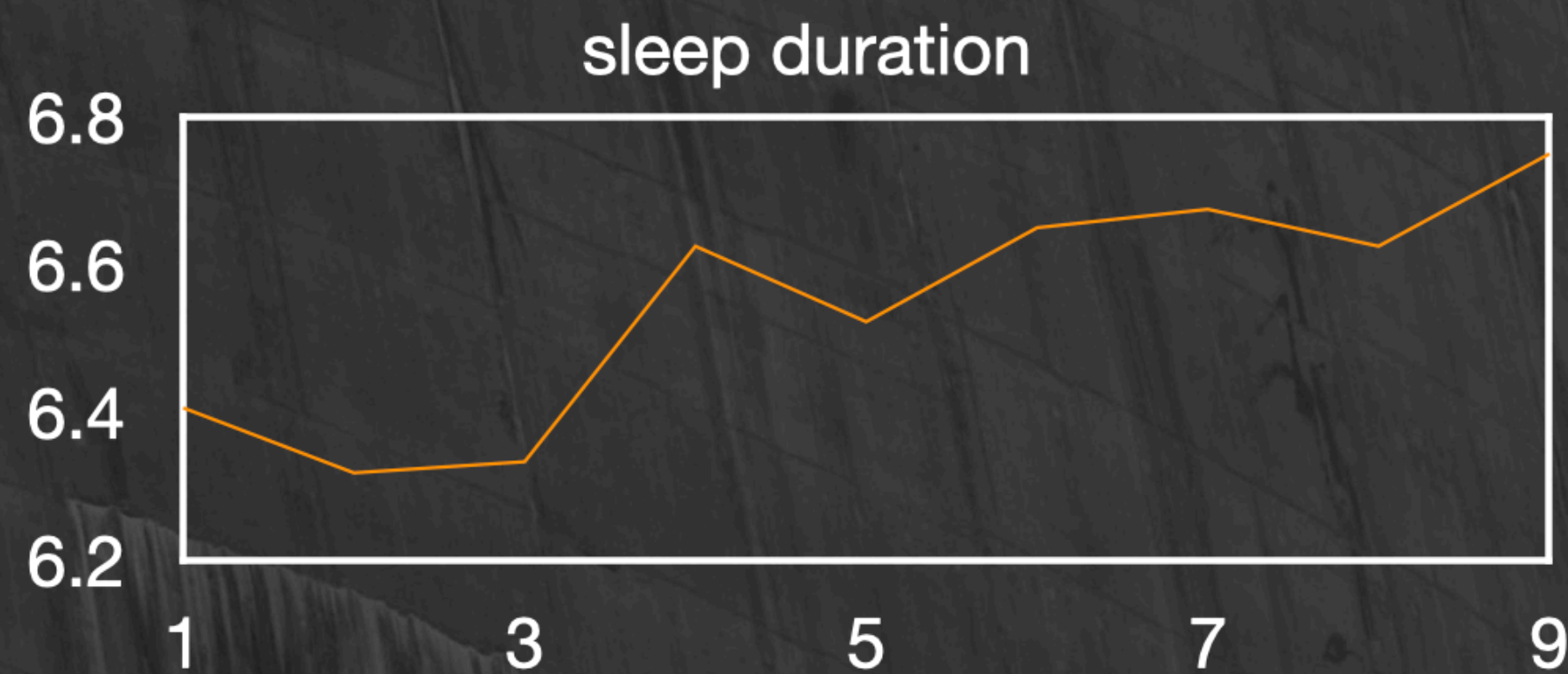
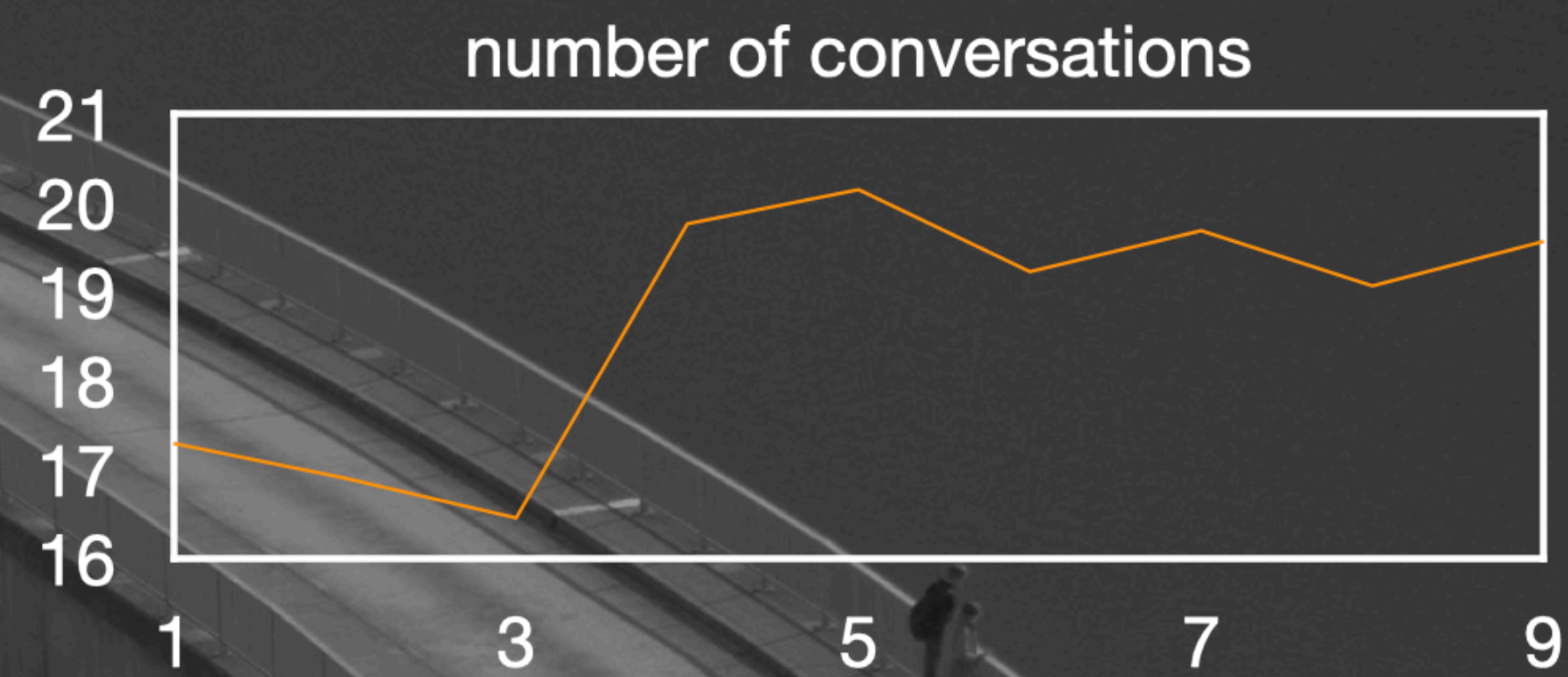
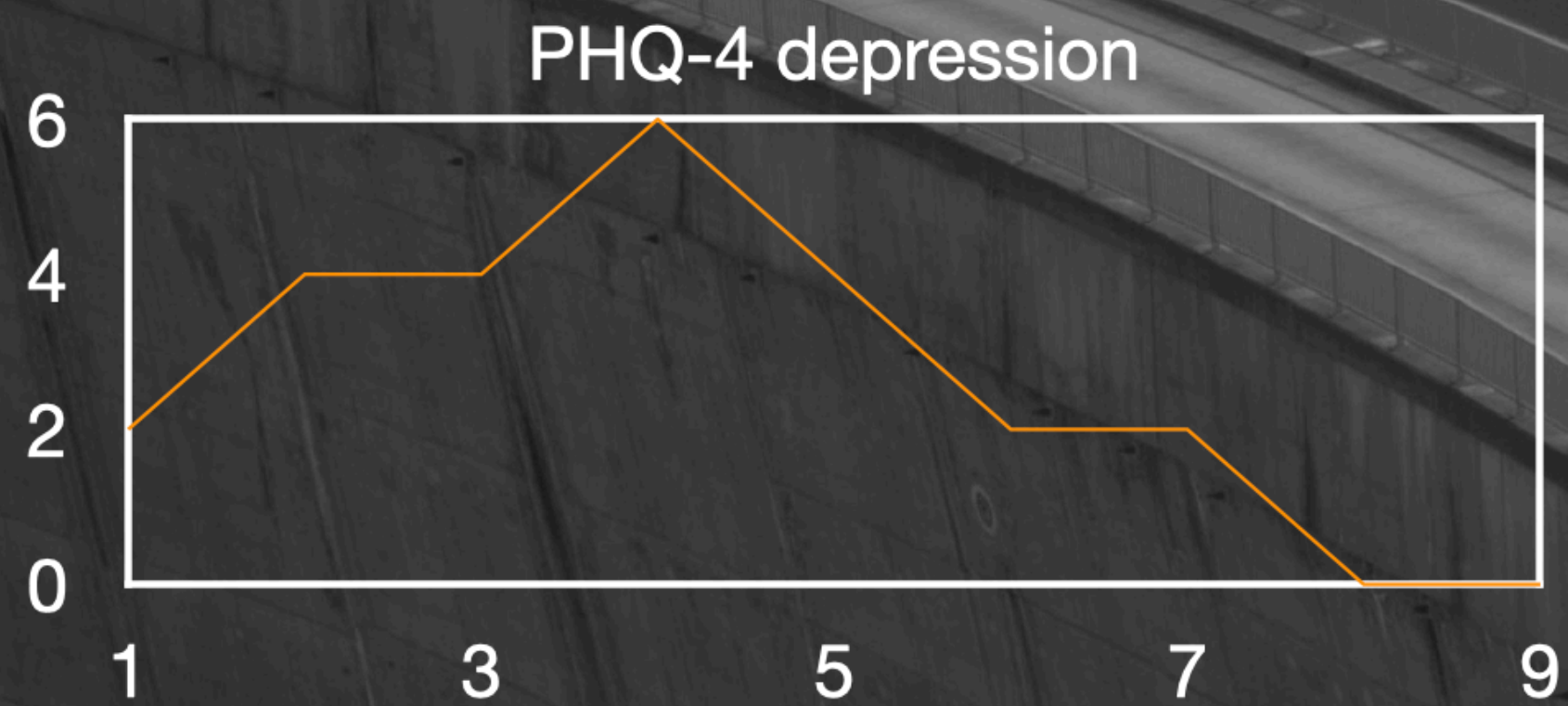


