

CHI'24

**PriviAware:**

Exploring Data Visualization and Dynamic Privacy Control  
Support for Data Collection in Mobile Sensing Research

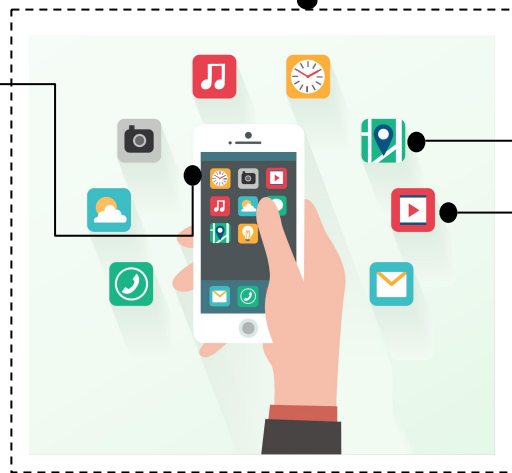
**Hyunsoo Lee**, Yugyeong Jung, Emily Law, Seolyeong Bae, Uichin Lee

**PriviAware**  
Privacy Data Management  
with Visualization Support

# Behavior and context sensing with smartphone sensors

**Temporal context:** time  
(from time stamps)

**Behavior:** physical activity  
(from accelerometer)



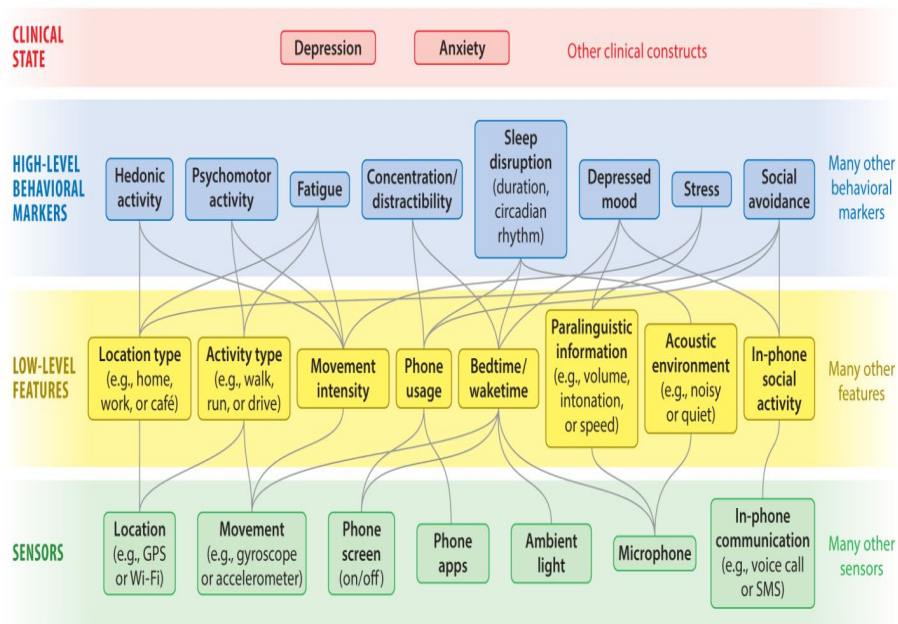
**Spatial context:** location  
(from GPS)

