UBICOMP ISWC2025

# Harnessing Home IoT for Self-tracking Emotional Wellbeing: Behavioral Patterns, Self-reflection, and Privacy Concerns

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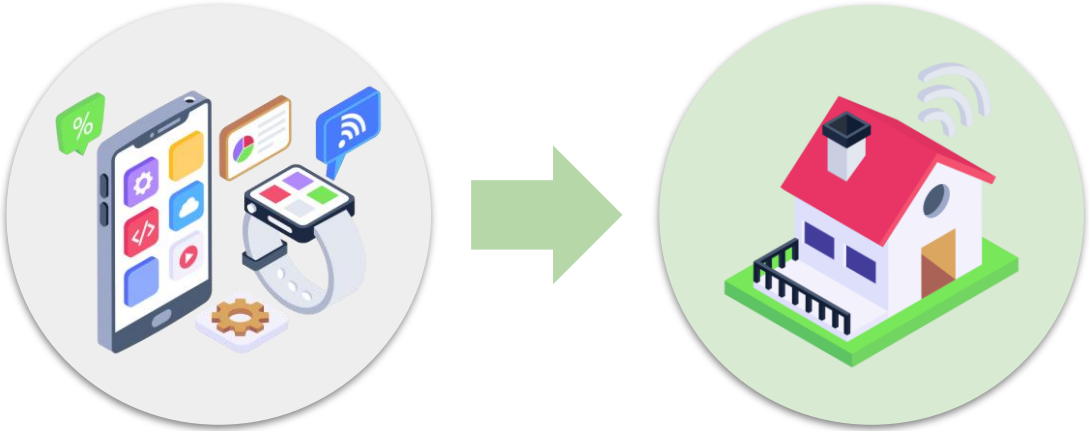
KAIST

## **Self-tracking** for Emotional Wellbeing

HCI/UbiComp research has explored **self-tracking for emotional wellbeing**, primarily through **mobile and wearable devices**

**Recent advances toward Ambient Intelligence**[1] extends this vision, shifting self-tracking from **personal devices** to **environmental sensing**



**Smart Devices** **Smart Space**



[1] Mark Weiser. "The computer for the 21st century." ACM SIGMOBILE mobile computing and communications review 1999

# **Home** as a Key Context for Emotional Wellbeing

***Home Stay*** ⬆

**Longer time at home** with poor mental health[1]

***Everyday Routines at Home***

**Daily routines at home** strongly linked to **mental health**[2]

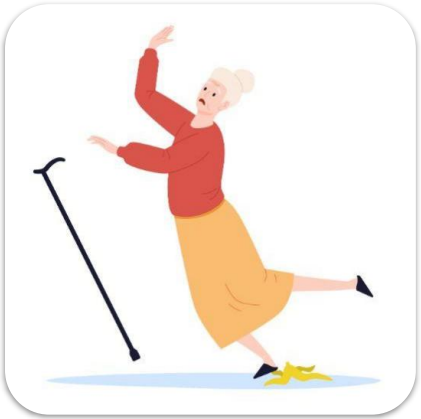
***Private & Natural Space***

Captures **natural behaviors** in a **comfortable environment**[3]

[1] Sheila J Linz and Bonnie A Sturm. "The phenomenon of social isolation in the severely mentally ill." Perspectives in psychiatric care 2013
[2] Sarris et al. "Lifestyle medicine for depression." BMC psychiatry 2014
[3] Rooksby et al. "Personal tracking as lived informatics." CHI 2014.