MAE = 2.4, R=0.74 P < 0.001

PREDICTING DEPRESSION WEEK BY WEEK

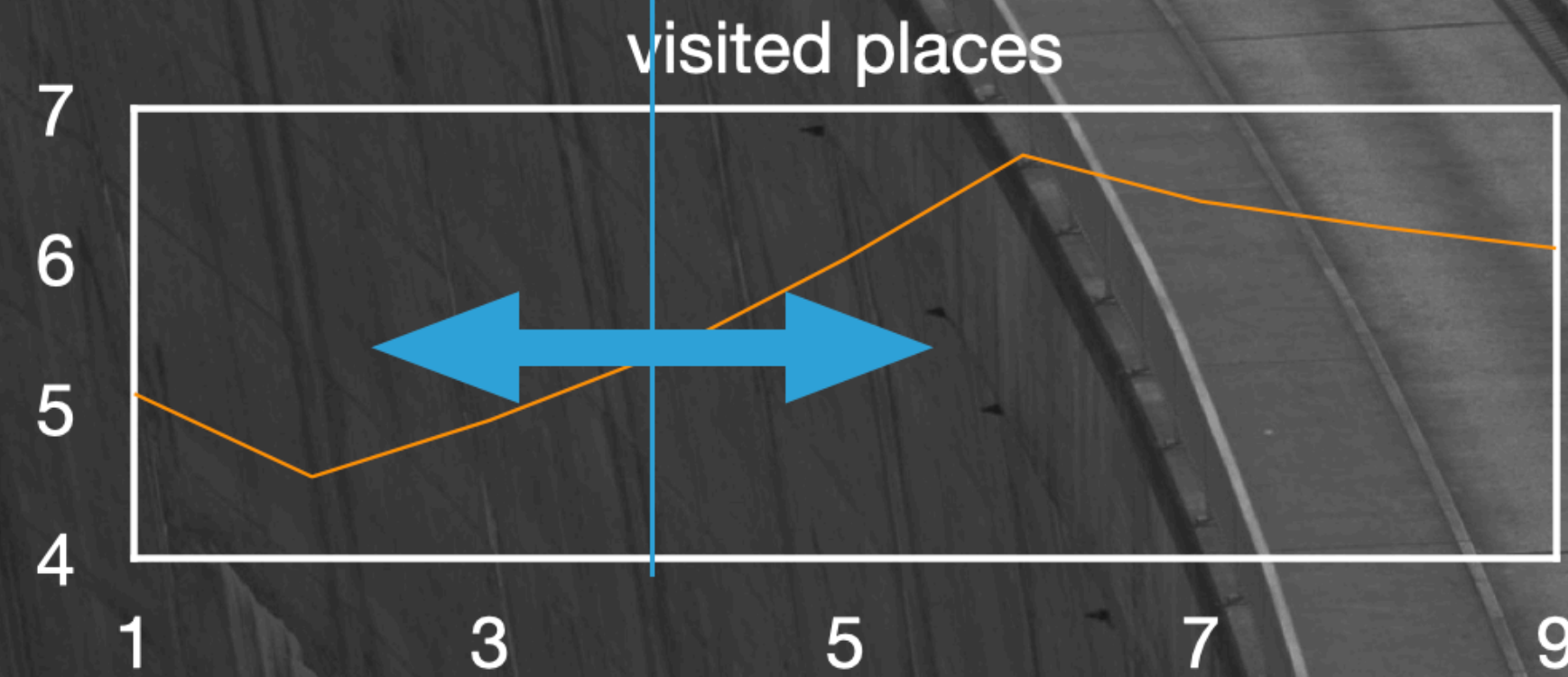
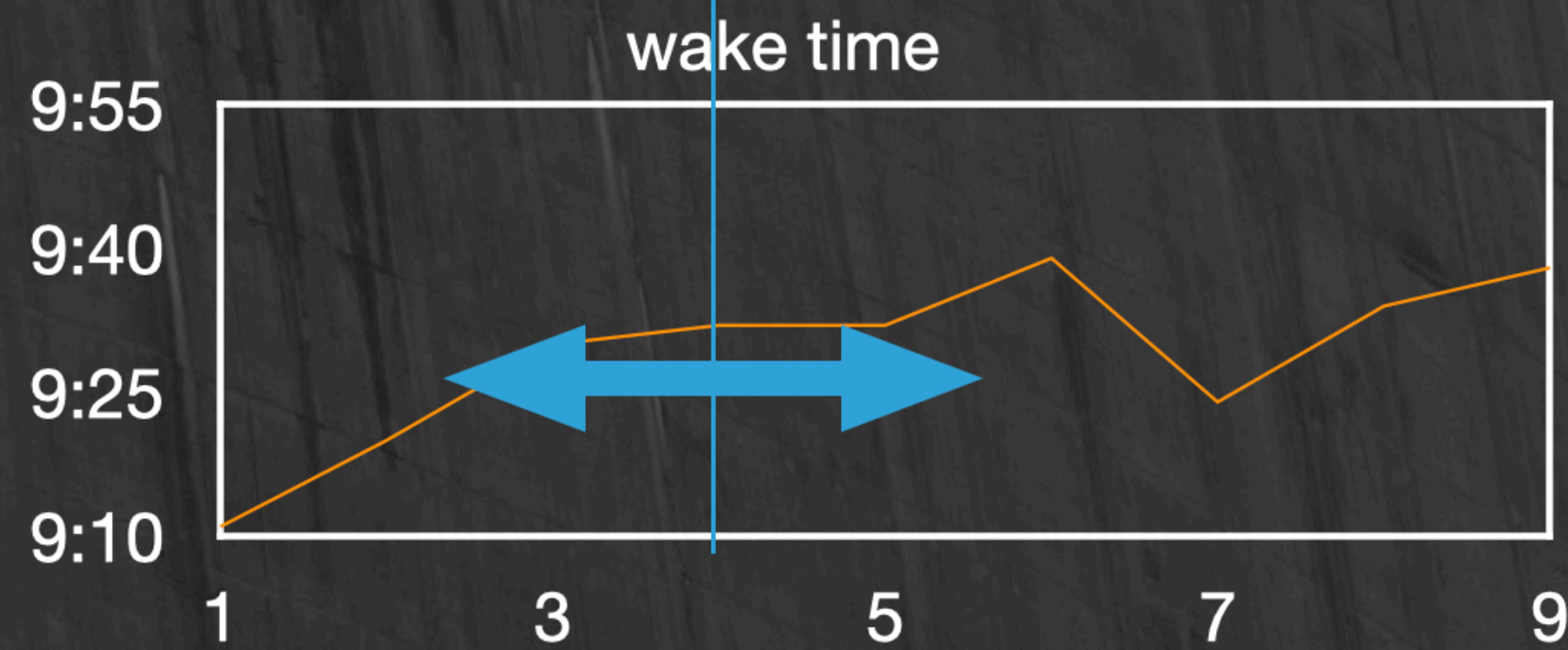
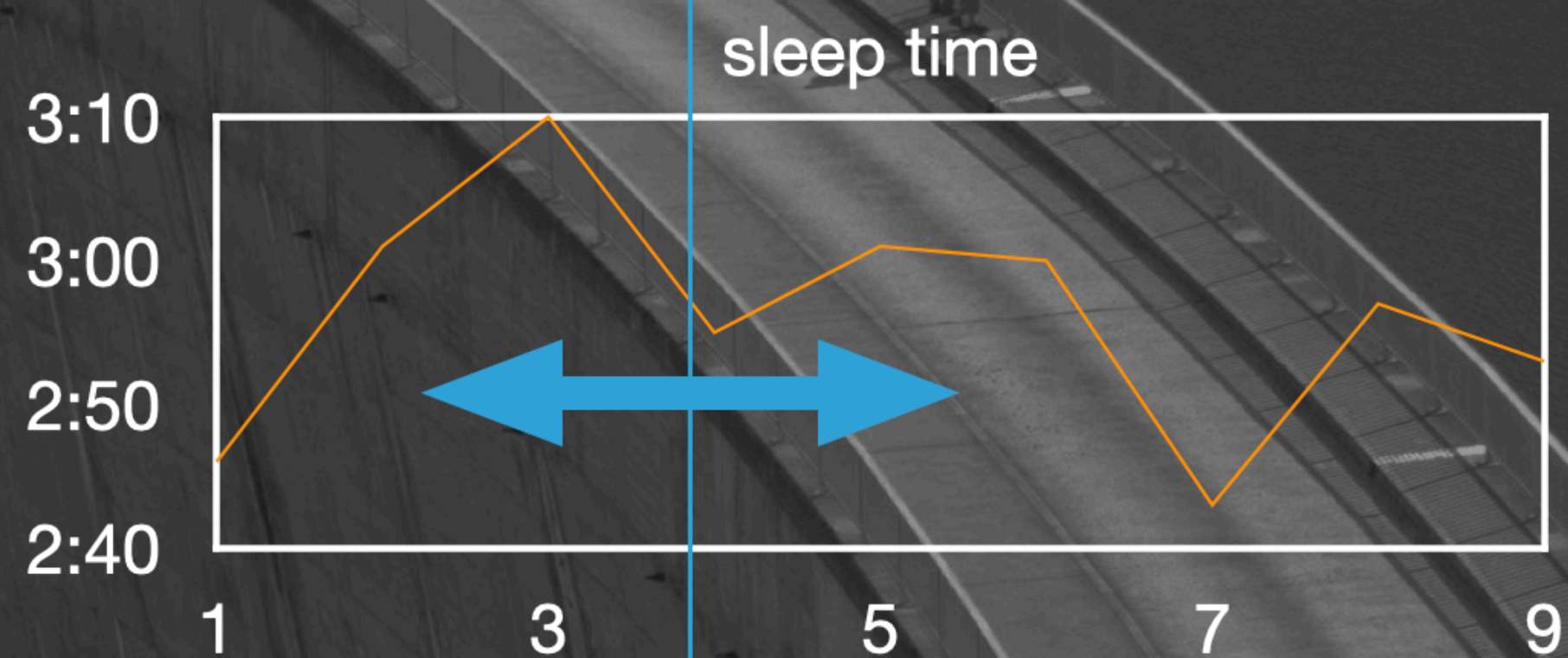
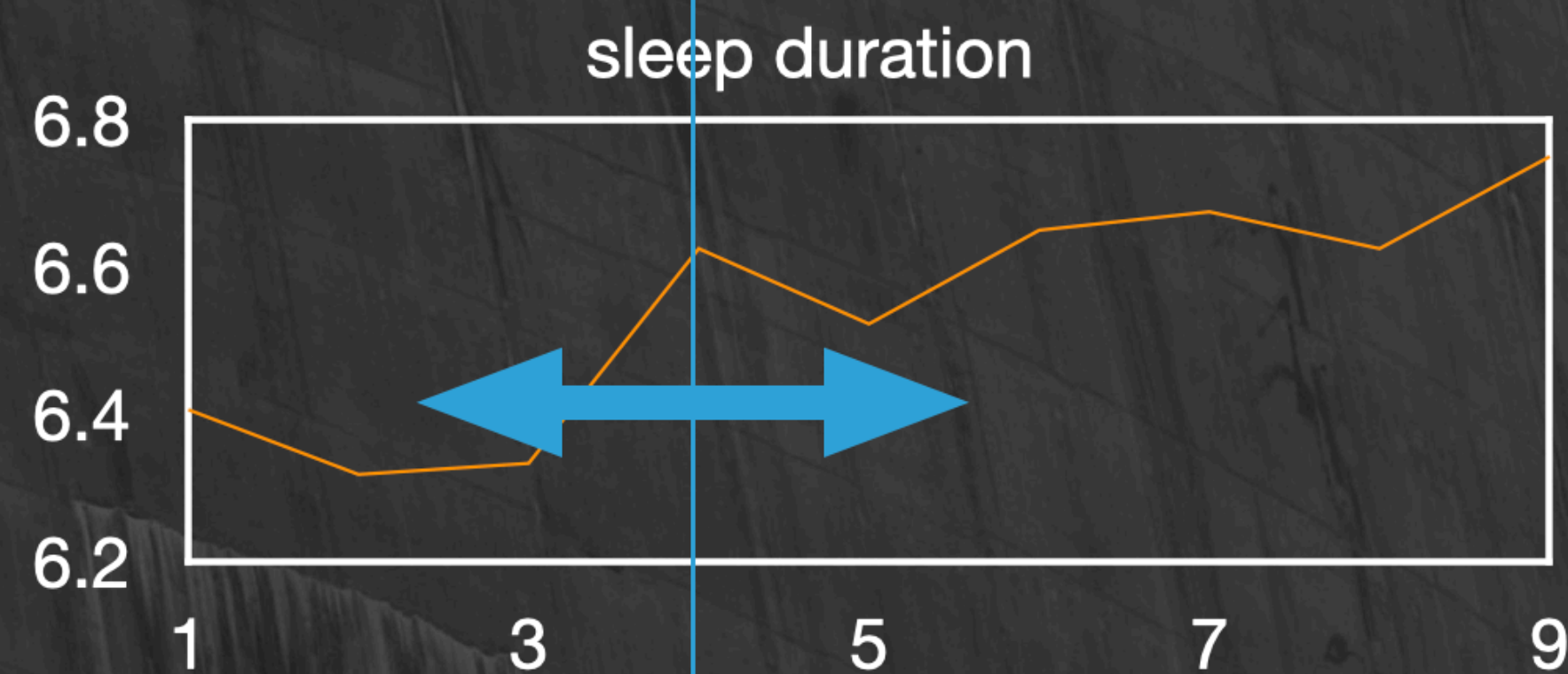
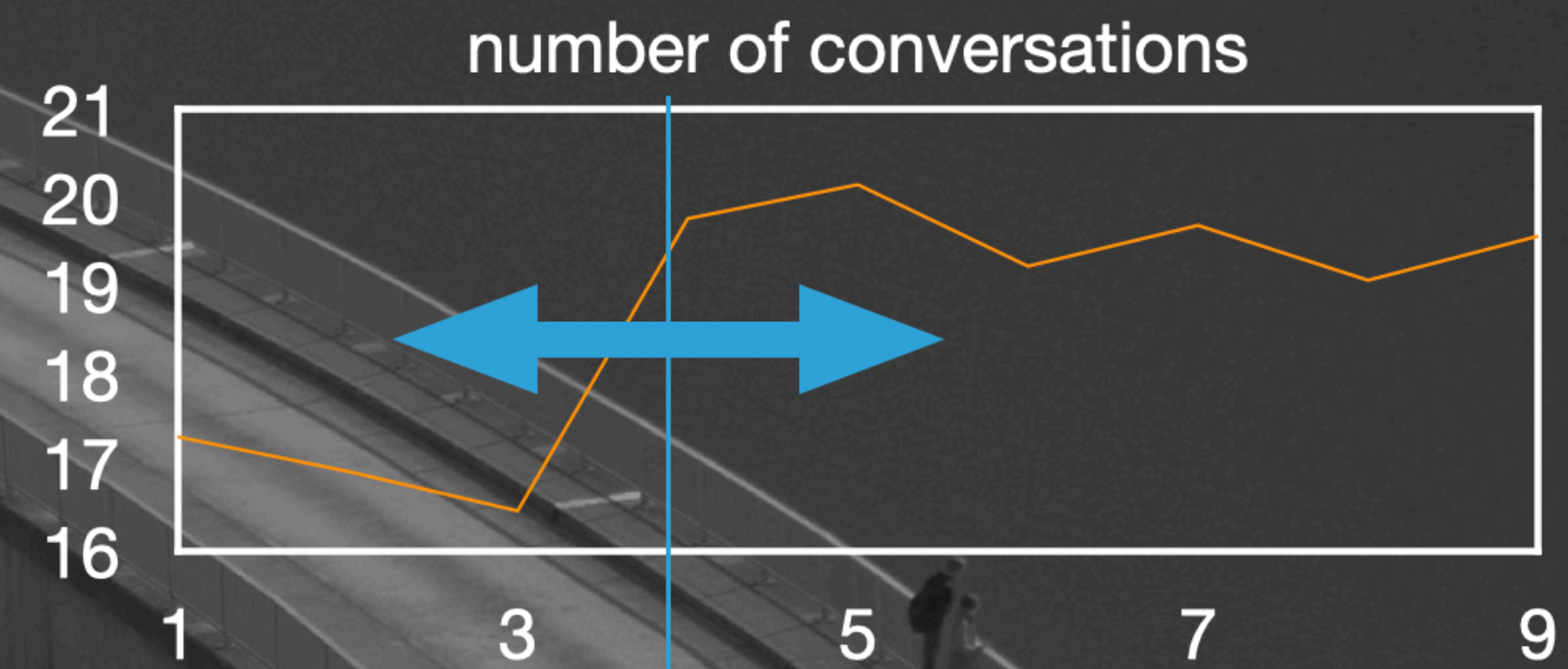
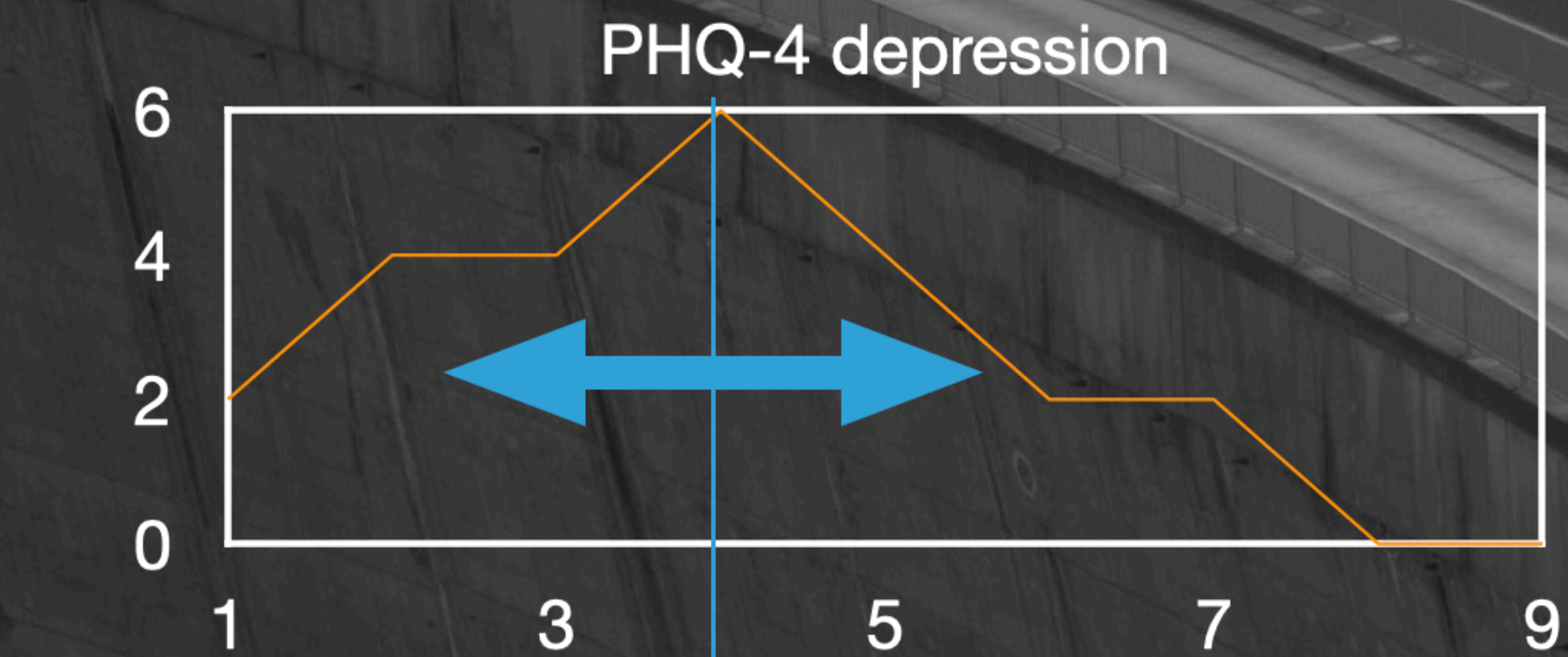


AUC = 0.80, RECALL = 0.81, PRECISION = 0.69



week

week



week

week

REPRODUCIBILITY

GENERALIZABILITY

REPRODUCIBILITY

GENERALIZABILITY

REPRODUCIBILITY

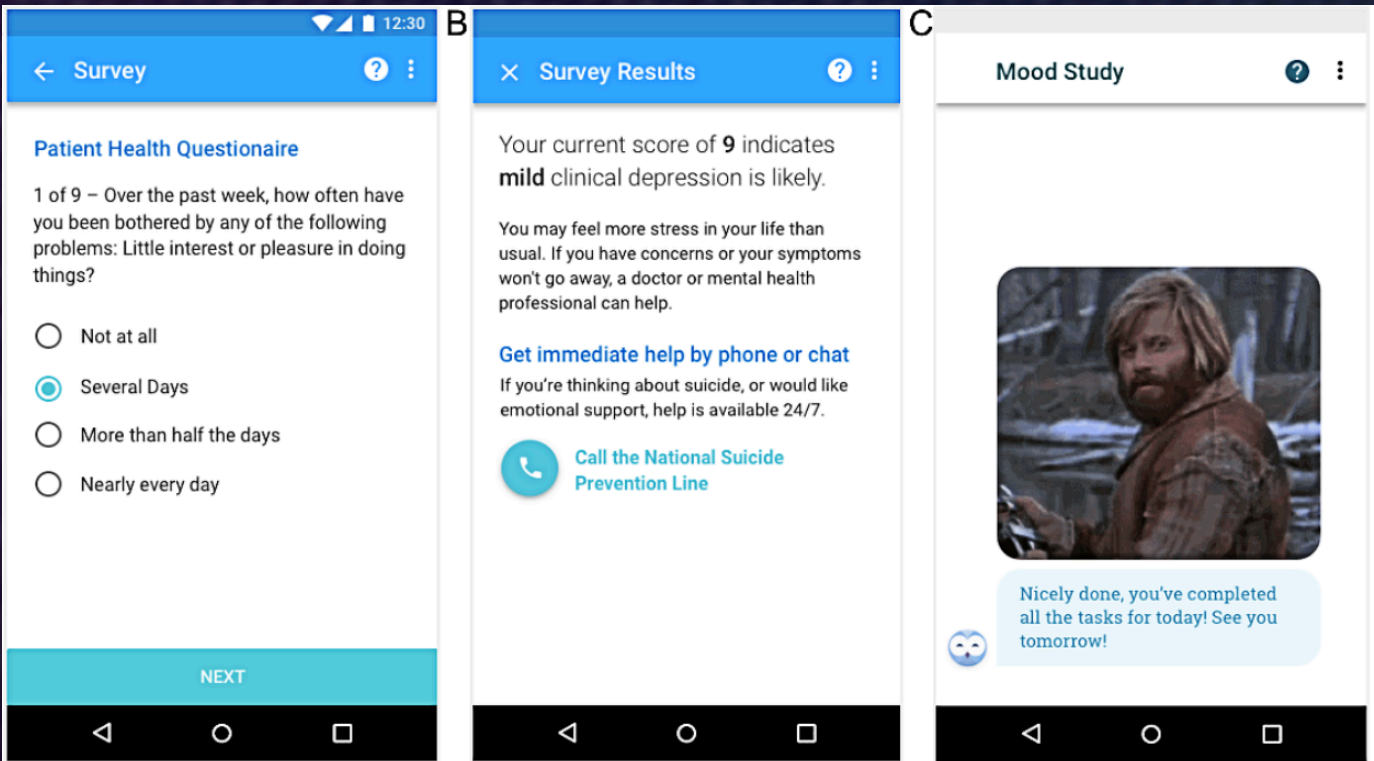
GENERALIZABILITY

REPRODUCIBILITY



Advancing precision health by closing the gap between research & care

We are an Alphabet company focused on applying AI & data science to accelerate evidence generation and enable more precise interventions.