**Digital context:** app usage  
(from phone logs)

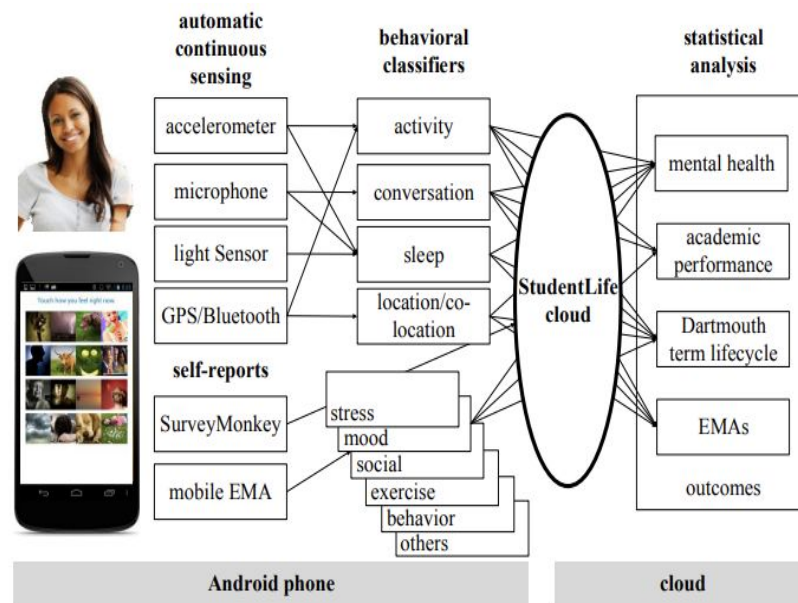
**Social context:** social interaction such  
as calls/messages (from phone logs)

