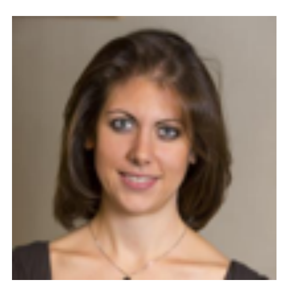
Passive sensing of circadian rhythms for individualized models of cognitive performance

Julie Kientz, Tanzeem Choudhury

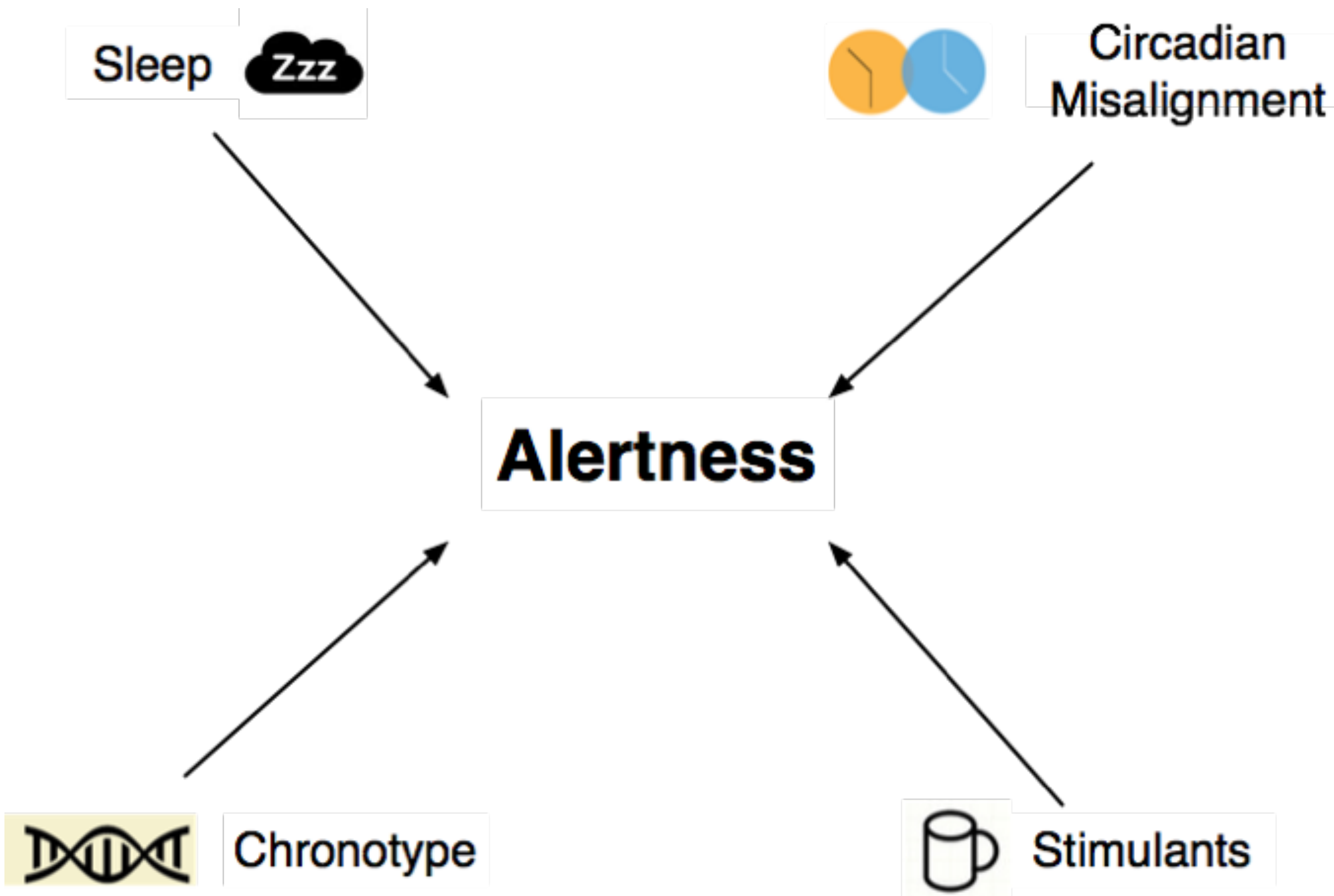

Saeed Abdullah, Elizabeth Murnane, Mark Matthews, Matt Kay

Cornell CIS
COMPUTING AND INFORMATION SCIENCE

HUMAN CENTERED DESIGN & ENGINEERING
UNIVERSITY of WASHINGTON

Alertness:
basic building block of cognitive performance


Sleep
Zzz
Circadian Misalignment
Alertness
Chronotype
Stimulants

Research Questions:

- How do body clock, time of day, and stimulant intake **impact** alertness?
- Do phone usage patterns **reflect** fatigue and sleepiness?
- Can we **automatically** assess alertness using passively sensed phone data?