Original Paper

Toward a Mobile Platform for Real-world Digital Measurement of Depression: User-Centered Design, Data Quality, and Behavioral and Clinical Modeling

Stefanie Nickels¹, PhD; Matthew D Edwards¹, PhD; Sarah F Poole¹, PhD; Dale Winter¹, PhD; Jessica Gronsbell¹, PhD; Bella Rozenkrants¹, PhD; David P Miller¹, MSc; Mathias Fleck¹, PhD; Alan McLean¹; Bret Peterson¹, PhD; Yuanwei Chen¹, PhD; Alan Hwang¹, ScB; David Rust-Smith¹, BCS; Arthur Brant¹, MD; Andrew Campbell², PhD; Chen Chen¹, MS; Collin Walter¹, MBA; Patricia A Arean³, PhD; Honor Hsin¹, MD-PhD; Lance J Myers¹, PhD; William J Marks Jr¹, MS-HCM, MD; Jessica L Mega¹, MPH, MD; Danielle A Schlosser¹, PhD; Andrew J Conrad¹, PhD; Robert M Califf¹, MD; Menachem Fromer¹, PhD

¹Verily Life Sciences, South San Francisco, CA, United States
²Department of Computer Science, Dartmouth College, Hanover, NH, United States
³Department of Psychiatry & Behavioral Sciences, University of Washington, Seattle, WA, United States

Corresponding Author:
Stefanie Nickels, PhD
Verily Life Sciences
269 E Grand Ave
South San Francisco, CA, 94080
United States
Phone: 1 833 391 8633
Email: stefnickels@verily.com

Abstract

Background: Although effective mental health treatments exist, the ability to match individuals to optimal treatments is poor, and timely assessment of response is difficult. One reason for these challenges is the lack of objective measurement of psychiatric symptoms. Sensors and active tasks, enabled by smartphones, provide a new paradigm for capturing and analyzing mental health data.