## Existing Research on **Home IoT Sensing**

Existing studies monitors **Activities of Daily Living (ADLs)** in home environments,
focusing on **older adults' cognitive and functional health**[1-4], with little attention to emotional wellbeing



**Functional Health**
**(e.g., fall detection)**

**Cognitive Health**
**(e.g., early detection of dementia)**

[1] Miao Yu et al. "A posture recognition-based fall detection system for monitoring an elderly person in a smart home environment." IEEE transactions on information technology in biomedicine 2012
[2] Daniele Riboni et al. "SmartFABER: Recognizing fine-grained abnormal behaviors for early detection of mild cognitive impairment." Artificial intelligence in medicine 2016
[3] Andreadis et al. "Dem@ Home: Ambient intelligence for clinical support of people living with dementia." European Semantic Web Conference 2016
[4] Ane Alberdi et al. "Smart home-based prediction of multidomain symptoms related to Alzheimer's disease." IEEE journal of biomedical and health informatics 2018

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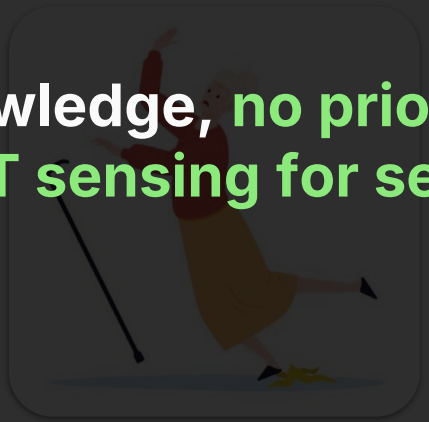
**To our knowledge, no prior study has explored the potential of home IoT sensing for self-tracking emotional wellbeing**



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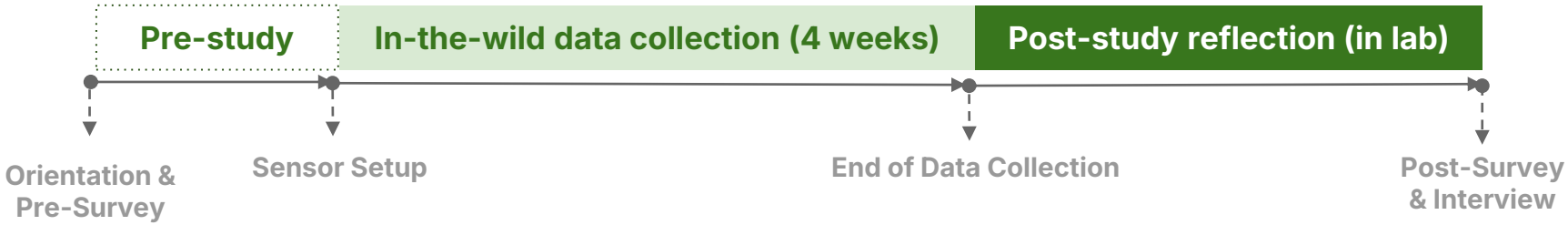
## Research Goal

Explore how **home IoT sensing** can be used for **self-tracking emotional wellbeing**, focusing on **behavioral patterns, user perceptions, and privacy concerns**

**Research Questions (RQs)**

💡 RQ1. How is **home IoT data** linked to **everyday emotional wellbeing**?
💡 RQ2. How do users **perceive behavioral patterns** derived from **home IoT data**?
💡 RQ3. What are users' **privacy concerns** about using **home IoT data** for wellbeing tracking?

## Overview of Study Phases




### Pre-study

- Baseline mental health assessment survey (PHQ-9, GAD-7, PSS)
- Privacy acceptability survey (before data collection)

### In-the-wild data collection (4 weeks)

- 20 single-person households (13 men, 7 women; avg age: 24.8), each living in a studio or one-bedroom unit
- Mobile, wearable, and home IoT sensor data, and self-reported emotional wellbeing survey via ESM