# Mobile sensing for mental health and well-being research

## Approach: Digital Phenotyping



## Case: StudentLife (Wang et al., 2014)

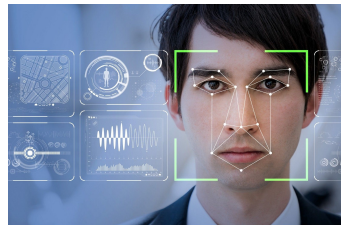


# Privacy concerns in mobile sensing research



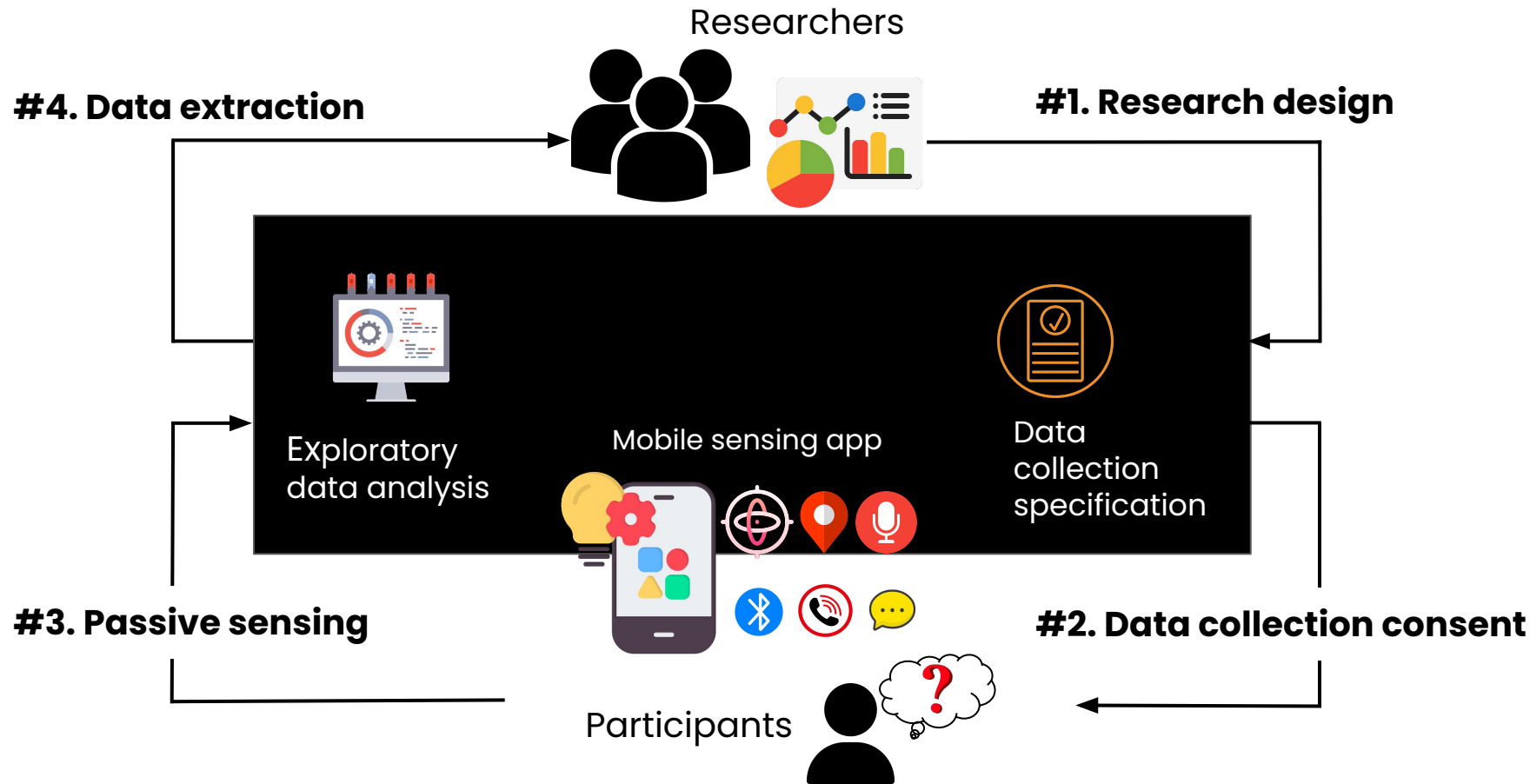
Mobile sensing

• • •



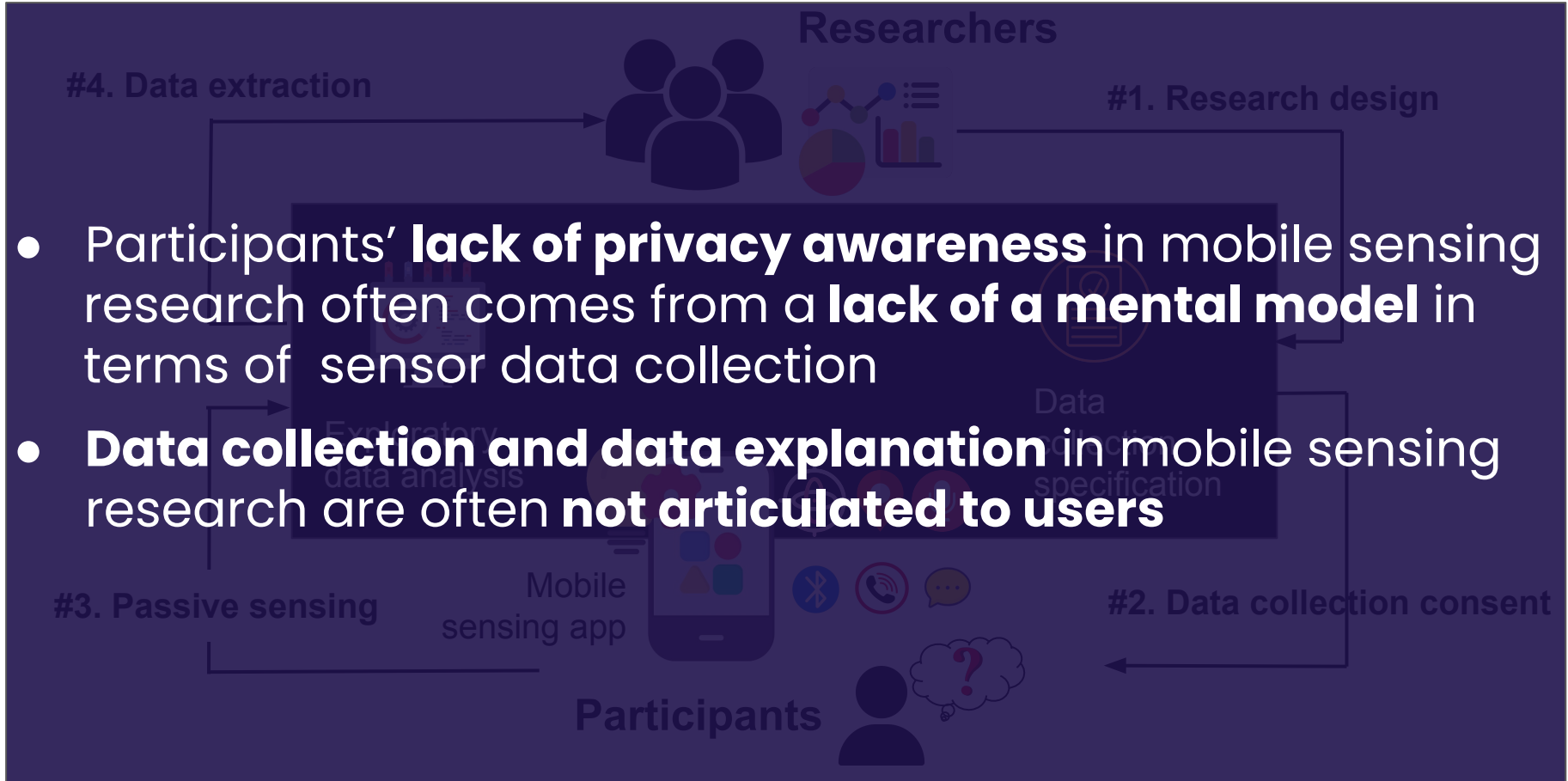
- **Social stigma**  
(Martinez-Martin et al., 2011)
- **Discrimination**  
(Skiljic et al., 2021)
- **Surveillance**  
(Kwapisz et al., 2011)
- **Private life inference**  
(Lee et al., 2022)