STUDENTLIFE 3.0

N=200: ACROSS FOUR YEARS OF DARTMOUTH

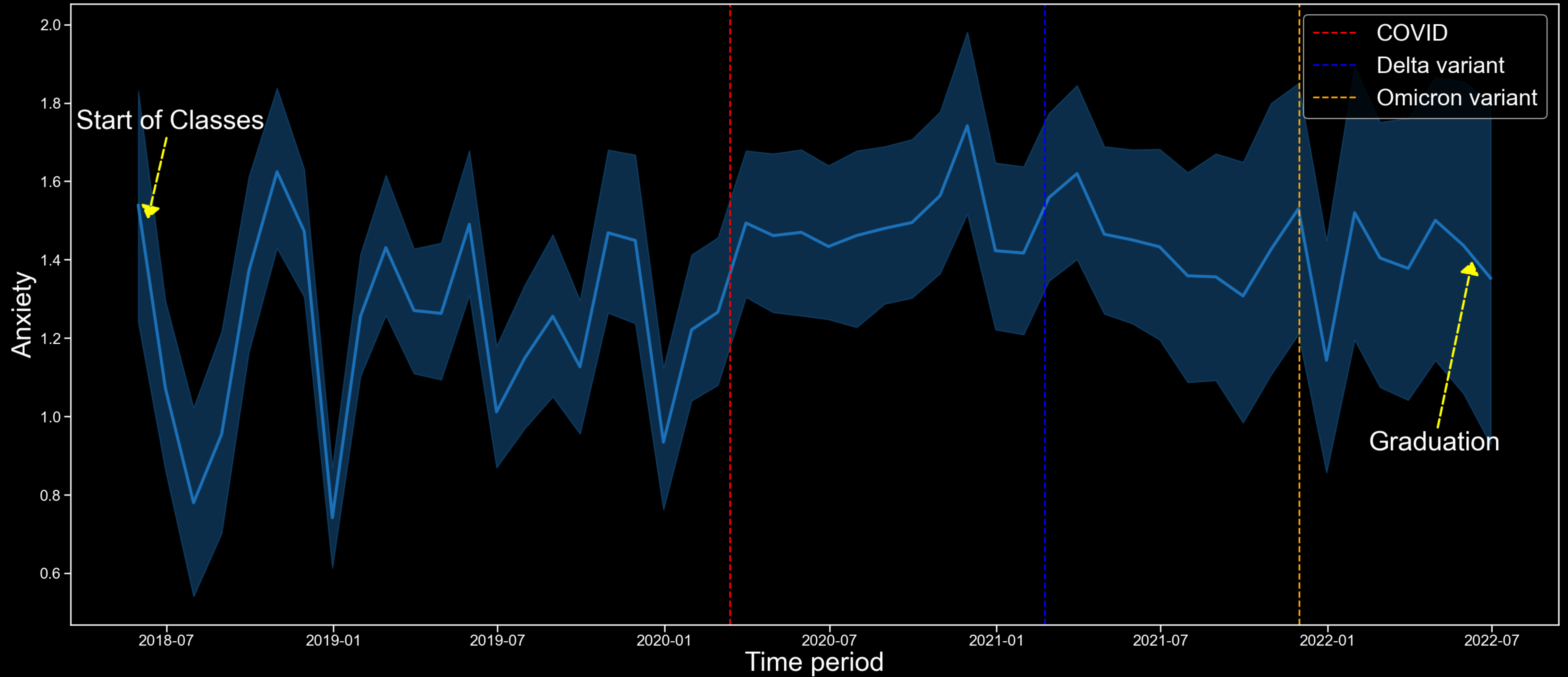


STUDENTLIFE 3.0 STARTED FALL 2018

THEN EVERYTHING CHANGED



COVID HAPPENED

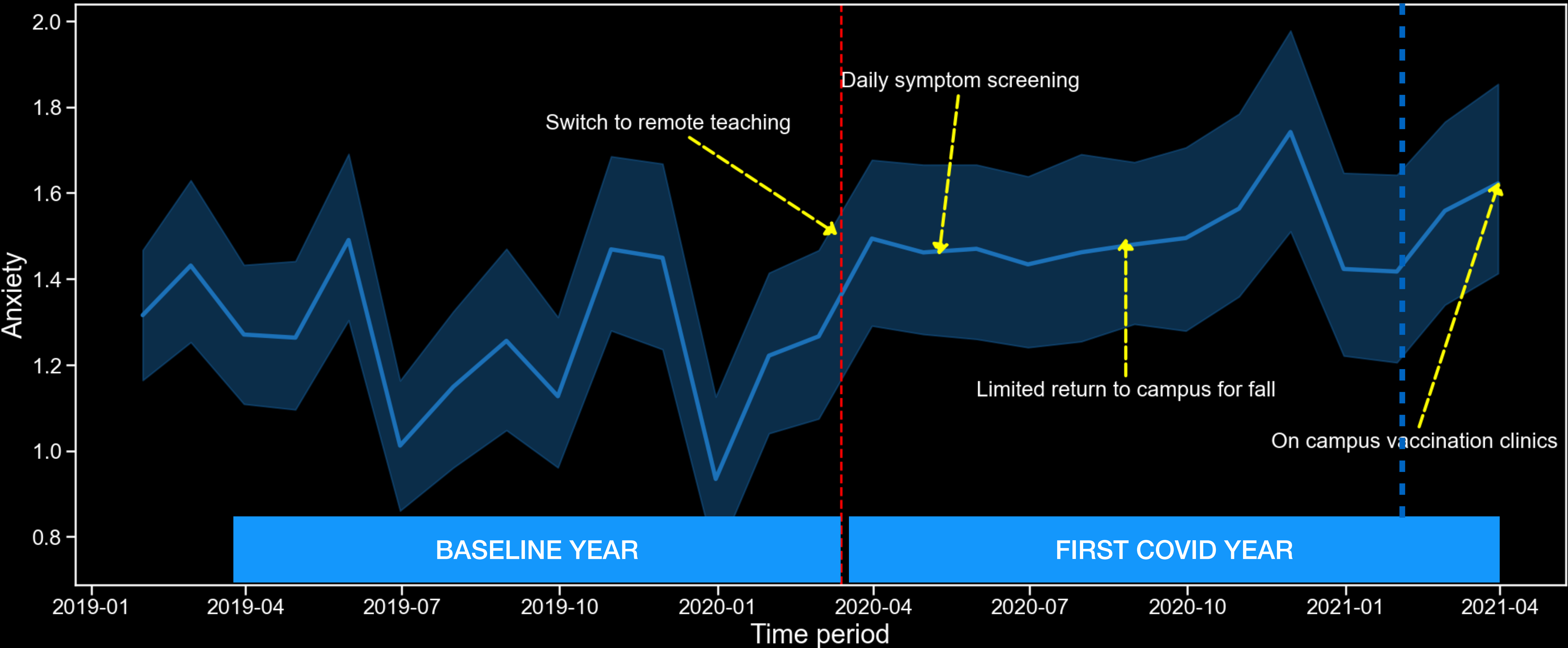


24-7-52-4 BEHAVIORAL SENSING

THE LONGEST LONGITUDINAL STUDY

7 MILLION HOURS OF DATA

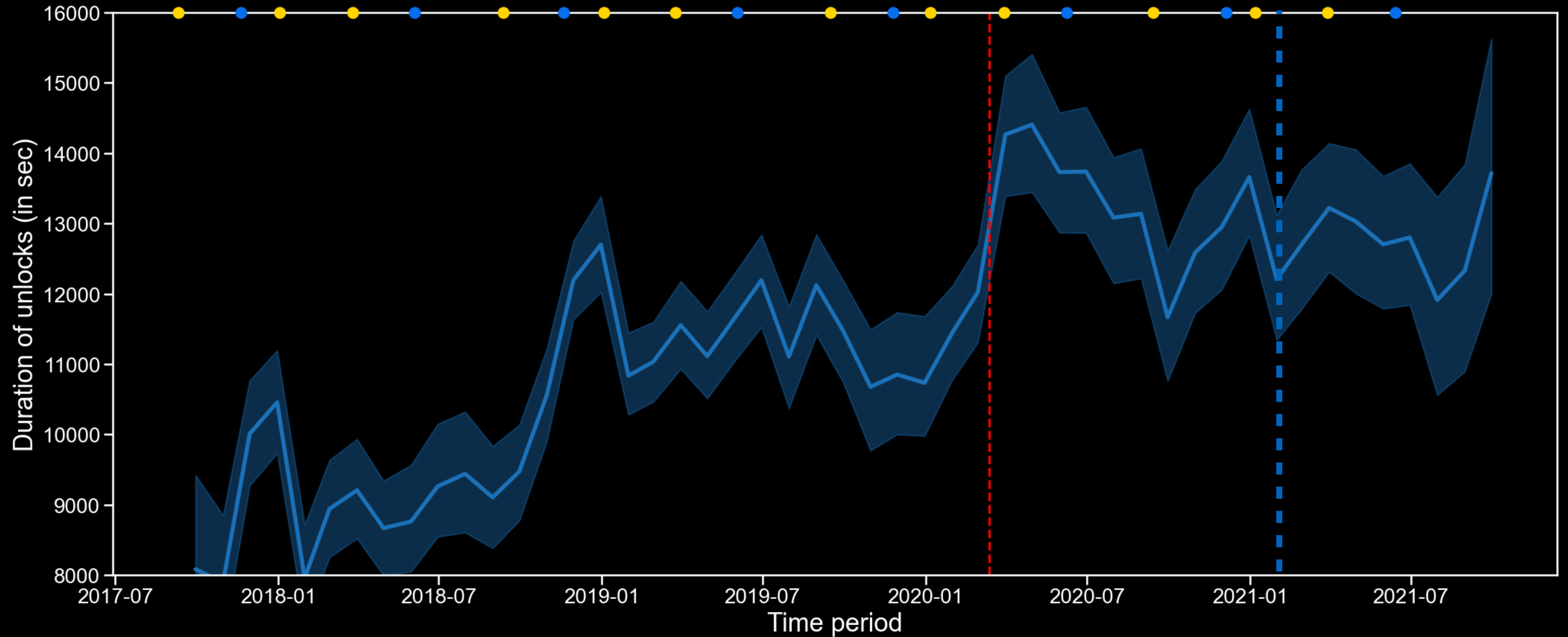
BASELINE AND FIRST COVID YEAR



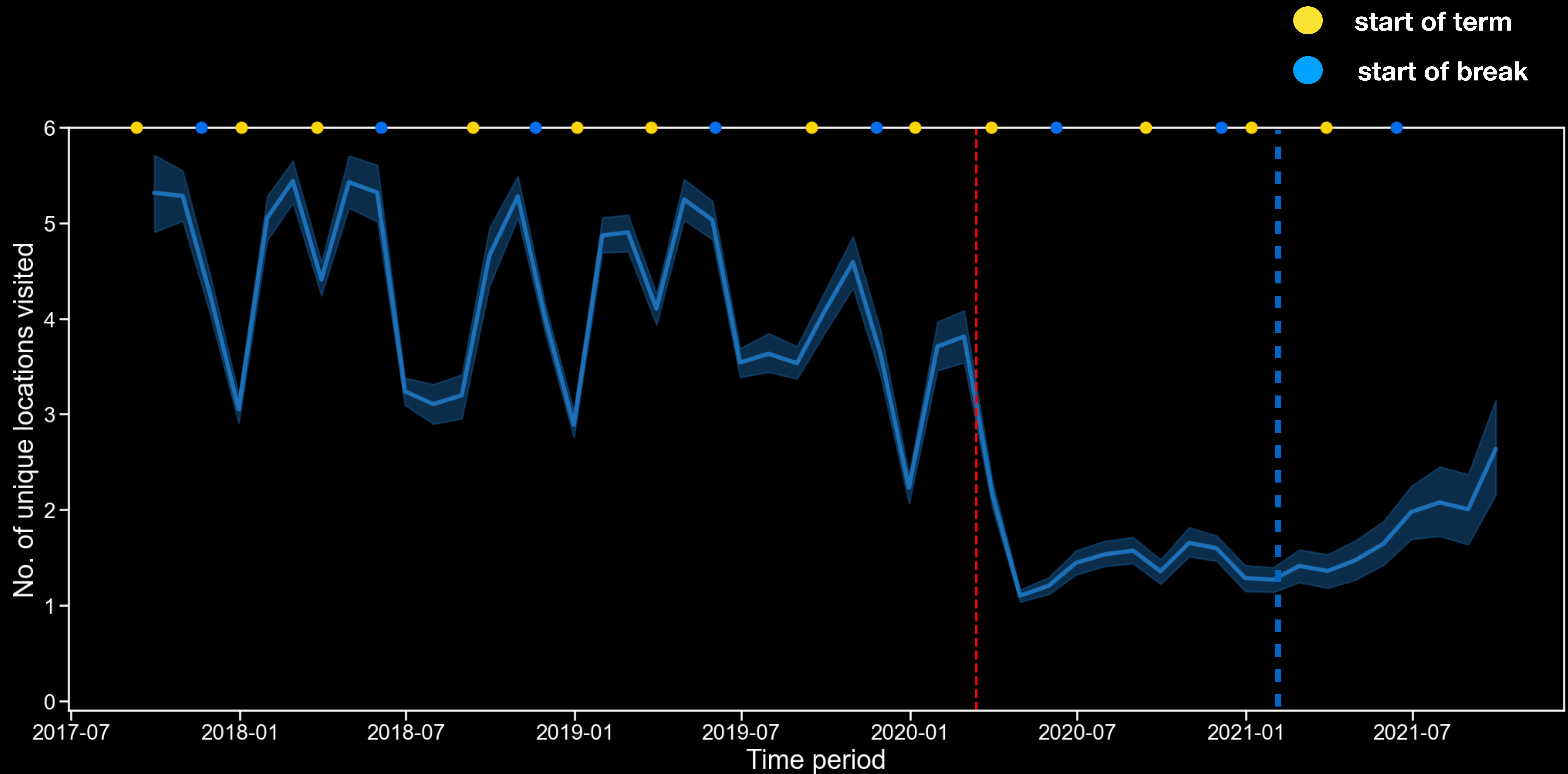
LET'S LOOK AT BEHAVIORIAL DIFFERENCES

PHONE USAGE

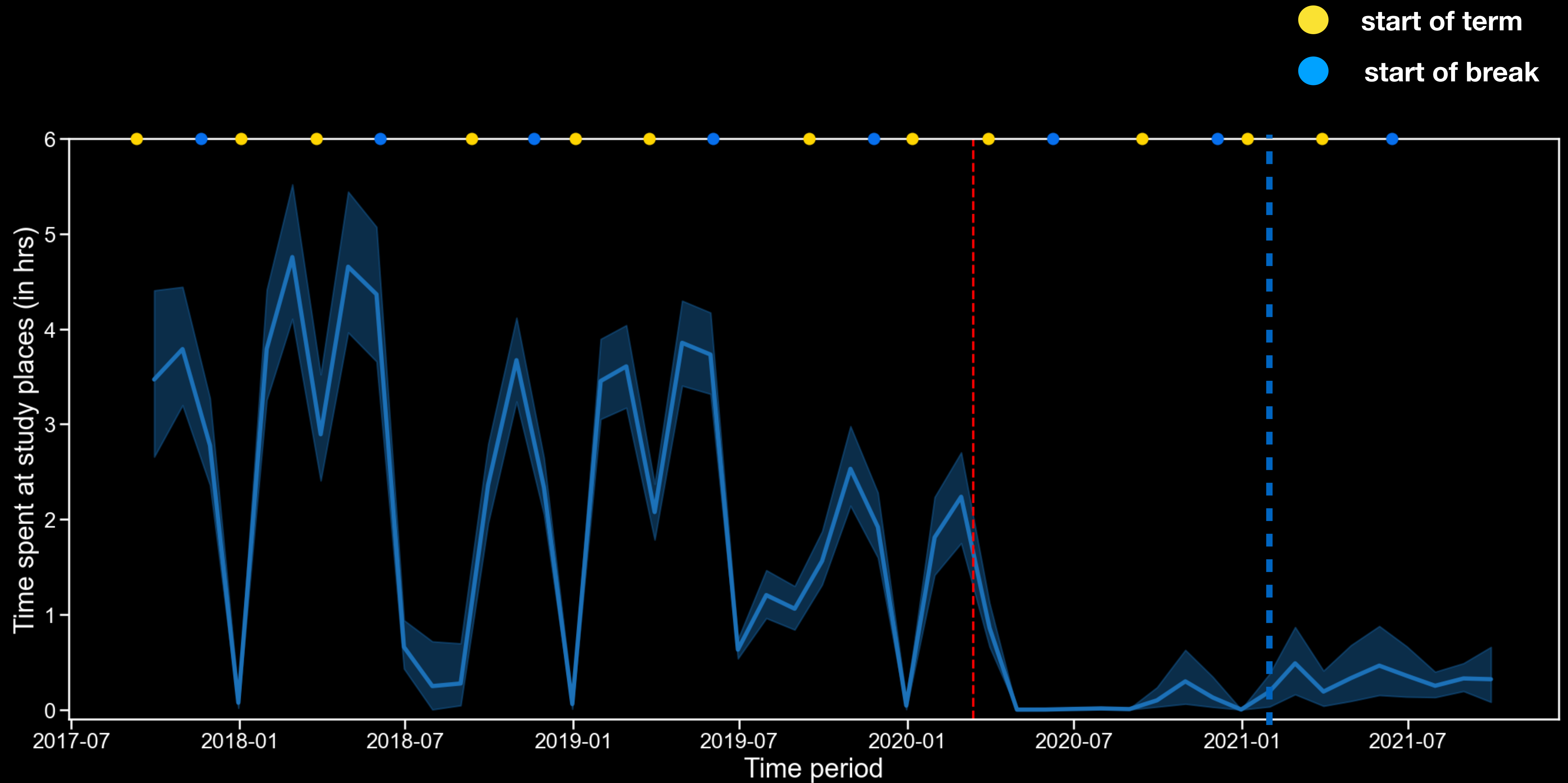
- start of term
- start of break



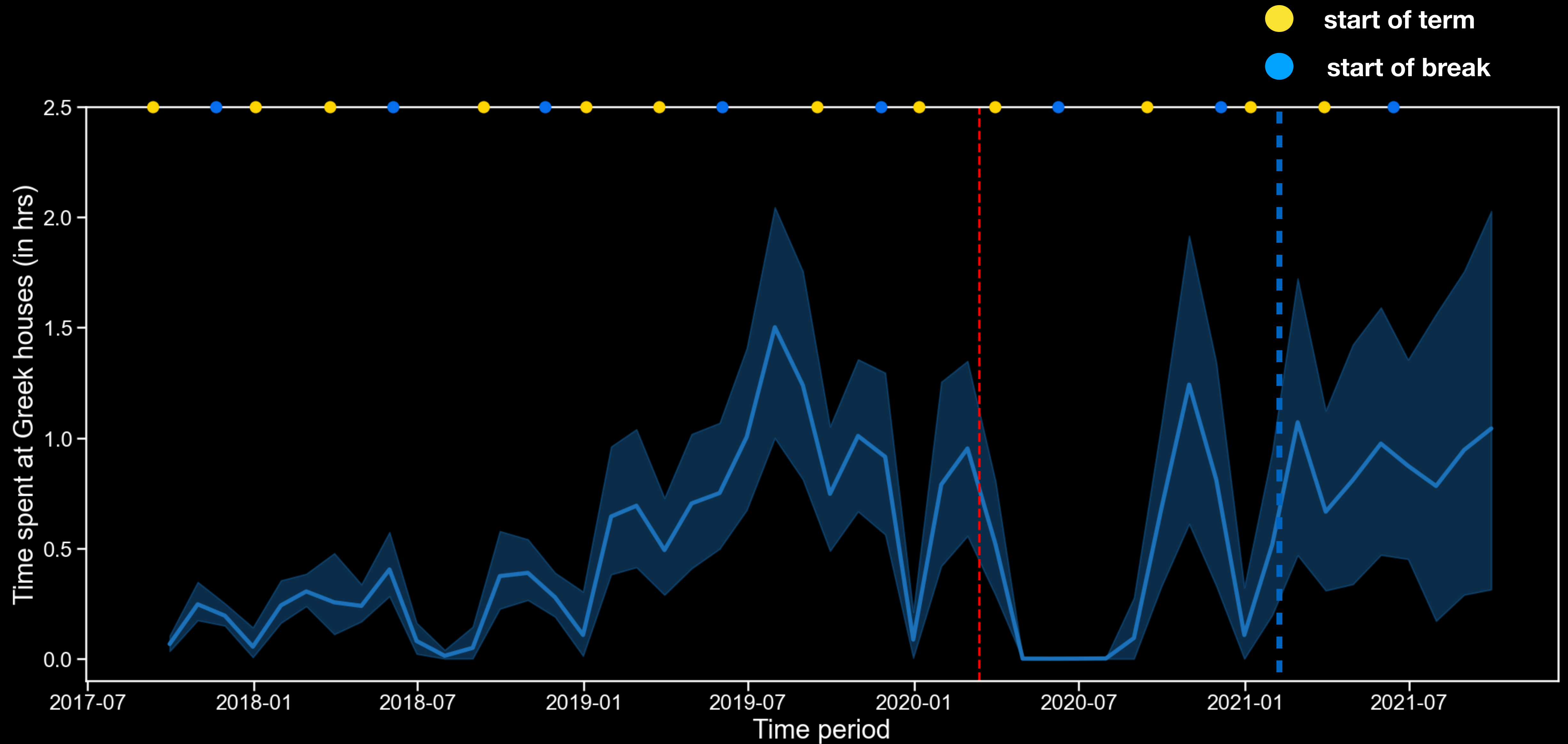
LOCATIONS VISITED



STUDYING



PARTYING

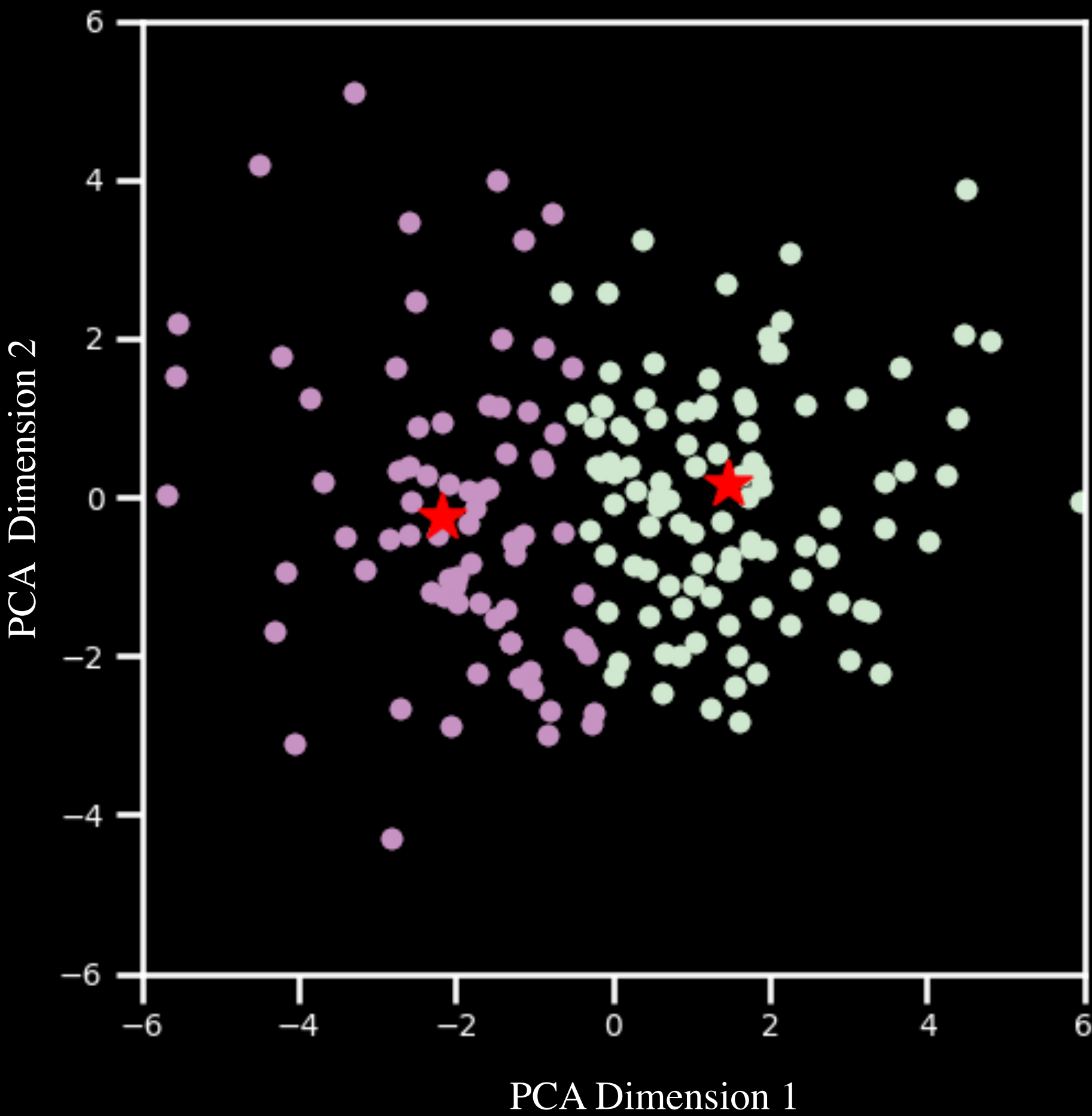




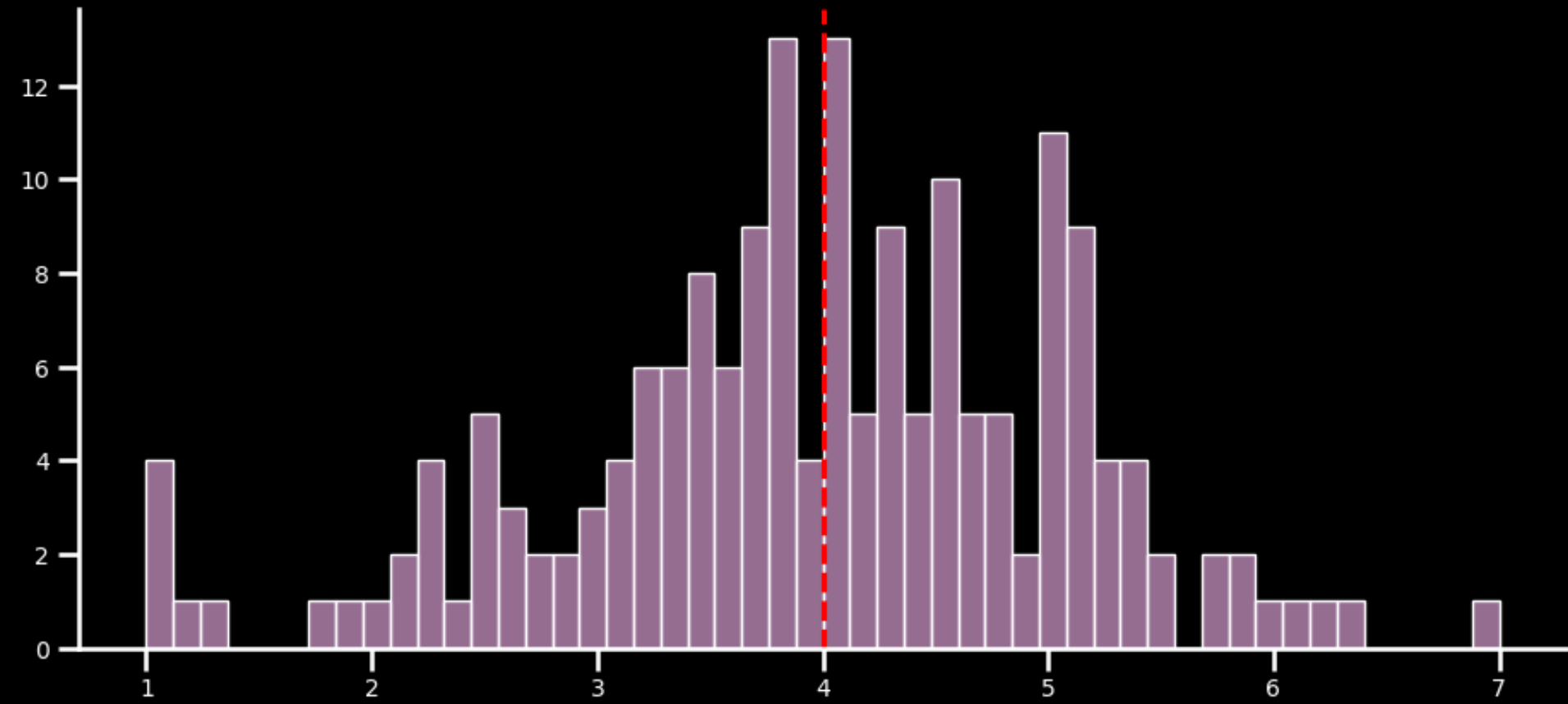
STUDENT BEHAVIOR CHANGED DURING COVID

TWO DIFFERENT DARTMOUTH GROUPS

POOR MENTAL HEALTH GROUP

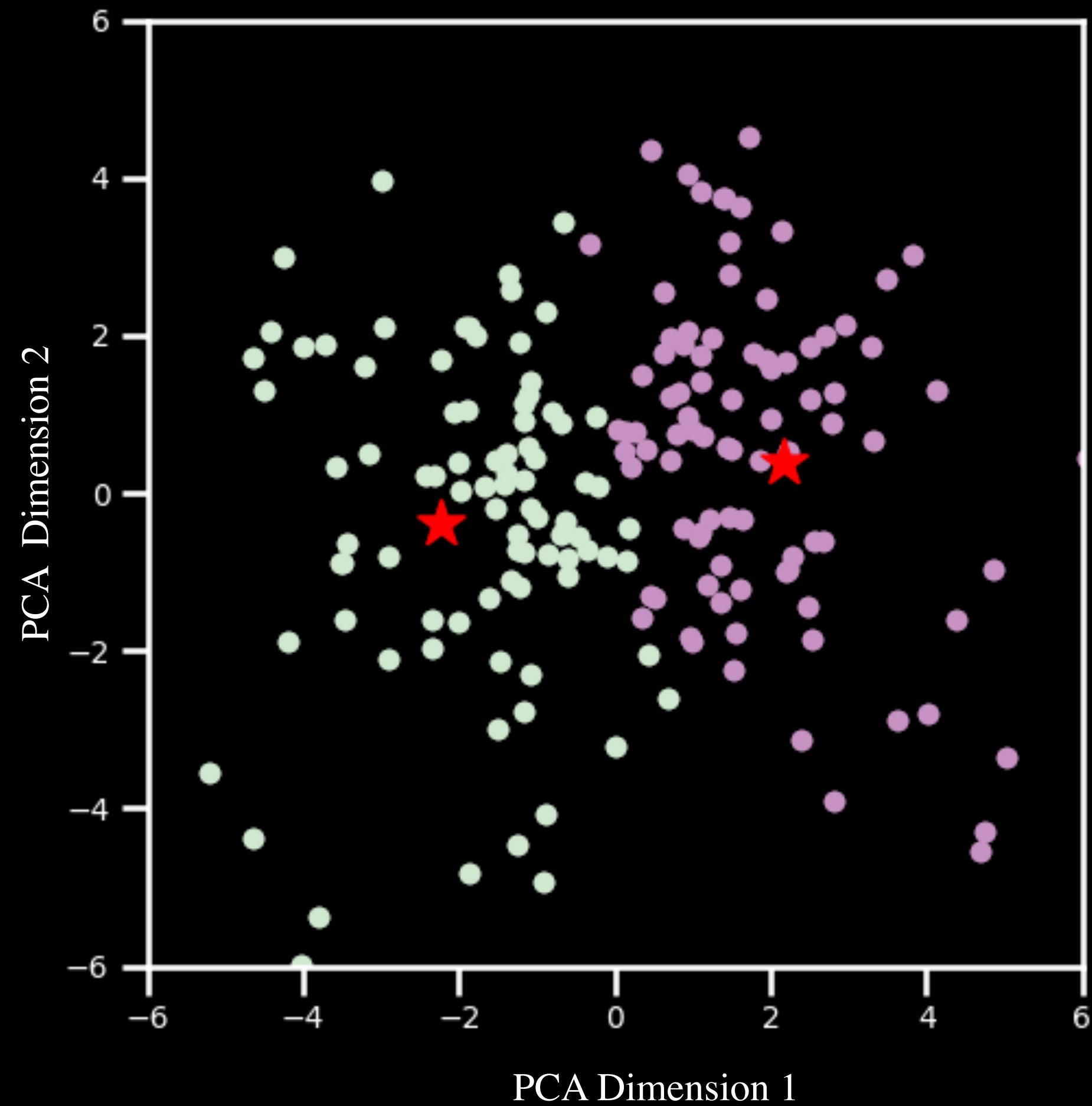


How concerned are you about COVID?