Participants & Procedure

20 participants

- 7 male, 13 female
- College students
- 18-29 years old
- Android users

40 days

Data

- Daily sleep diary
- 4-times-per-day alertness assessment (EMA)
- Phone use logs
- Interviews

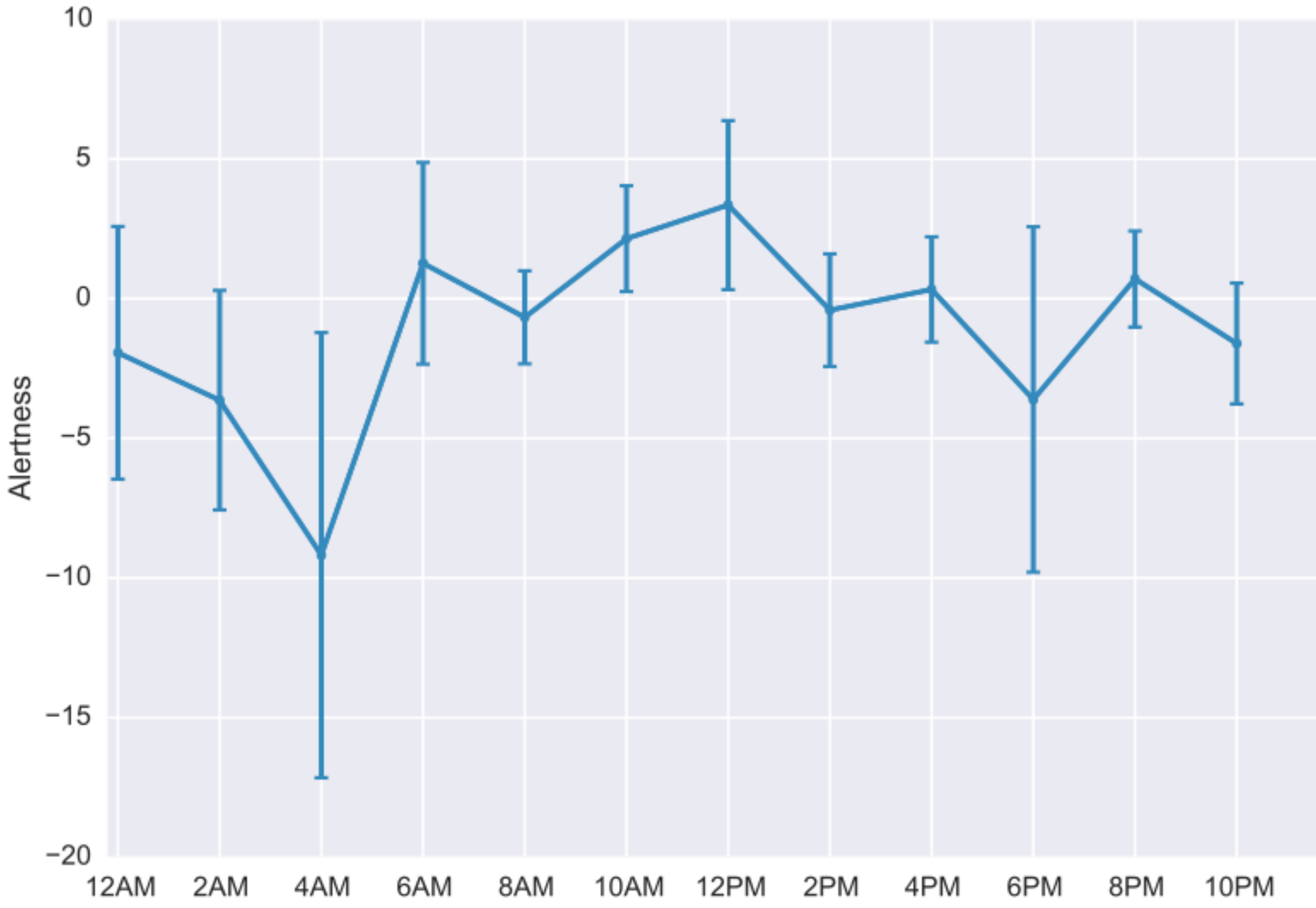
EMA data

Self-report

Psychomotor vigilance task (PVT)
(reaction time)