# Transparency issues in mobile sensing research



# Transparency issues in mobile sensing research

- Participants' **lack of privacy awareness** in mobile sensing research often comes from a **lack of a mental model** in terms of sensor data collection
- **Data collection and data explanation** in mobile sensing research are often **not articulated to users**



How can we design a system that supports user-friendly privacy decision in mobile sensing research?

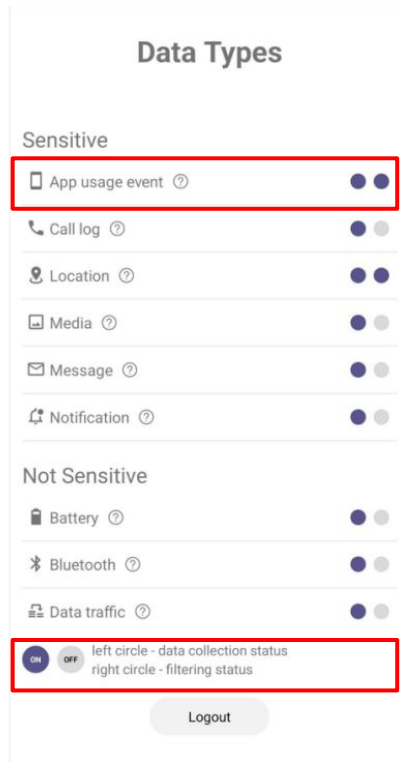
# PriviAware study

- Designed PriviAware, a mobile intervention app that promotes flexible user consent to data collection with data exploration and contextual filter (time & location)
- Conducted the three-week deployment study in the wild (N = 58)