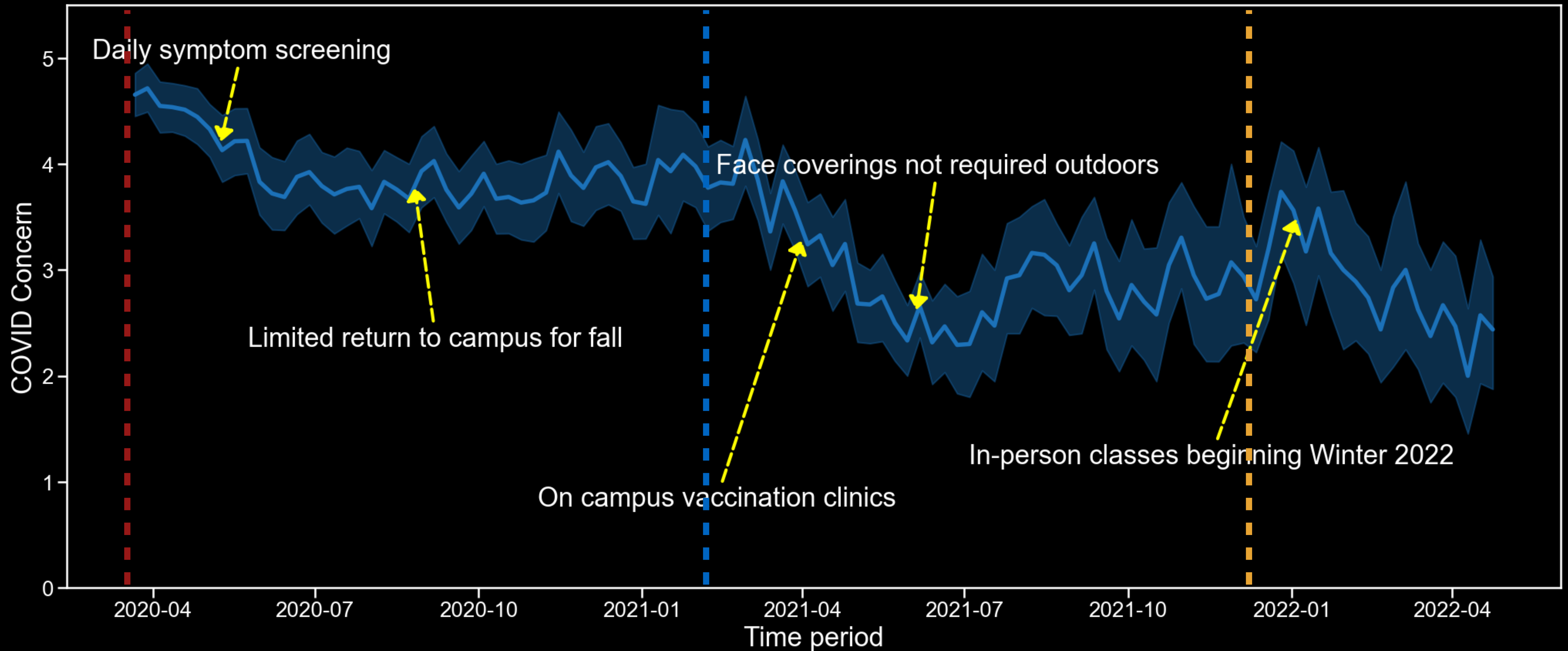
self-reports	c1	c2	mean	H statistic
phq-4	1.78	4.21	2.91	58.04***
depression	0.94	2.18	1.52	60.76***
anxiety	0.84	2.03	1.40	48.17***
stress	2.42	3.06	2.72	38.95***
self-esteem	12.00	11.16	11.60	8.02***
COVID-1	3.48	4.82	4.1	75.30***

RESILIENT GROUP

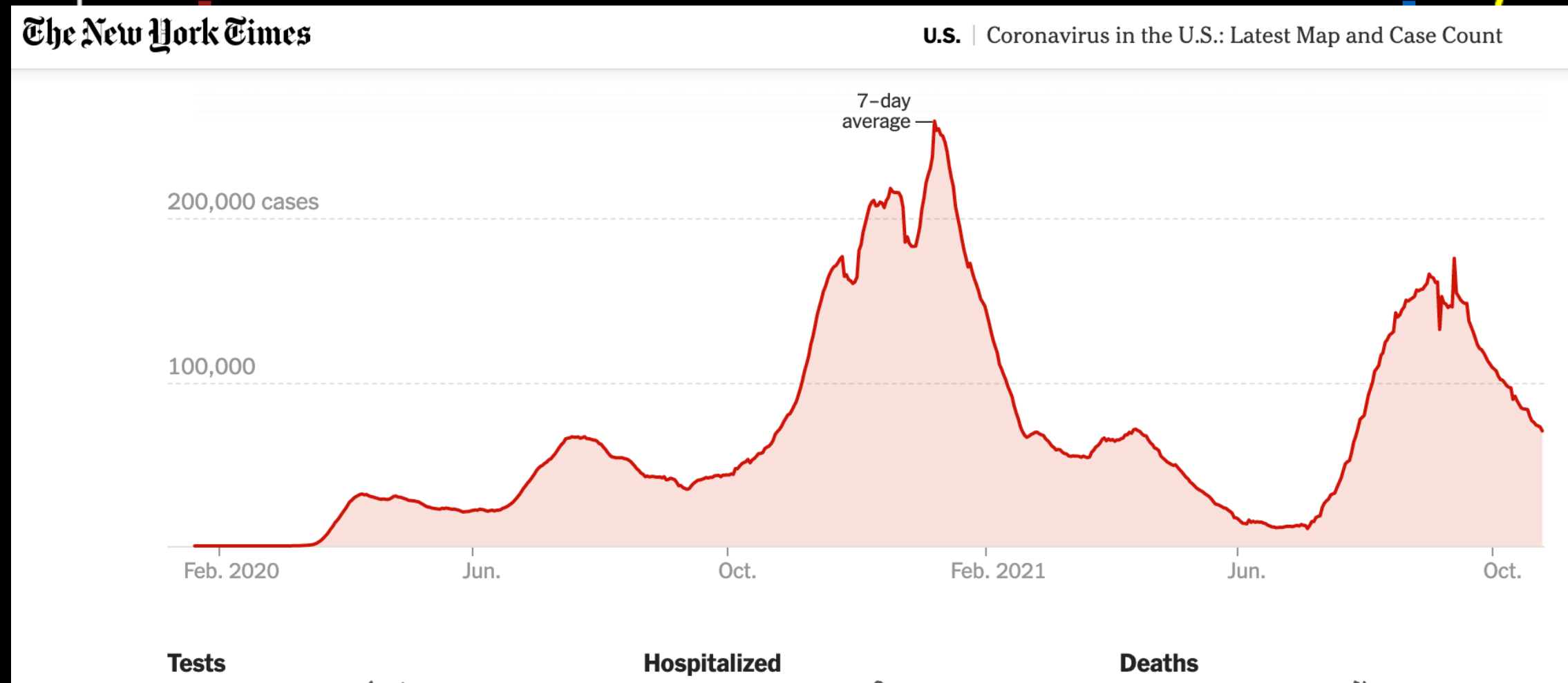
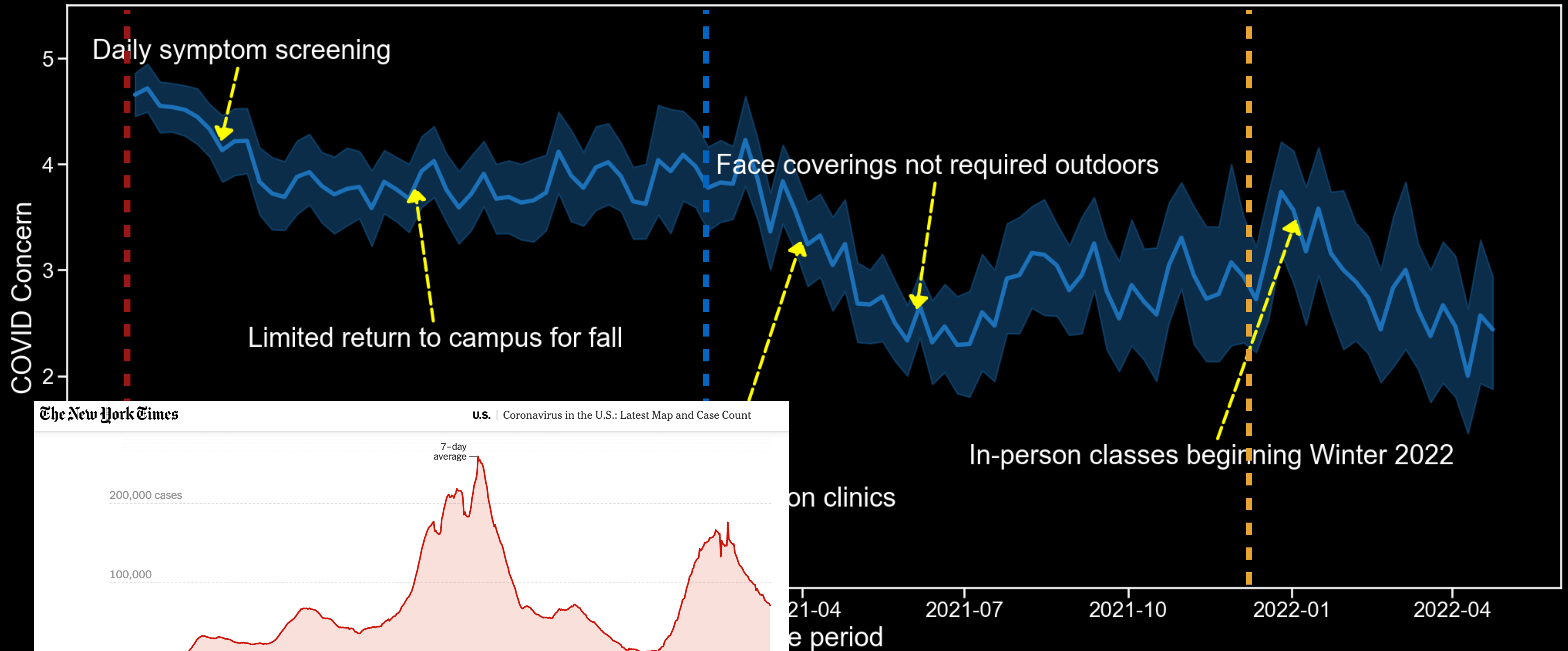


features	c1	c2	mean	H statistic
phone unlock duration per day	-7.93	57.14	26.15	74.14***
sleep start time	-18.60	12.75	-2.18	13.17***
number of phone unlocks per day	-36.20	-15.74	25.48	29.44***
sleep end time	36.38	-4.00	15.23	7.67**
sleep duration	55.20	-16.74	17.44	30.93***
duration of audio plays per day	10.72	83.73	48.78	66.61***
still duration at home	95.09	-22.30	31.32	33.91***
distance travelled per day	-69.10	-9.74	-37.13	5.42*
walking duration per day	-76.89	-34.36	-54.61	38.17***
still duration per day	113.13	42.65	76.21	63.92***