Results

Alertness **varies** across time



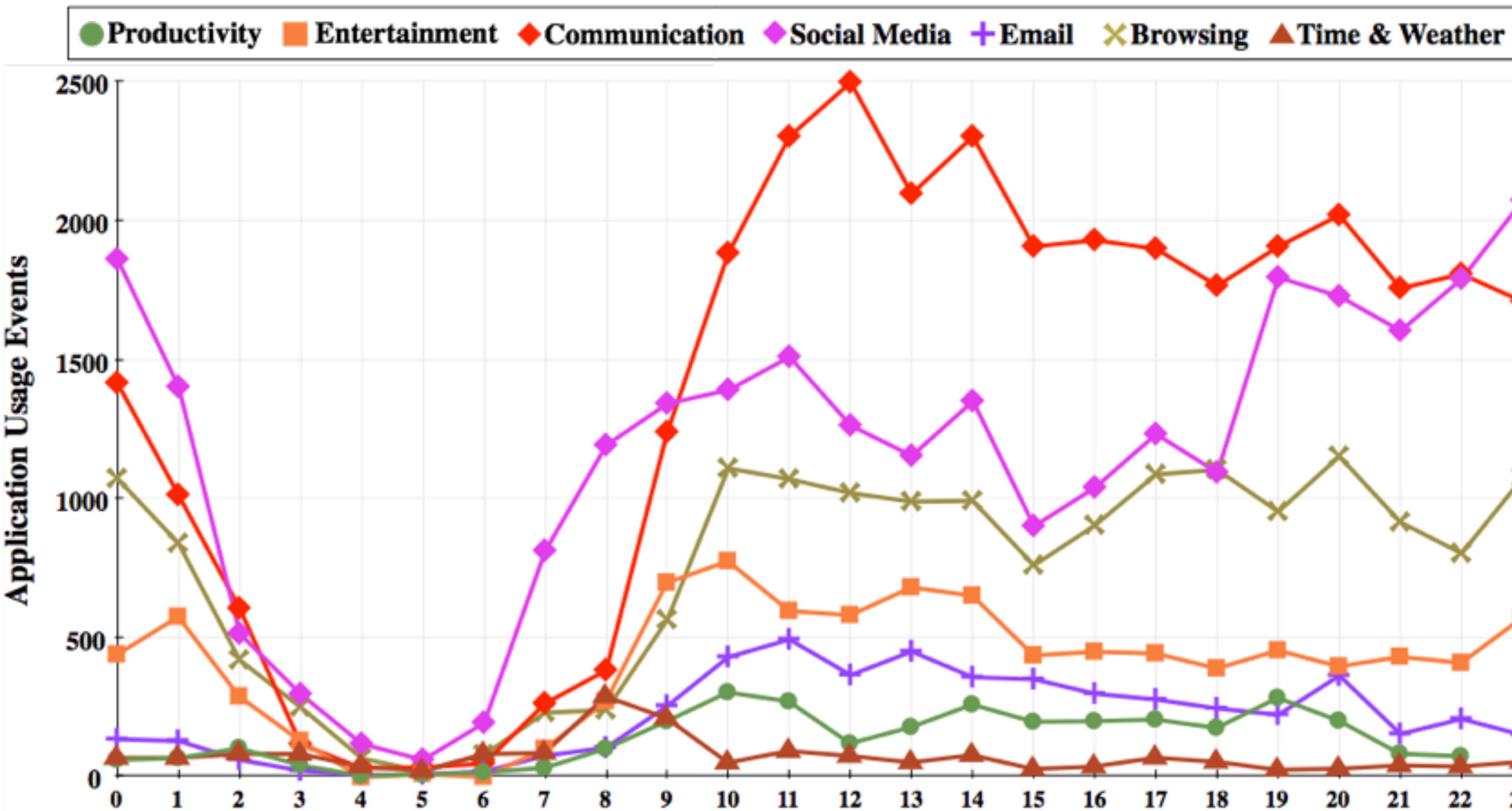
Stimulant intake

5.1% increase after positive stimulants (e.g., caffeine)

1.37% drop after negative stimulants (e.g., alcohol)