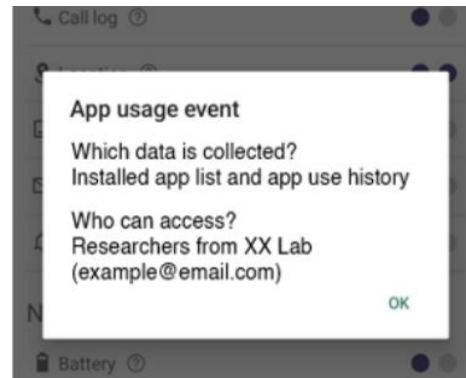


# System Design & Implementation \_ PriviAware System

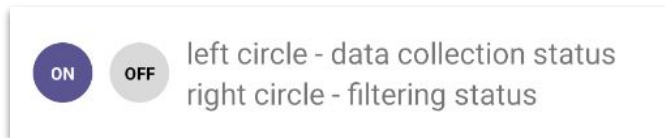
Main page



Data information



Data collection status

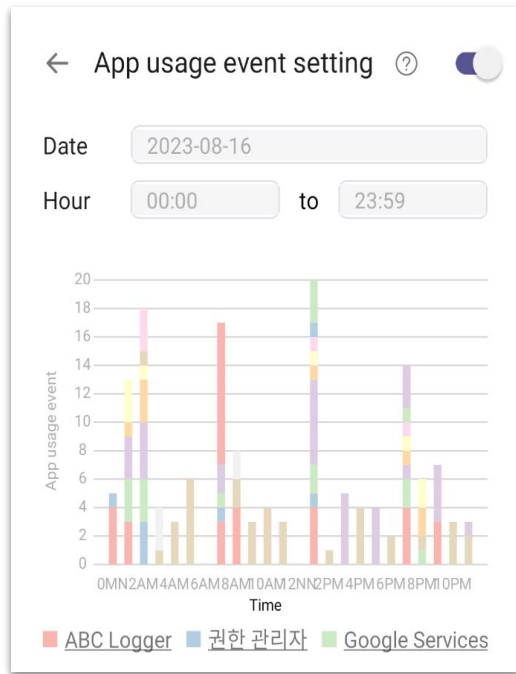


# System Design & Implementation \_ PriviAware System

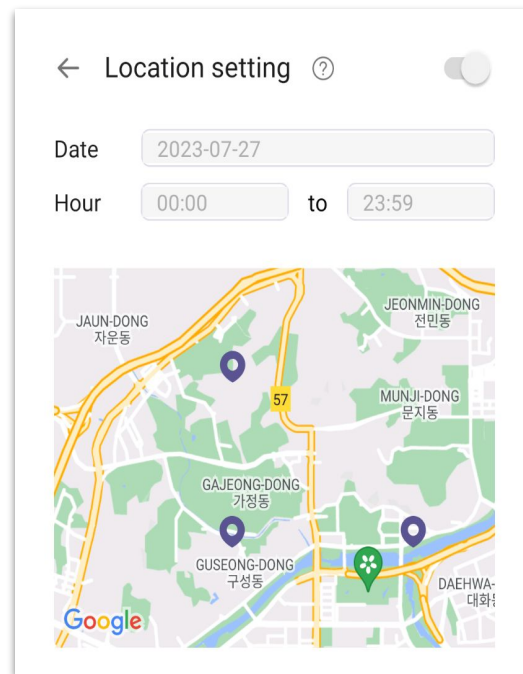
Key Feature #1. Data exploration: Data visualization of collected data



Numeric data view



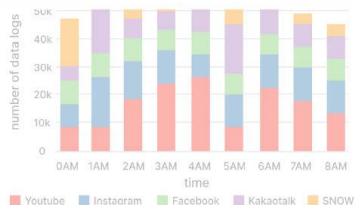
Categorical data view



Location data view

# System Design & Implementation \_ PriviAware System

## Key Feature #2. Data control: Contextual filtering (disable data collection)



### Contextual Filtering

1. Time Filter

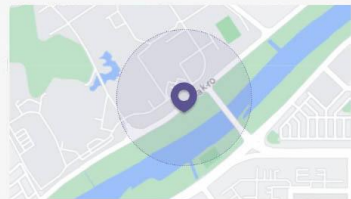
New Filter

Time

Do not collect from 07:00 to 10:00

Location

Do not collect within 150 m of the pin



Add

## 1. Time Filter

- Set the period for filtering

*"Do not collect app usage data from 10PM to 11PM, this is my private time before going to bed."*