COVID CONCERNS

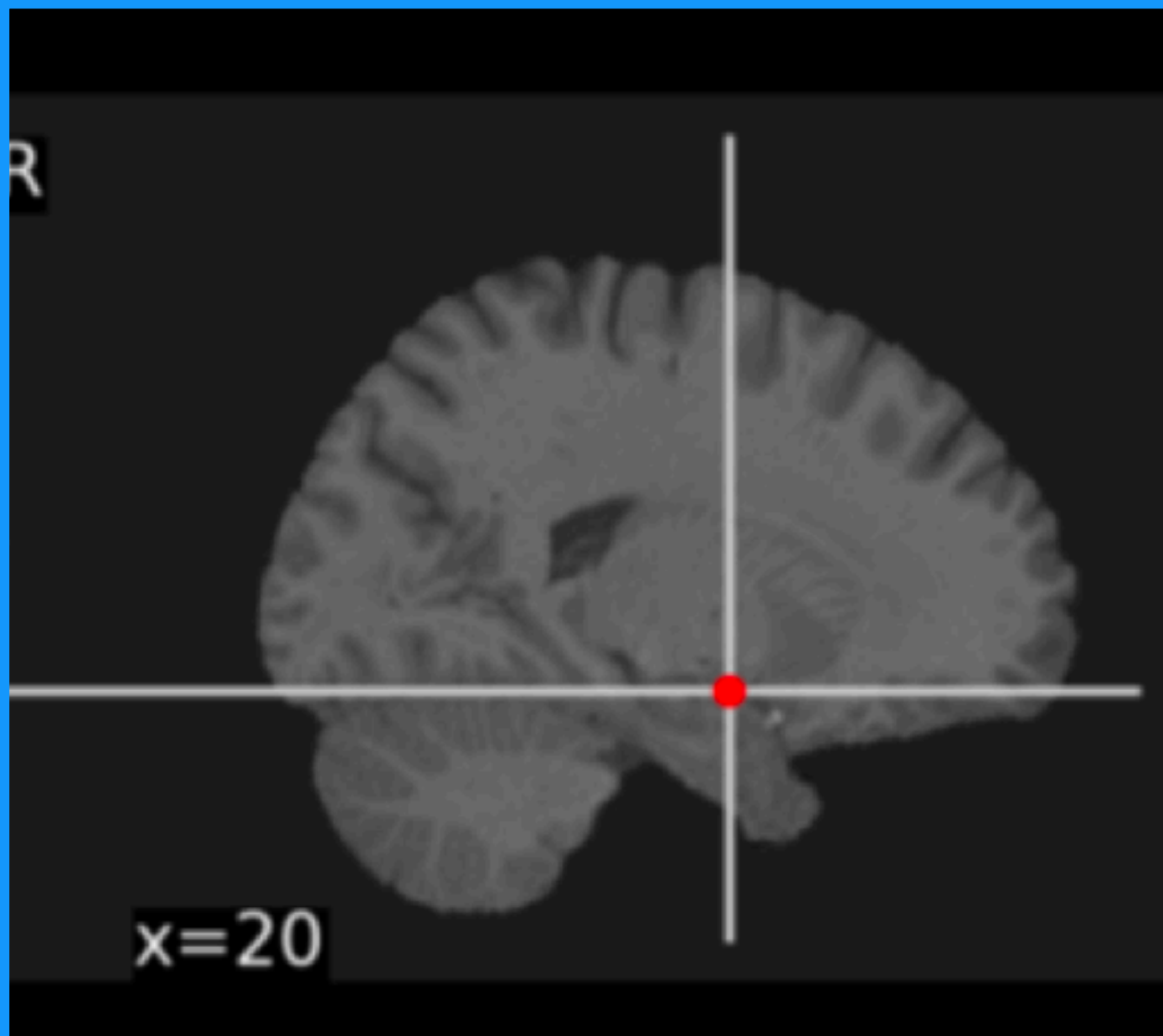


COVID CONCERNS



FUTURE DIRECTIONS

PREDICTING FUNCTIONAL CONNECTIVITY



BRAIN IMAGING

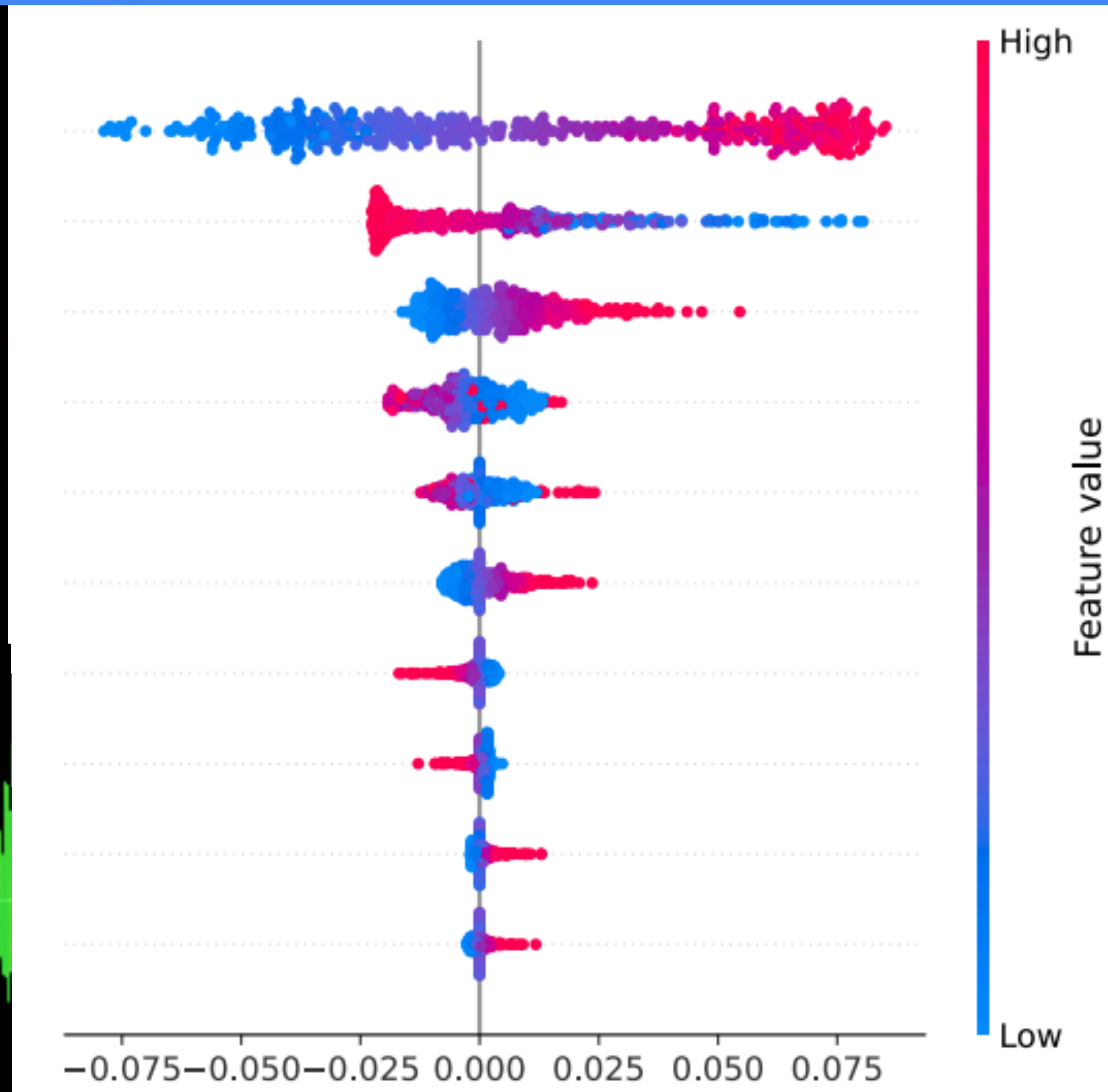
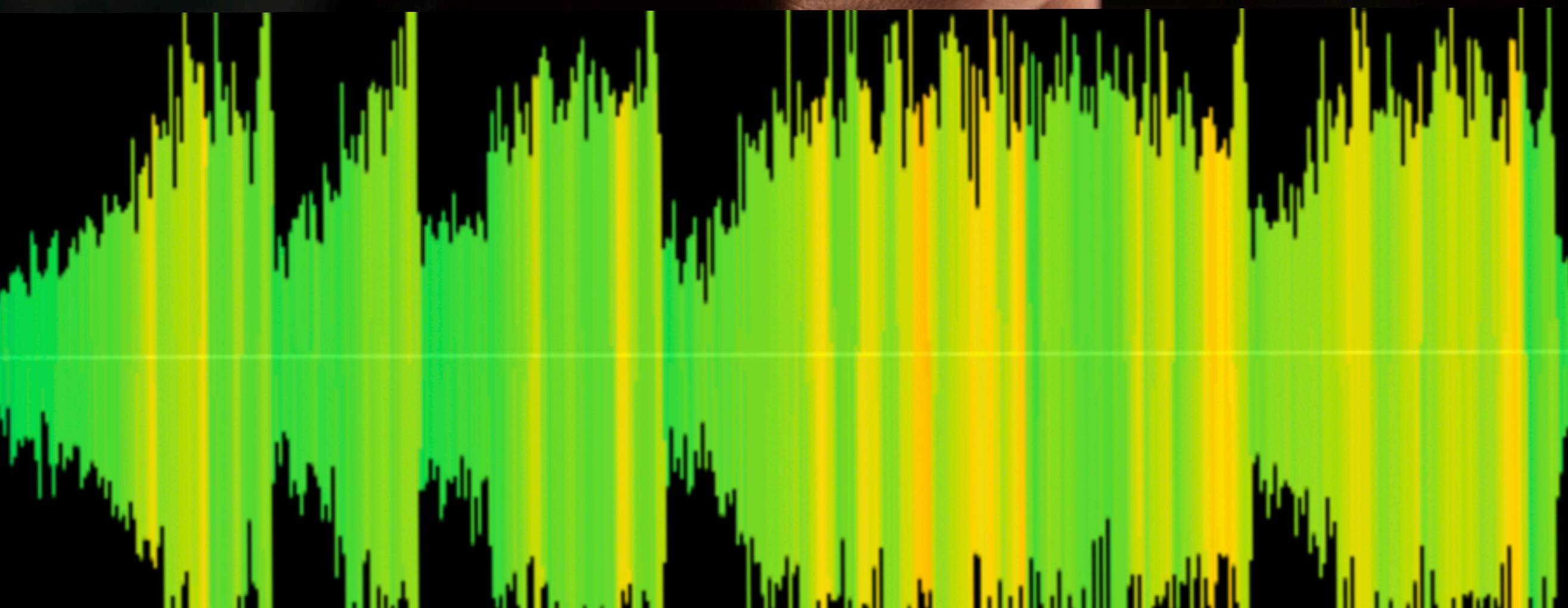
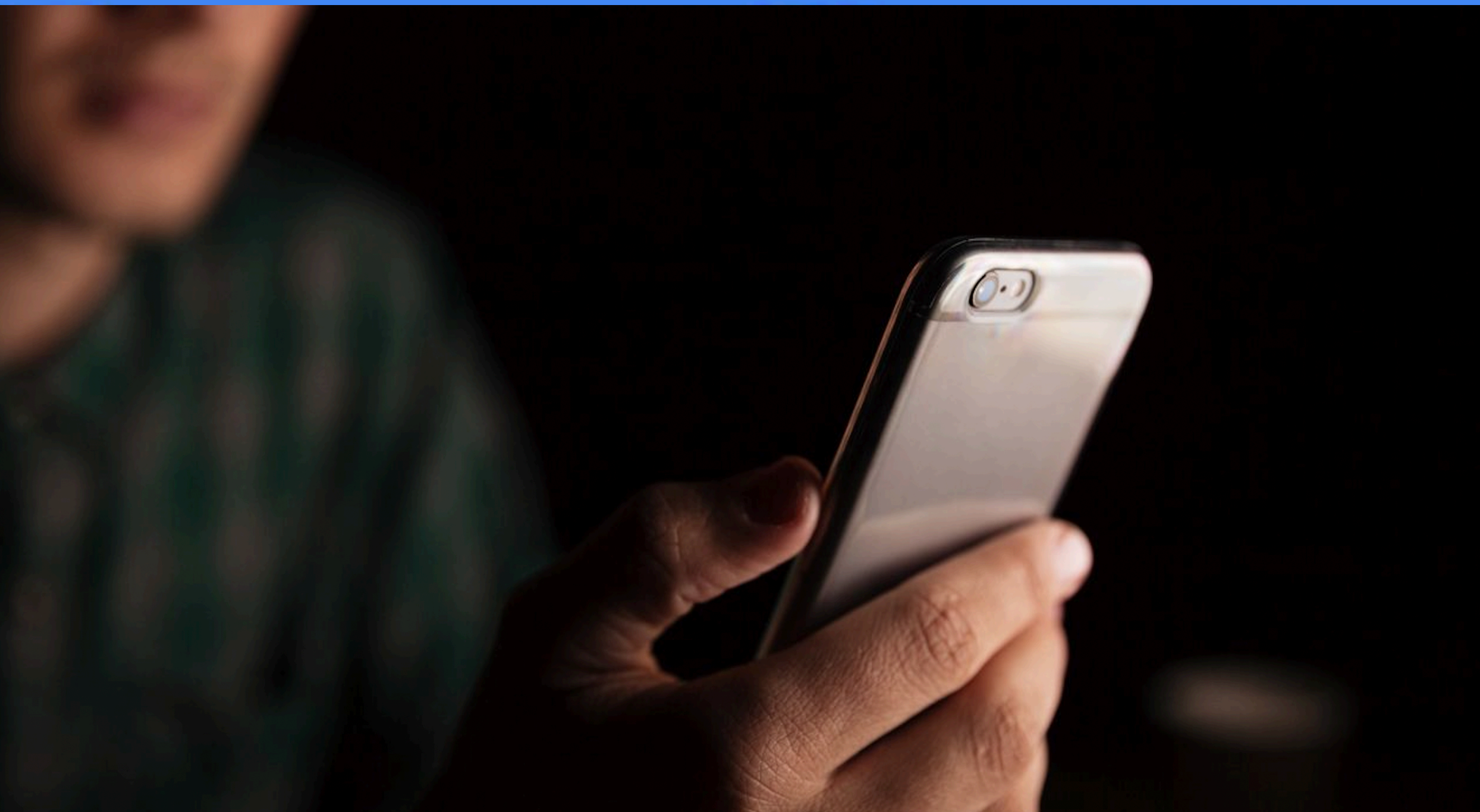


BEHAVIORS



SELF-REPORT

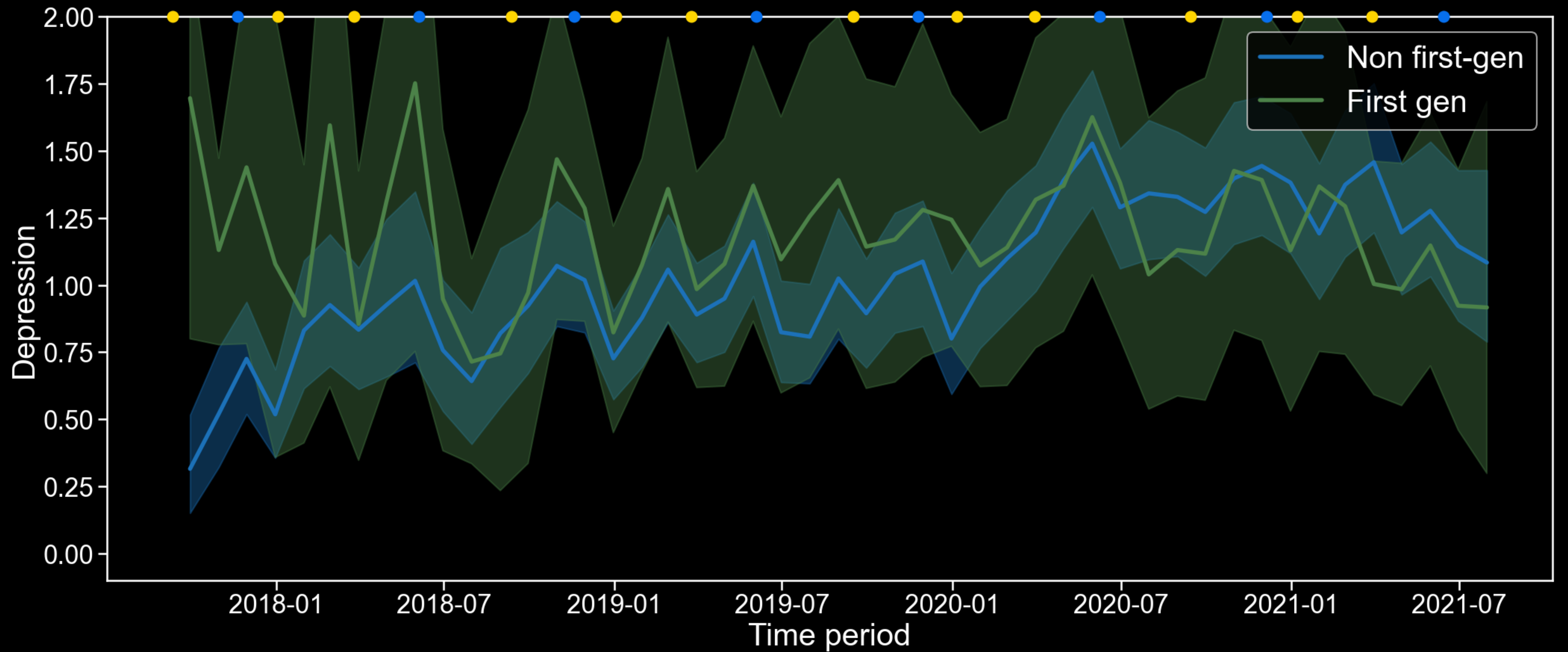
PREDICTING SUICIDAL IDEATION FROM SPEECH



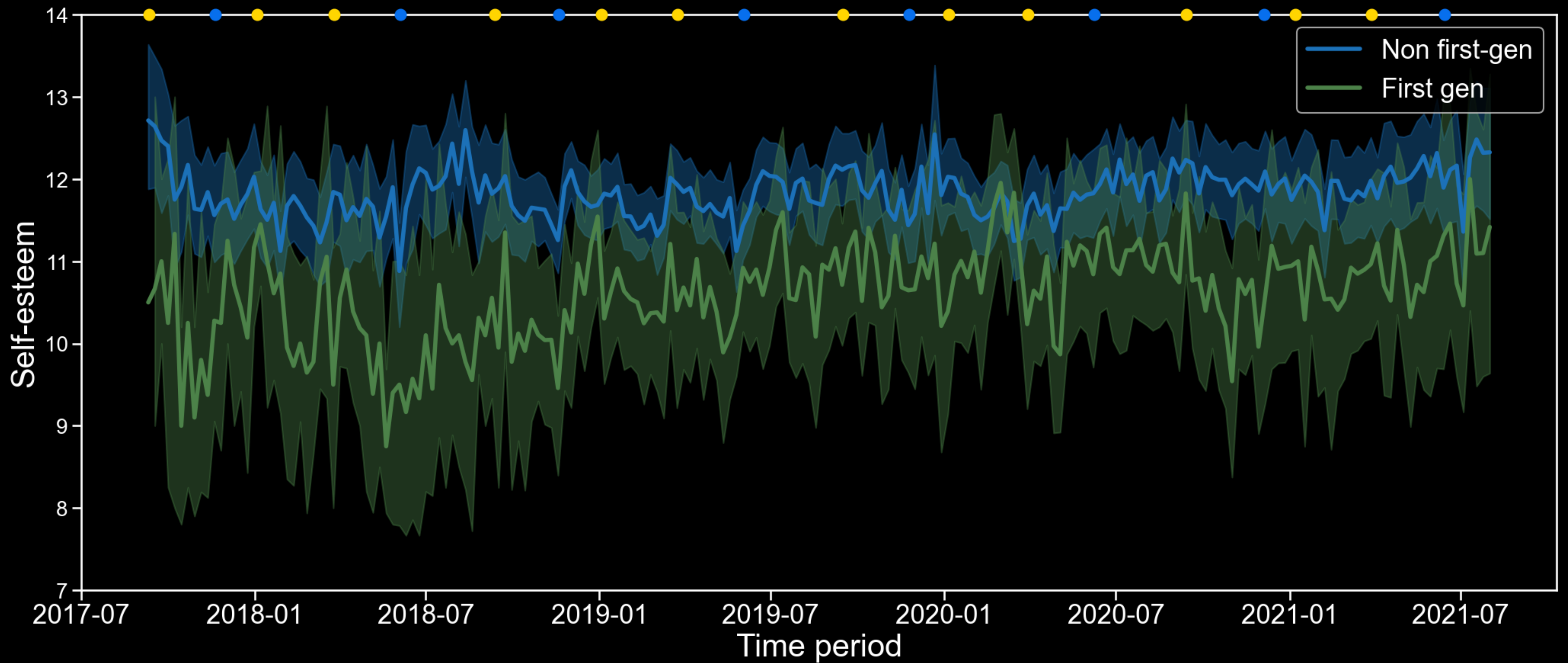
FIRST GENERATION STUDENTS



ONE STUDENT CAN CHANGE EVERYTHING



HIGHER DEPRESSION RATES



LOWER SELF-ESTEEM RATES

First-Gen Lens: Assessing Mental Health of First-Generation Students across Their First Year at College Using Mobile Sensing

[WEICHEN WANG](#), Dartmouth College, USA

[SUBIGYA NEPAL](#), Dartmouth College, USA

[LESSLEY HERNANDEZ](#), Dartmouth College, USA

[VLADO VOJDANOVSKI](#), Dartmouth College, USA

[JANE PLOMP](#), Dartmouth College, USA

[ARVIND PILLAI](#), Dartmouth College, USA

[MIKIO OBUCHI](#), Dartmouth College, USA

[ALEX DASILVA](#), Dartmouth College, USA

[EILIS MURPHY](#), Dartmouth College, USA

[ELIN HEDLUND](#), Dartmouth College, USA

[COURTNEY ROGERS](#), Dartmouth College, USA

[MEGHAN MEYER](#), Dartmouth College, USA

[ANDREW CAMPBELL](#), Dartmouth College, USA

The transition from high school to college is a taxing time for young adults. New students arriving on campus navigate a myriad of challenges centered around adapting to new living situations, financial needs, academic pressures and social demands. First-year students need to gain new skills and strategies to cope with these new demands in order to make good decisions, ease their transition to independent living and ultimately succeed. In general, first-generation students are less prepared when they enter college in comparison to non-first-generation students. This presents additional challenges for first-generation students to overcome and be successful during their college years. We study first-year students through the lens of mobile phone sensing across their first year at college, including all academic terms and breaks. We collect longitudinal mobile sensing data for N=180 first-year college students, where 27 of the students are first-generation, representing 15% of

Authors' addresses: [Weichen Wang](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA, weichen.wang.gr@dartmouth.edu; [Subigya Nepal](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA; [Jeremy F. Huckins](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Lessley Hernandez](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA; [Vlado Vojdanovski](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA; [Dante Mack](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Jane Plomp](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Arvind Pillai](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA; [Mikio Obuchi](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA; [Alex daSilva](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Eilis Murphy](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Elin Hedlund](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Courtney Rogers](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Meghan Meyer](#), Dartmouth College, Psychological and Brain Sciences, Hanover, NH, 03755, USA; [Andrew Campbell](#), Dartmouth College, Computer Science, Hanover, NH, 03755, USA.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