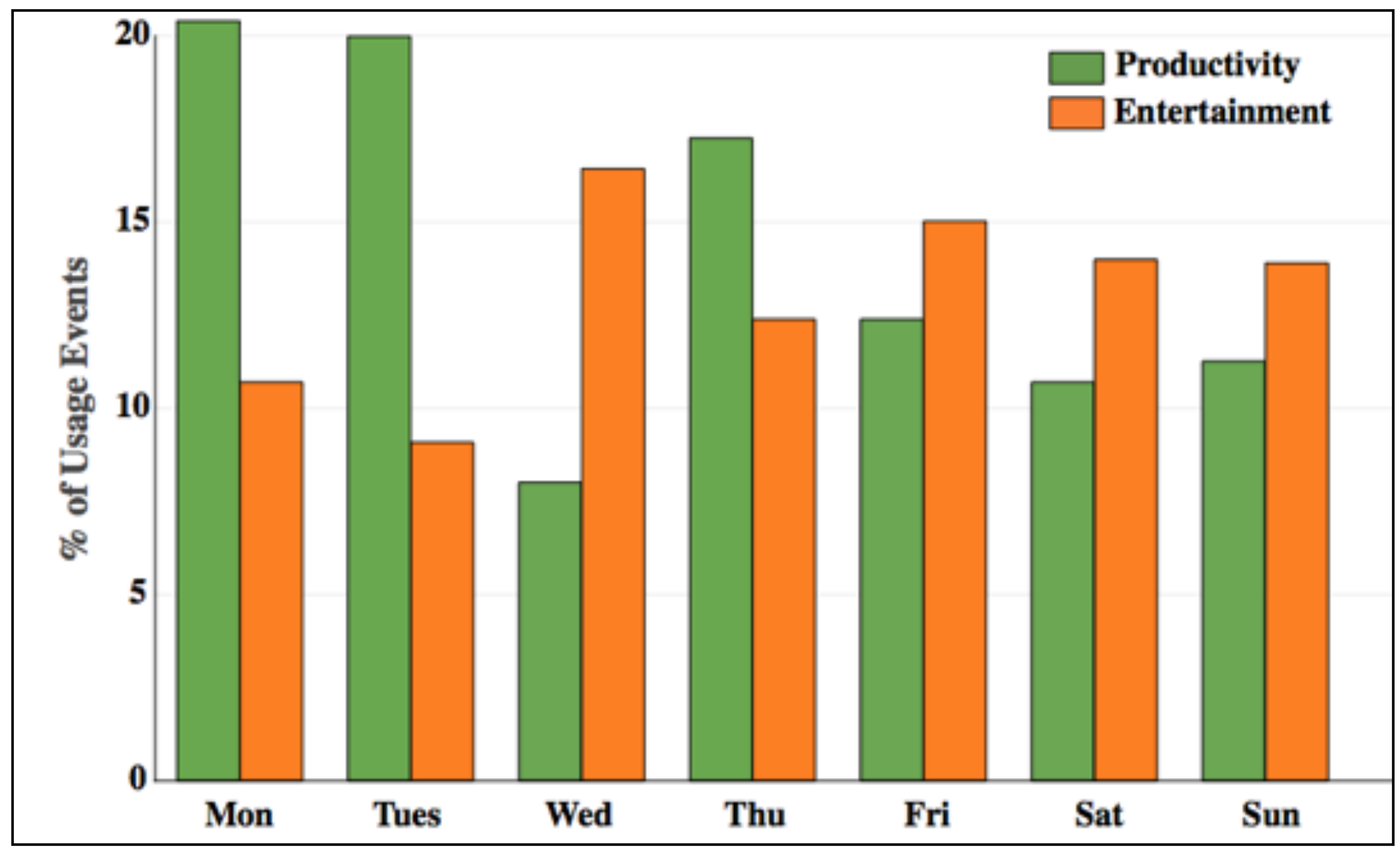
Statistically significant ($t = 2.2$, $p = 0.03$)

Rhythms in App Use



Productivity vs. Entertainment

- Work days
- Free days
- Mid-week dip



App Use and Sleep

- Less sleep: less productivity (r=0.43), more entertainment apps (r=-0.19)
- Adequate sleep: **61%** more productivity apps
- Inadequate sleep: **33%** more entertainment apps
- Nightly use events reflect sleep **interruptions**

Predicting Alertness

- 10 fold cross-validation
- RMSE of **11.39** across all participants
- Accurate enough for scalable deployment

Internal Time
Avg. time between phone usage sessions
Short Session frequency
Phone usage duration
Relative sleep need

Top-ranking features for predicting alertness

Contributions:

- **In-situ** alertness sensing
- Manifestations of biological rhythms in **mobile use**
- Automated alertness **prediction**

Future work:

Circadian-aware technology

Informatics tools & intervention studies

Potential for Data Donation

Currently working with Cornell IRB to enable sharing

To publish per-participant data, need to get user consent

Will likely need to release aggregate data