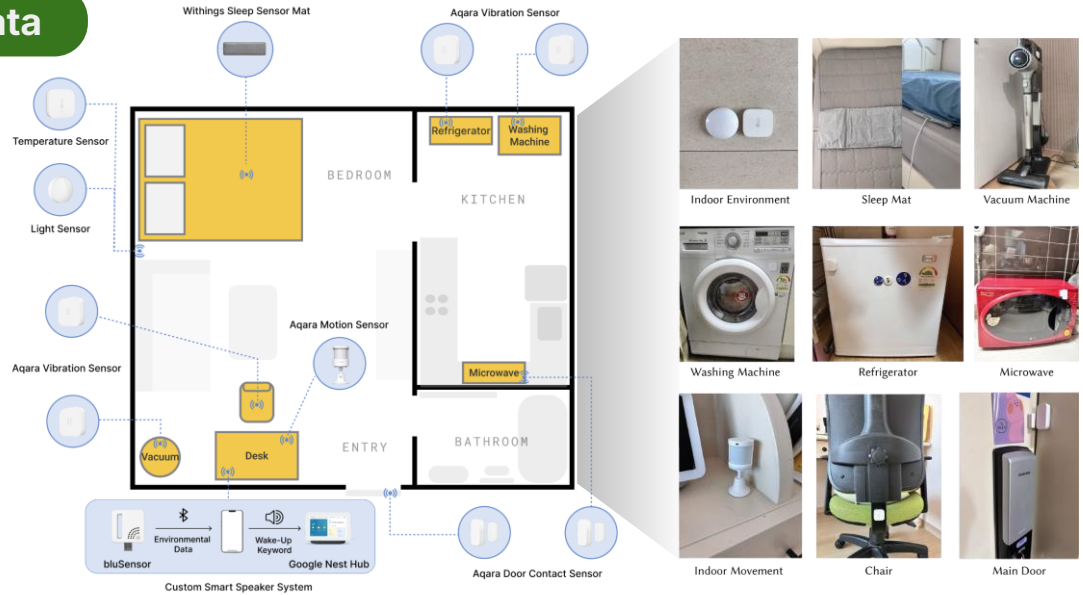
### Post-study reflection (in lab)

- Baseline mental Self-reflection using visualization tool
- Privacy acceptability survey (after data collection)
- Exit interview

# In-the-Wild Data Collection: Sensor Data

**Smartband**
(Fitbit Inspire 2)

**Participants' Smartphones**
(installed phone logger)



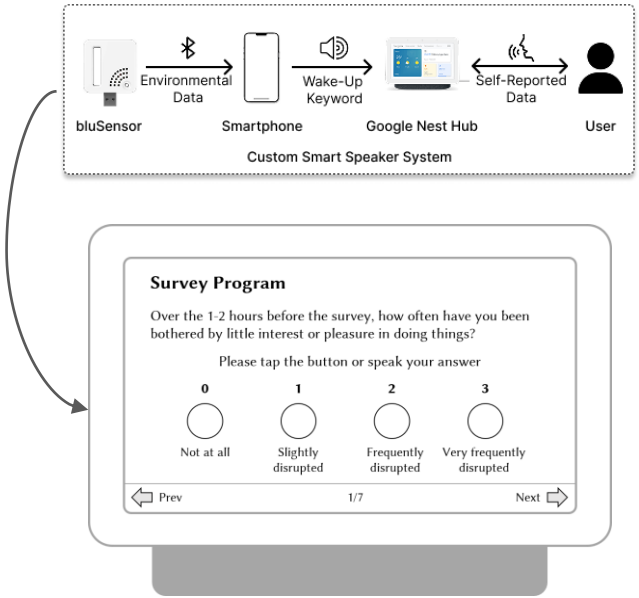

## Mobile & Wearable

- Call & SMS metadata (frequency, duration)
- Step counts

## Home IoT Sensors

- Sleep time
- Appliance usage
- Indoor movement
- Outgoing/arrival events
- Environment (brightness, temperature, humidity)