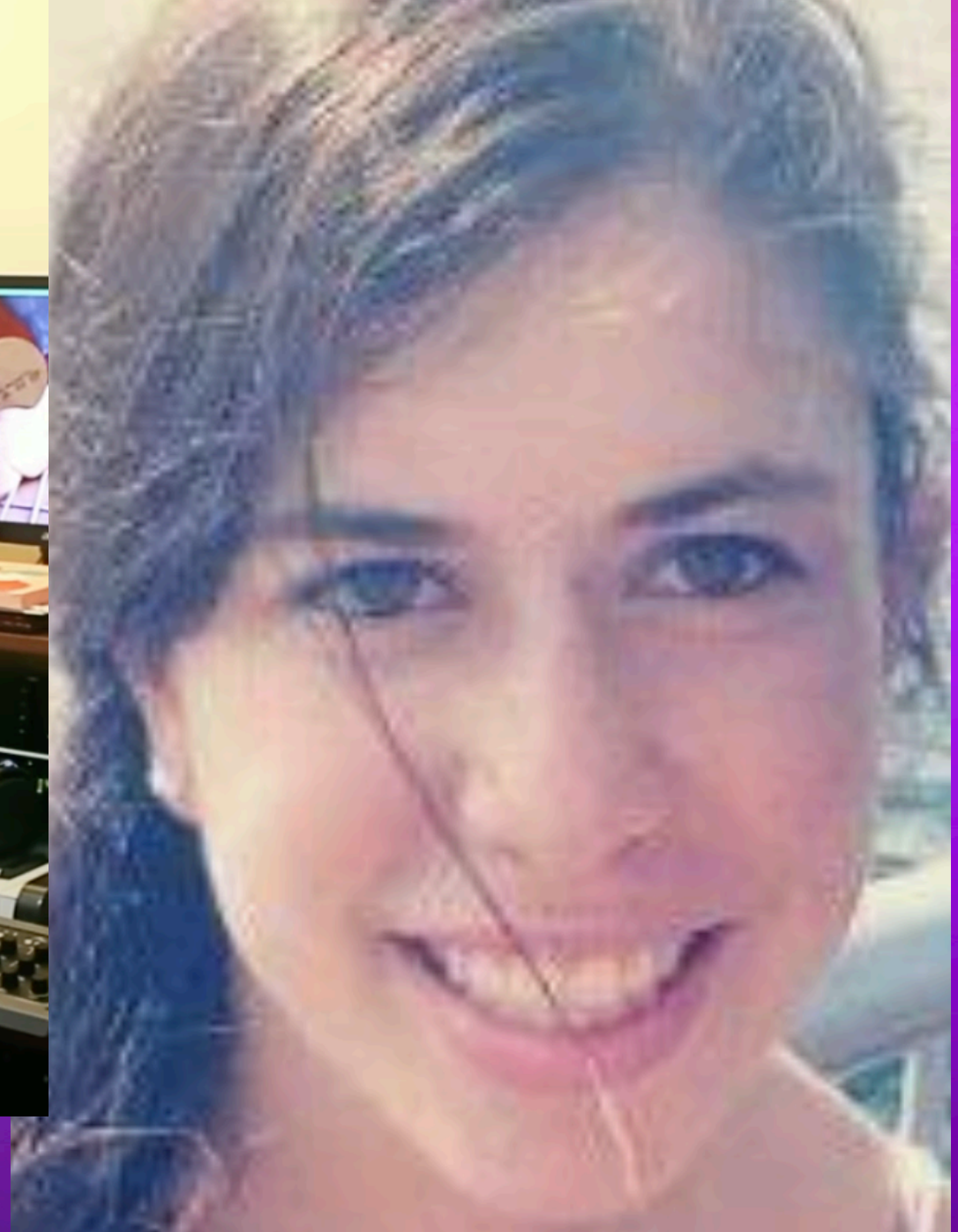
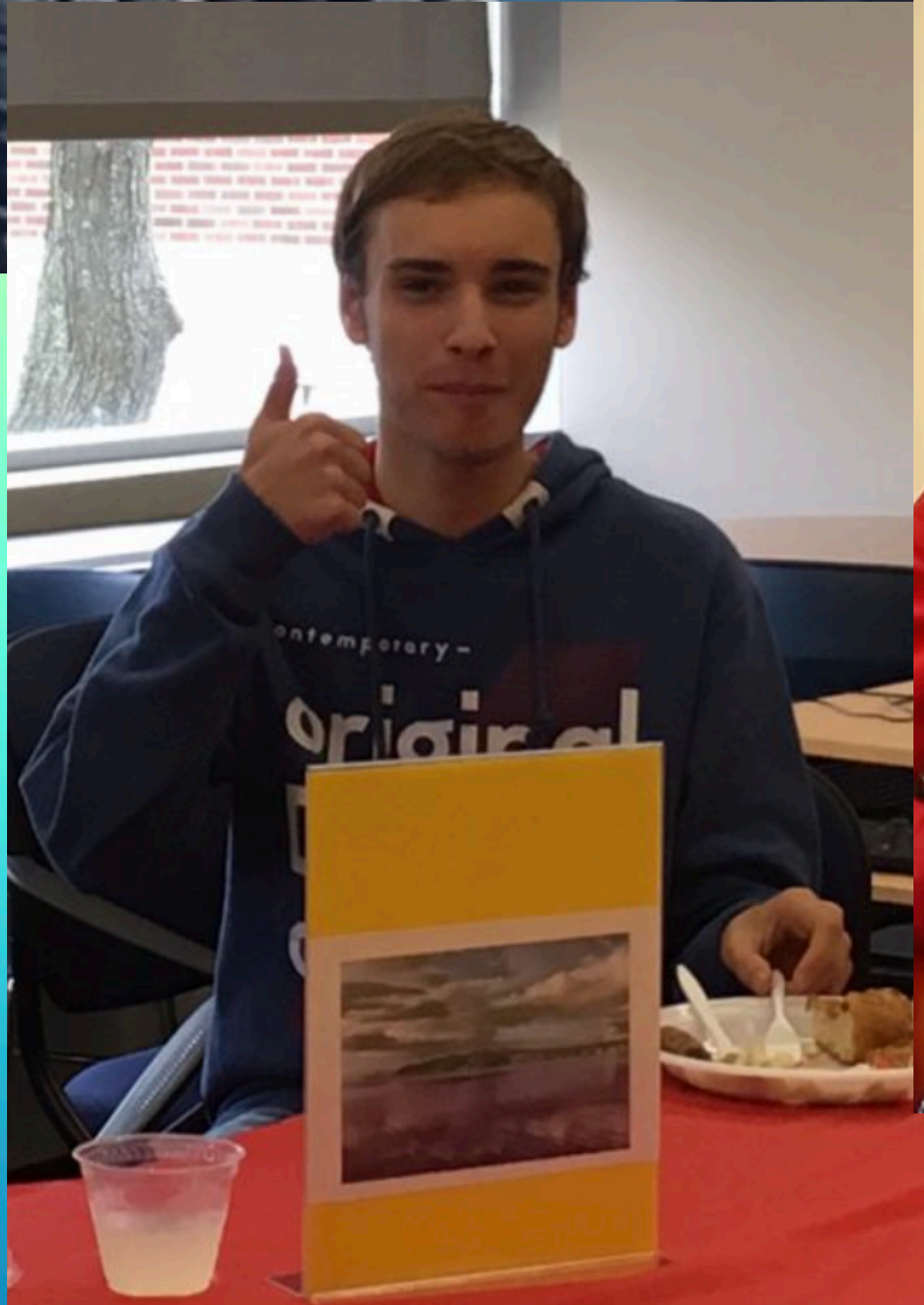
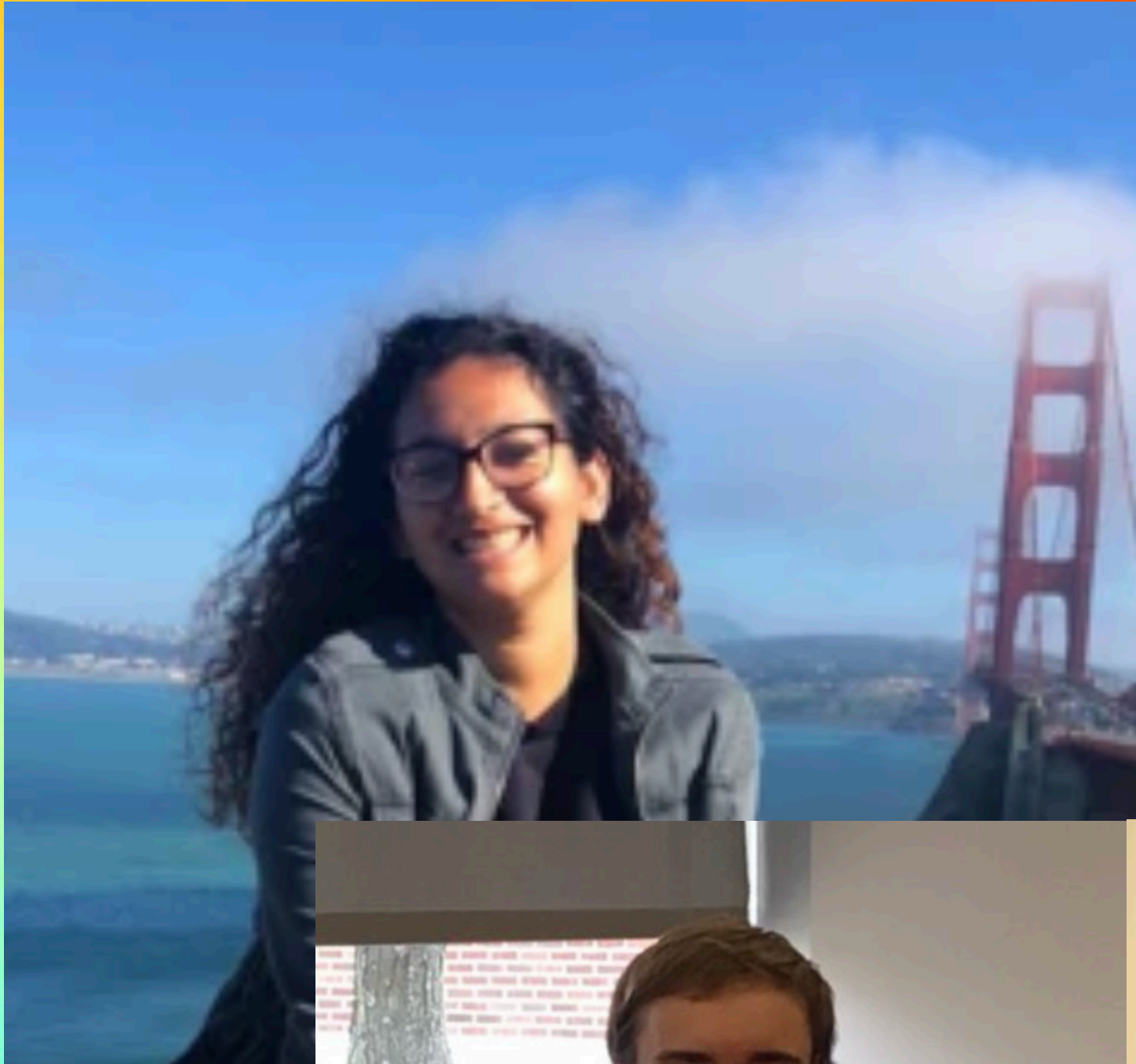
© 2022 Association for Computing Machinery.