## 2. Location Filter

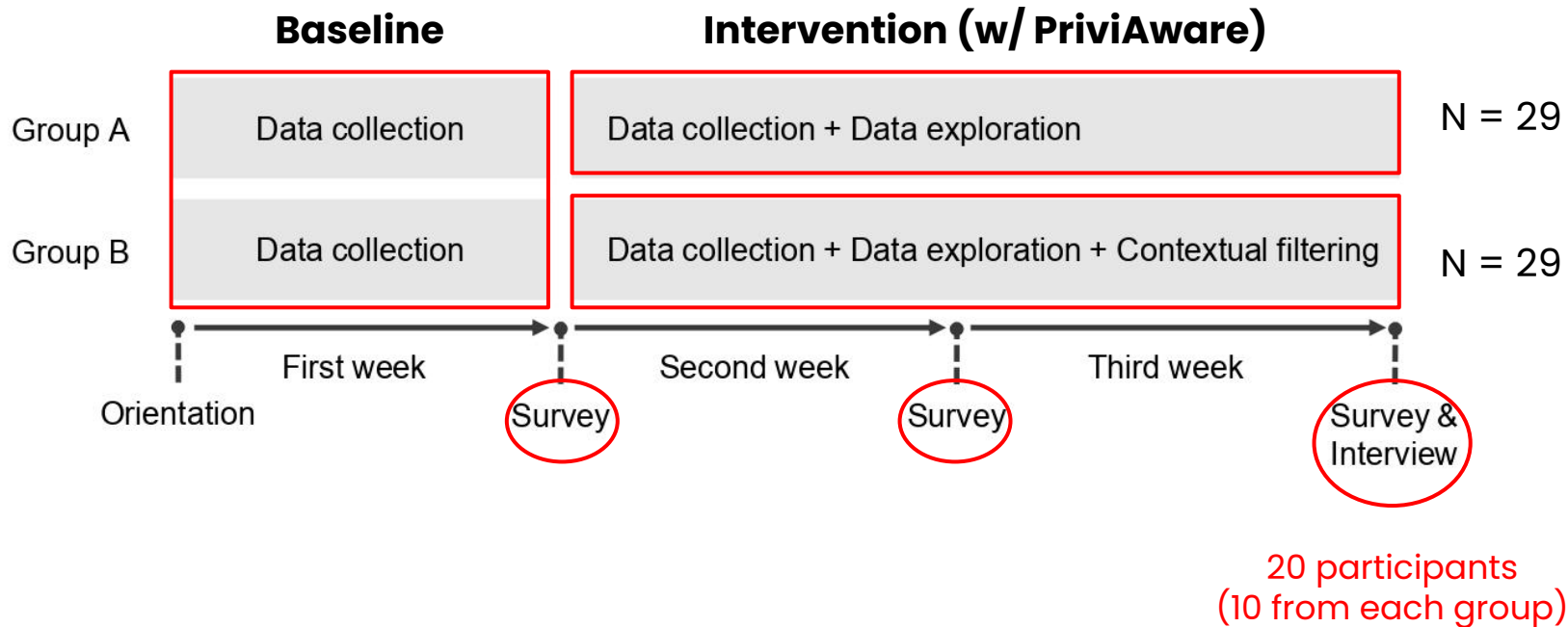
- Set the location for filtering

*"Do not collect my data within this area, this is my boyfriend's neighborhood."*

RQ1: What are the user perceptions and perceived usability of the PriviAware system?

RQ2: Does PriviAware positively affect participants' privacy awareness, and how do data exploration and contextual filtering influence participants' behavior?

# User Study



RQ1: What are the user perceptions and perceived usability of the PriviAware system?

RQ2: Does PriviAware positively affect participants' privacy awareness, and how do data exploration and contextual filtering influence participants' behavior?

# User Perception and Perceived Usability of PriviAware (RQ1)

Data exploration (Data visualization): Intuitiveness



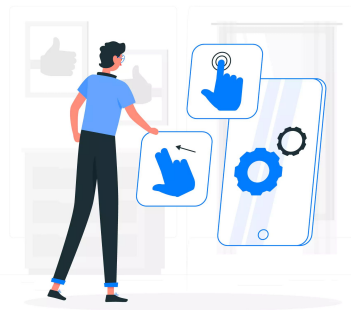
*"All the graphs shown in the app were **easy to understand**, and nothing posed any difficulty." (B5)*



*"I think the biggest advantage of this visualization was that I could see a **graph tailored to each data type**. Bar graphs, line graphs, and maps were all appropriate choices for each data." (A8)*

# User Perception and Perceived Usability of PriviAware (RQ1)

Data control (contextual filter): Ease of customization



*" I could customize these conditions according to my time and location preferences. Right? It was **intuitive to configure** data collection filtering. If the filtering configuration conditions were more complex, I wouldn't have used them so often. " (B10)*



# User Perception and Perceived Usability of PriviAware (RQ1)

Data control (contextual filter): Ease of customization



*“ I liked both time and location filter. Although I had trouble setting up a location filter because I had no idea to which extent I should disable data collection, I enjoyed filtering. Compared to location filter, **time filter was much easier.**” (B7)*

RQ1: What are the user perceptions and perceived usability of the PriviAware system?