# In-the-Wild Data Collection: Self-reported Data

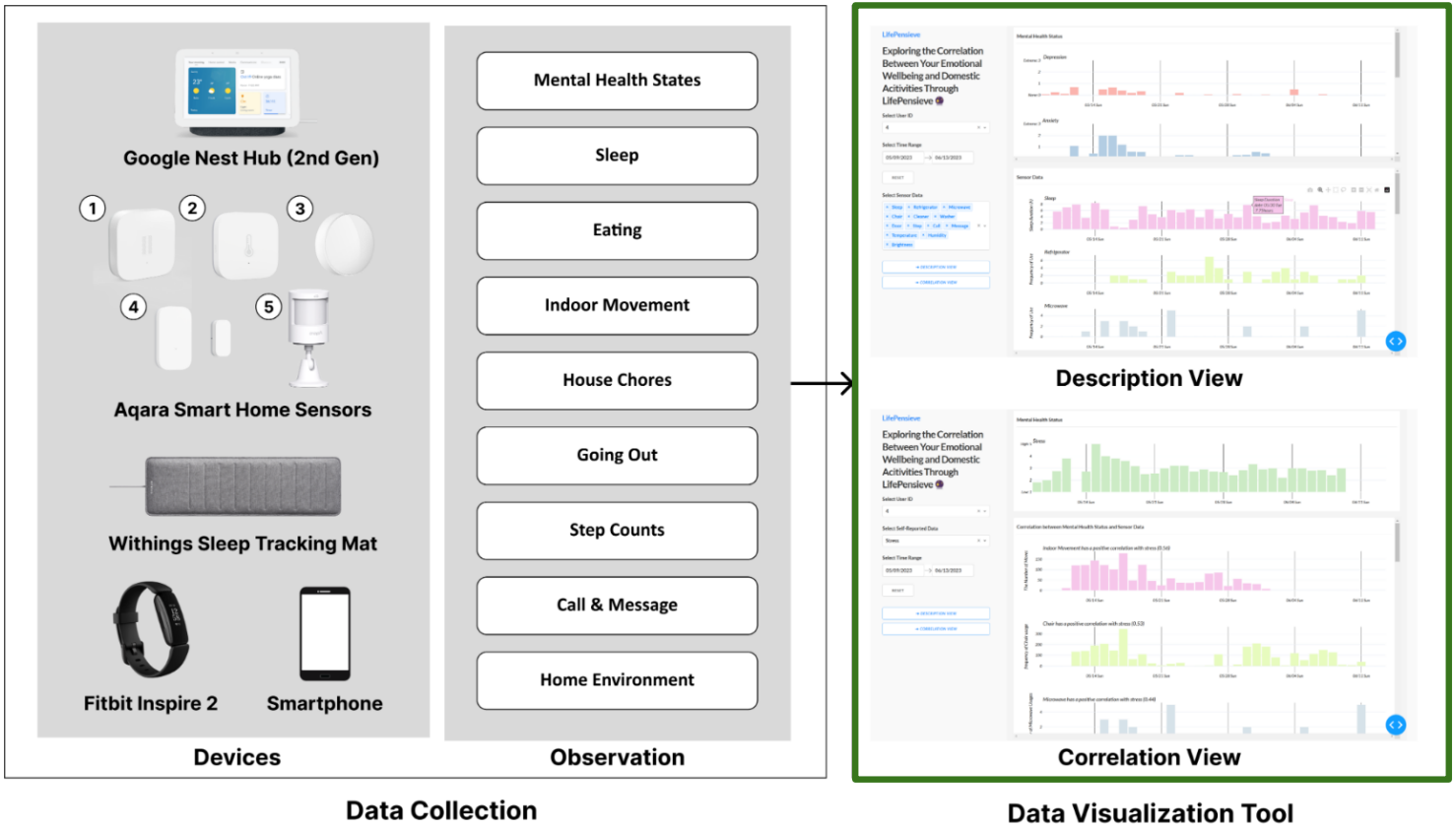



[Smart Speaker UI Example]

## Mental Health Surveys Conducted via a Smart Speaker

- Every 90 minutes or at contextually opportune moments
  - Opportune moments: noise ↓, user nearby
  - Smartphone app activates speaker with a wake-up keyword
- Users answer **mental health questionnaires**
  - PHQ-2, GAD-2, Stress, Emotional Arousal & Valence
  - Response via **voice** or **touch**