2474-9567/2022/6-ART95 \$15.00





DARTMOUTH COMPUTER SCIENCE



active
minds



University of Nebraska
at Omaha

active
minds



Virginia Commonwealth
University

active
minds



Colorado School
of Mines

active
minds



University of Missouri
at Saint Louis

active
minds



James Madison
University

active
minds



University of Maine

active
minds



George Mason
University

active
minds



Rochester Institute
of Technology

active

active

active

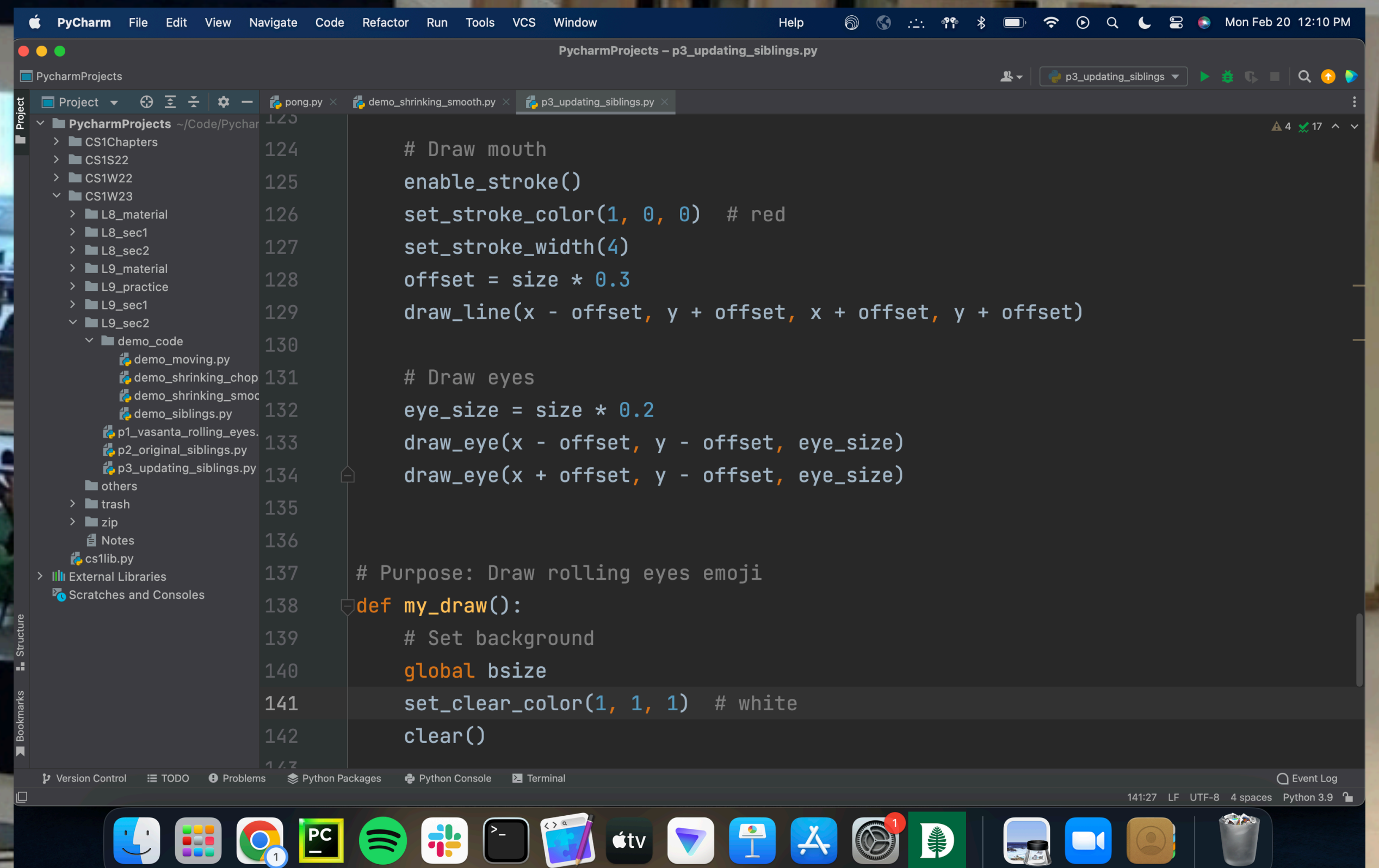
active

AN AI WILL BE YOUR THERAPIST



AN AI WILL DO INTERVENTIONS

DARTMOUTH COMPUTER SCIENCE



FACULTY ARE ON THE FRONTLINE

FREE 24/7/365
**Teletherapy &
Crisis Support**
for Dartmouth students



Student Mental Health & Wellness





I NEED HELP

I WANT TO HELP

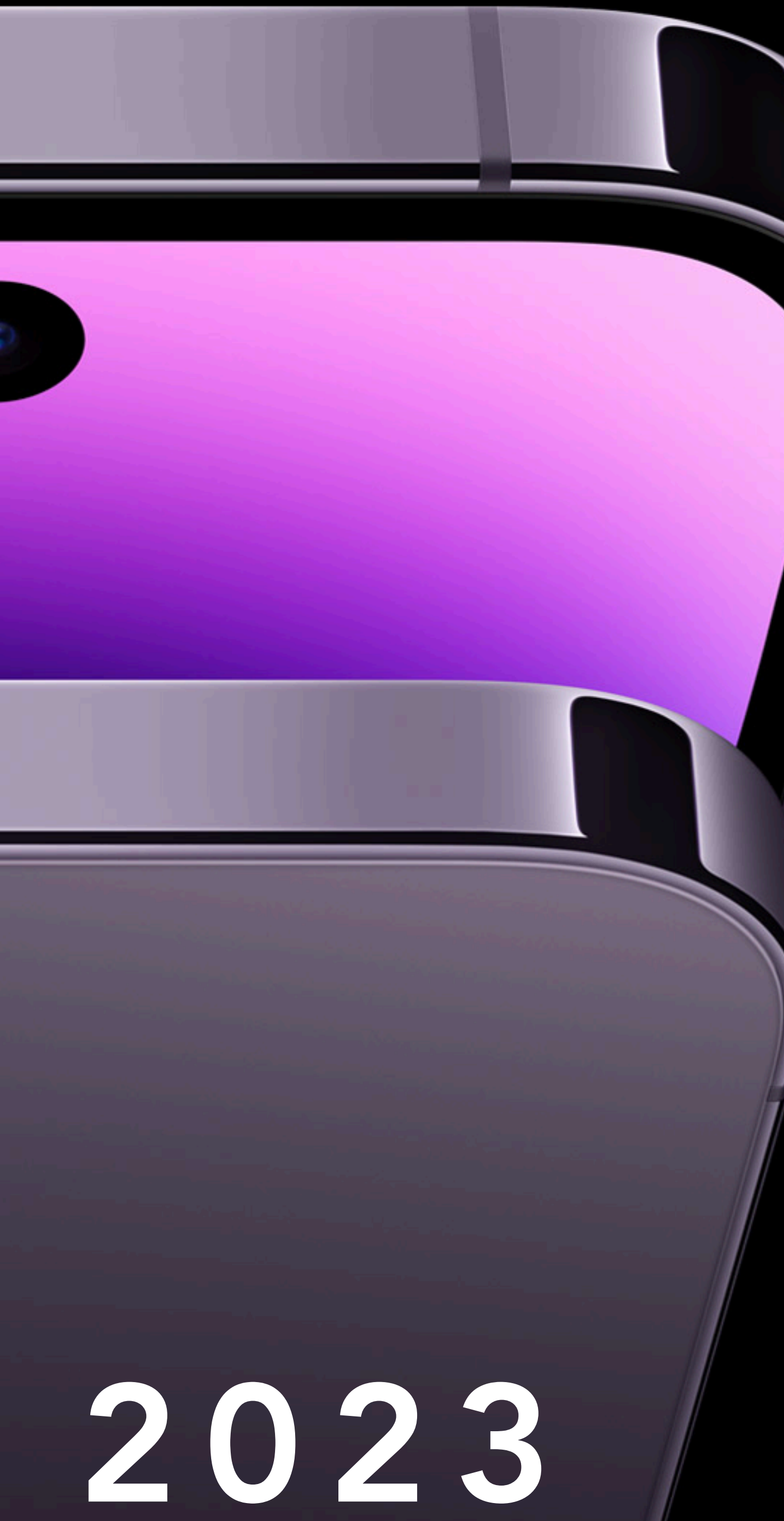
The Jed Foundation

**Together, we're
changing and saving
lives.**

The Jed Foundation (JED) is a nonprofit that



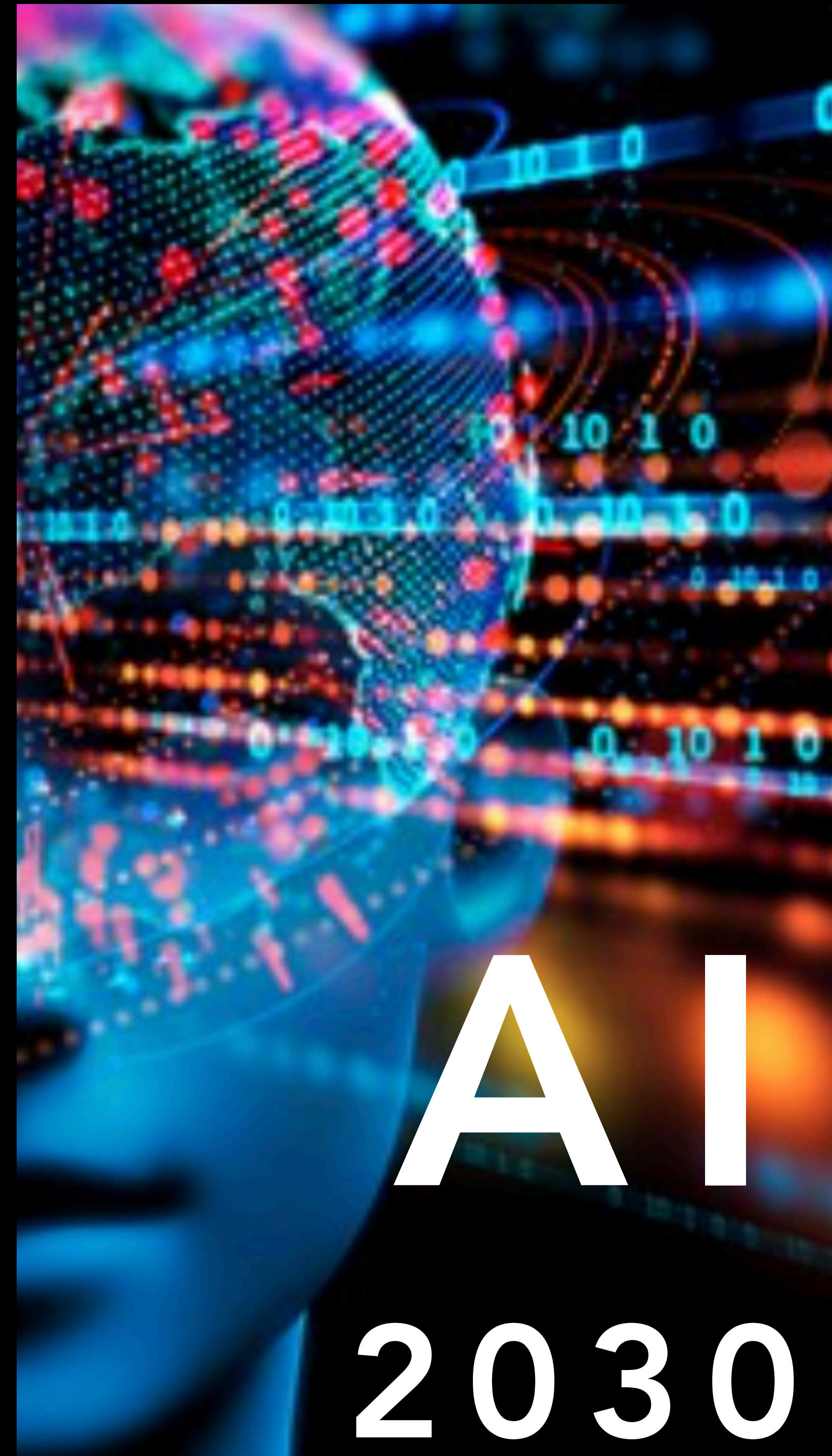
WHAT DOES THIS
FUTURE LOOK LIKE?



2023



2025



2030

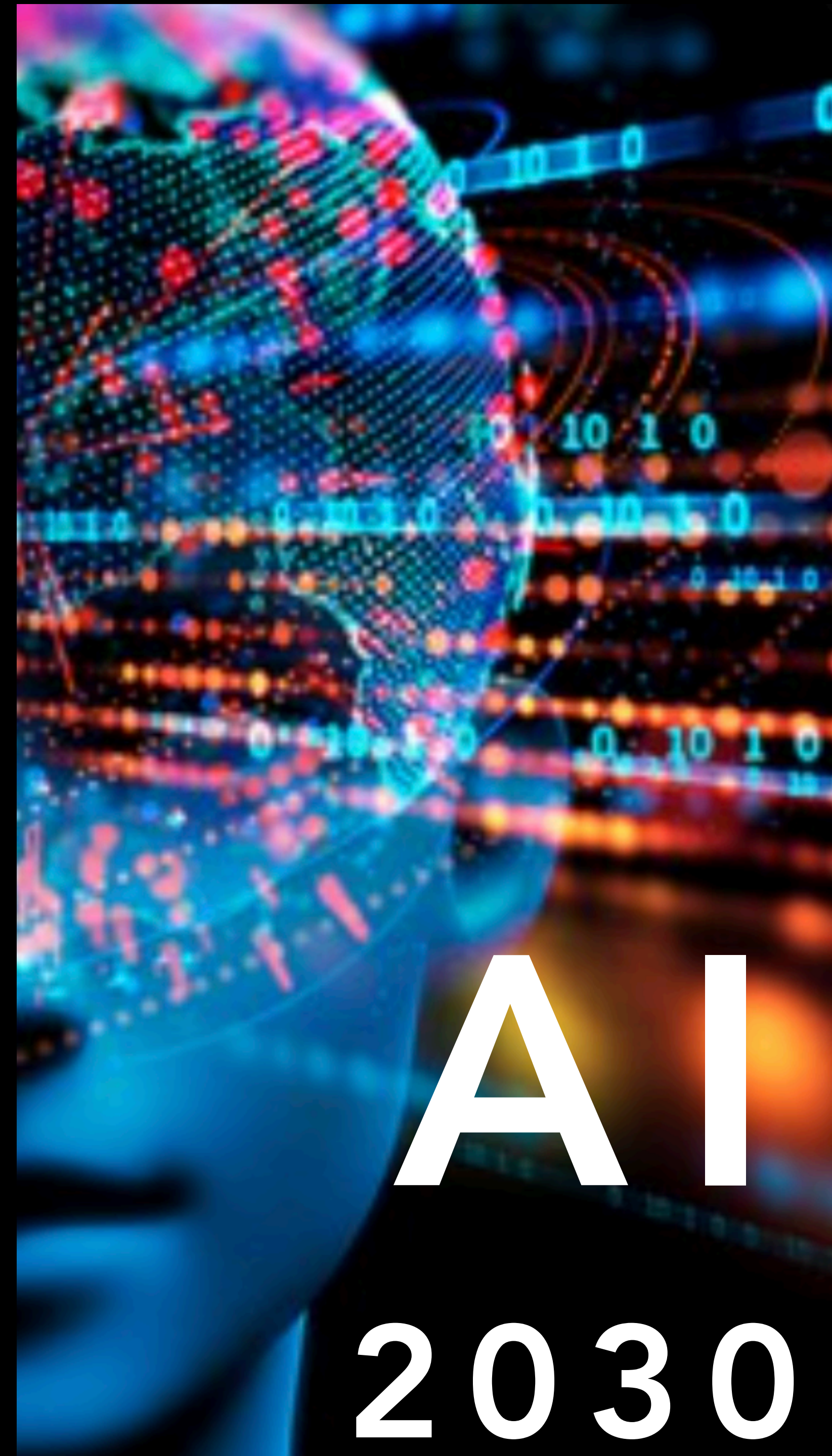
A DARTMOUTH WELLNESS AI WILL LEARN AND
GET KNOW THE STUDENT WELL

IT WILL UNDERSTAND RISKS AND KNOW WHAT
TO DO IN REAL-TIME BASED ON BEHAVIORAL
SENSING AND PERSONALIZED MODELING

IT WILL STEP IN AT JUST THE RIGHT MOMENT
WITH INTERVENTIONS THAT ARE PROVEN TO
WORK FOR THE STUDENT

IT KEEP THE STUDENT ON TRACK AND
HEALTHY

AND IMPORTANTLY IT WILL PROTECT THE
PRIVACY OF THE STUDENT AT ALL TIMES



AI

2030



DEPARTMENT OF
Psychological and Brain Sciences

Psychological science is traditionally defined as the study of behavior; neuroscience as the study of the brain.

DEPARTMENT OF
Computer Science

The Neukom Institute for Computational Science



Center for **Technology**
and **Behavioral Health**



The Magnuson Center
for Entrepreneurship
at Dartmouth

THE BIG IDEA







KUUSUMO





← **Personal settings** ⓘ



Mental wellbeing



Mobile network
Singtel



Data usage
2.40 GB of data used



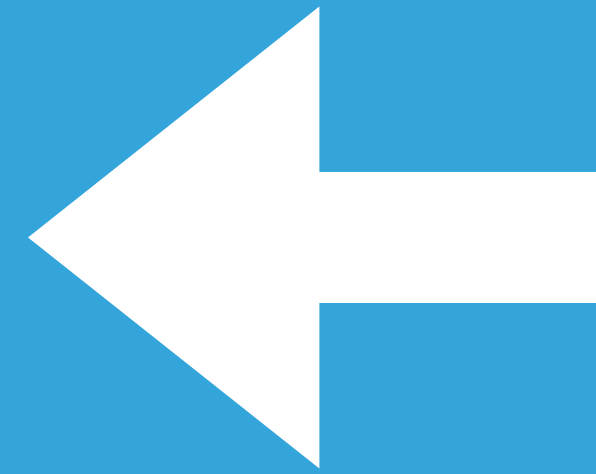
Hotspot & tethering
Off



Airplane mode



Advanced
VPN, Private DNS



← **Personal settings**



Mental wellbeing



Mobile network
Singtel



Data usage
2.40 GB of data used



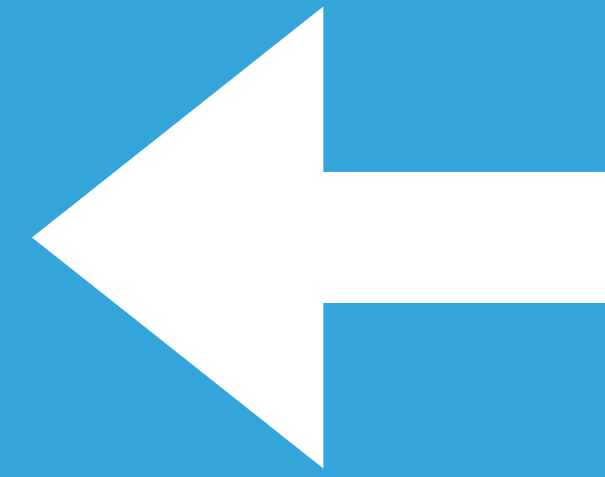
Hotspot & tethering
Off



Airplane mode



Advanced
VPN, Private DNS



WELLNESS AI ENABLED

← **Personal settings** ⓘ



Mental wellbeing



Mobile network
Singtel



Data usage
2.40 GB of data used



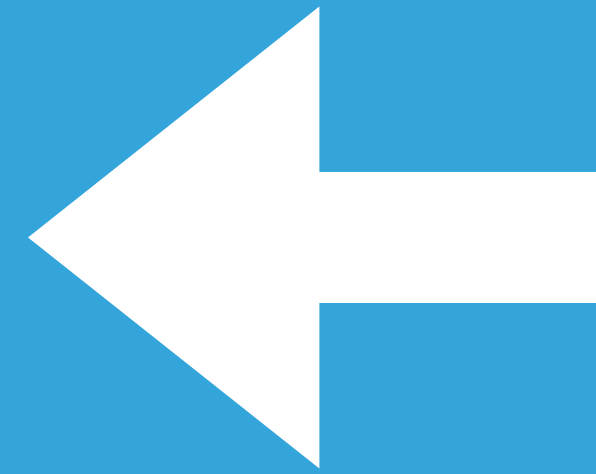
Hotspot & tethering
Off



Airplane mode



Advanced
VPN, Private DNS



← Personal settings



Mental wellbeing



Mobile network
Singtel



Data usage
2.40 GB of data used



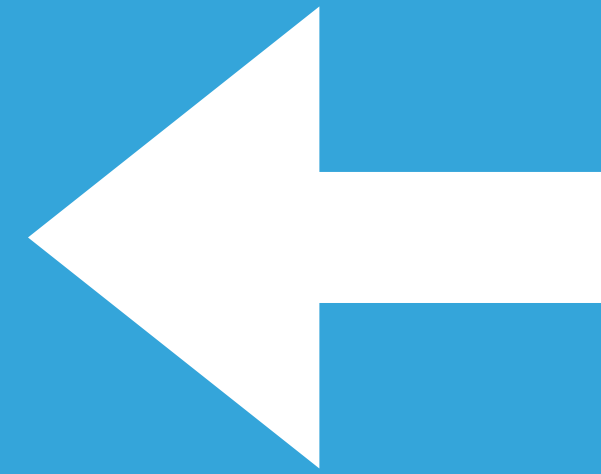
Hotspot & tethering
Off



Airplane mode



Advanced
VPN, Private DNS



WELLNESS AI ENABLED

BIG THANKS!



STUDENTS AND COLLABORATORS

Rui Wang, Shayan Mirjafari, Weichen Wang, Subigya Nepal, Lessley Hernandez, Arvind Pillai, Vlado Vojdanovski, Wenjun Liu, Tanzeem Choudhury, Gabriella Harari, Dror Ben-Zeev, Sam Gosling, John Kane, Jeremy Huckins, Deanna Barch, Menachem Fromer, Nicholas Jacobson, Meghan Meyer, Rachel Brian, Ethan Berke, Randy Colvin, Jim Haxby, Xia Zhou, Emily Scherer, Alex daSilva, Lydia Tapia, Evan Carter, Caroline Robertson, Adam Steel, Aaron Striegel, Sidney DMello, Gloria Mark, Anind K. Dey, Nitesh Chawla.



National Institutes
of Health



The Washington Post

THE CHRONICLE OF HIGHER EDUCATION

abc NEWS

FINANCIAL TIMES

The New York Times

n p r

CBS NEWS

B B C

NewScientist

WIRED

The
Economist

TE

Bloomberg

THE
NEW YORKER



THANKS!



**AI IS THE FUTURE OF
MENTAL HEALTH**