RQ2: Does PriviAware positively affect participants' privacy awareness, and how do data exploration and contextual filtering influence participants' behavior?

# Effectiveness of Intervention (RQ2)

## Group A (Data exploration only group)

Increased privacy awareness



*"I think there's a big gap between just knowing and knowing upon seeing visible data. I just had a vague idea of smartphone data collection because you don't know what's happening once you consent. It's like putting all your data into a black box. But this app is transparent..." (A2)*

# Effectiveness of Intervention (RQ2)

## Group A (Data exploration only group)

Decreased privacy concerns



*“As I constantly checked my data with the data exploration, I felt it was helping me be conscious of my rights to protect personal data. Since I could check my data at any time and find out what data types were being collected, I felt rather safe.” (A9)*

# Effectiveness of Intervention (RQ2)

## Group A (Data exploration only group)

Personal data reflection as daily ritual with data exploration



*"I think it's hard to talk about certain sensitive contexts regarding time and place. I think I checked my data in my dorm room at the end of the day. You know, you wrap up your day by reflecting upon all the private data collected daily. It's like a daily ritual." (A8)*

# Effectiveness of Intervention (RQ2)

## Group B (Data exploration + Contextual filtering group)

Active use of both time and location filter



**TIME + PLACE**

*"As I did my data exploration, I found that collecting private data such as location or app notifications is especially clustered around after midnight.*

*After that, I actively set both a time and location filter. I think choosing to use just one filter is not enough.*

*First, I would set the time filter on any irregular data collection outside my routine. Then, I would make granular adjustments with the location filter." (B6)*

# Effectiveness of Intervention (RQ2)

## Group B (Data exploration + Contextual filtering group)

Contextual filtering as a habit



*“From 9 to 6, most of the calls are related to work, so I didn’t set any filter. After that, however, I actively set time and location filters on my call logs because I go to the gym and do many social gatherings outside. Sometimes I forgot to set up a filter and was so upset (laughs).” (B8)*

# Effectiveness of Intervention (RQ2)

## Group B (Data exploration + Contextual filtering group)

A sense of empowerment from contextual filtering



*“Once I explored my data, I was concerned that so much of the data was collected. But since I can filter data collection that occurs during the time while I am at a certain place, I think I was instantly relieved and empowered (laughs).” (B8)*



# Effectiveness of Intervention (RQ2)

## Group B (Data exploration + Contextual filtering group)

Lessened privacy concerns due to full data control



*"I think contextual filter got rid of all my existing privacy concerns. The fact that I could set up a rule at any time just for myself made me feel like I had full control. It's ironic, but that's why I didn't use the filter that much."* (B10)

# Revisiting Key Findings

## # RQ1: User Perception and Perceived Usability of PriviAware

- Both features were intuitive and easy to use

## # RQ2: Effectiveness of Intervention

- Group A (Data exploration):
  - Increased privacy awareness
  - Self-reflect their daily lives in terms of personal data collection
- Group B (Data exploration + Contextual filtering):
  - Active use of both time and location filter
  - Configuring filter as a habit
  - A sense of empowerment from contextual filtering
  - Lessened privacy concerns due to full data control

# Discussion

## Promoting privacy awareness in mobile sensing



Combining data exploration and contextual filters amplifies participants' privacy awareness



Accommodating and balancing the needs and tensions of both data contributors and researchers



Focusing on fewer data types closely related to privacy issues and balancing the data granularity

# PriviAware

## Takeaway messages

- Offering fine-grained control is a promising approach to raising users' privacy awareness under the dynamic nature of the pervasive sensing context
- Combining data exploration and contextual filters amplifies participants' privacy awareness

## Looking Forward

- Promoting privacy awareness in mobile sensing
- Data-driven and automated intervention & Privacy nudge support

***In the job market & Open to research opportunities!***



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