# Post-study reflection



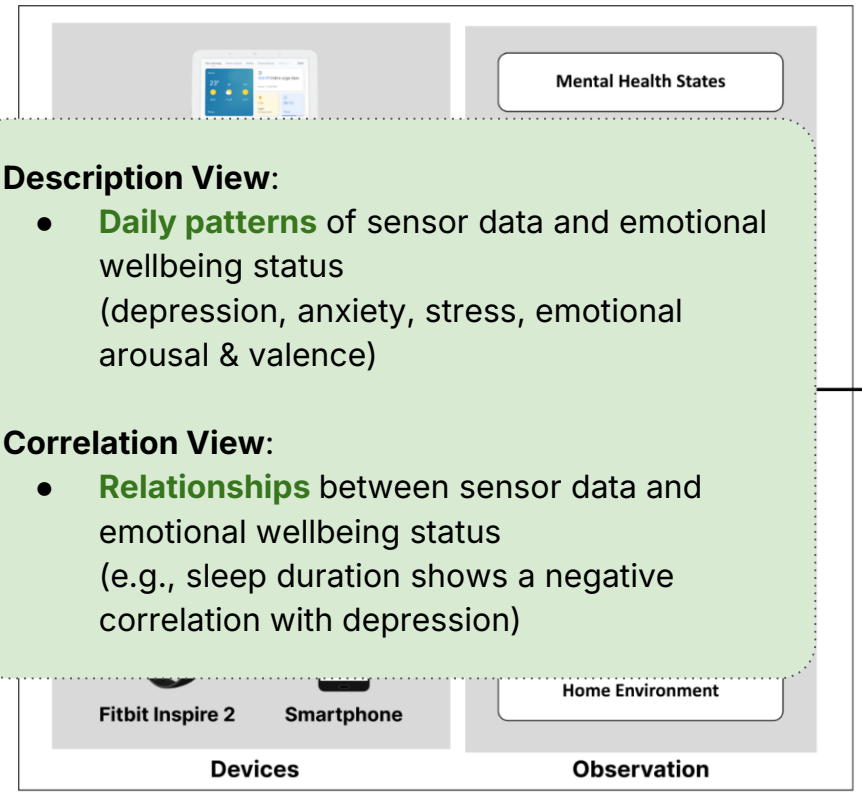
## Post-study reflection

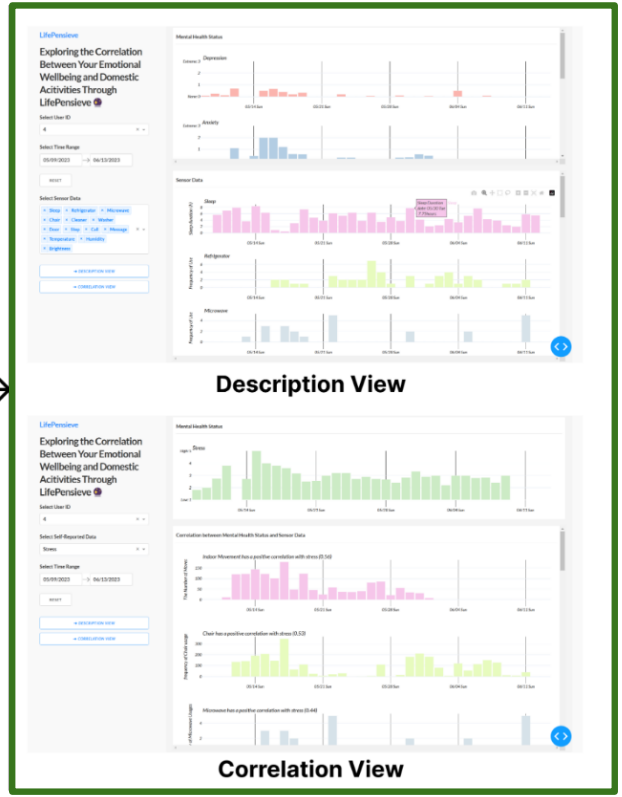
**Description View**:

- **Daily patterns** of sensor data and emotional wellbeing status
  (depression, anxiety, stress, emotional arousal & valence)

**Correlation View**:

- **Relationships** between sensor data and emotional wellbeing status
  (e.g., sleep duration shows a negative correlation with depression)



## Findings for RQ1. Exploring Home IoT Data Associated with Emotional Wellbeing

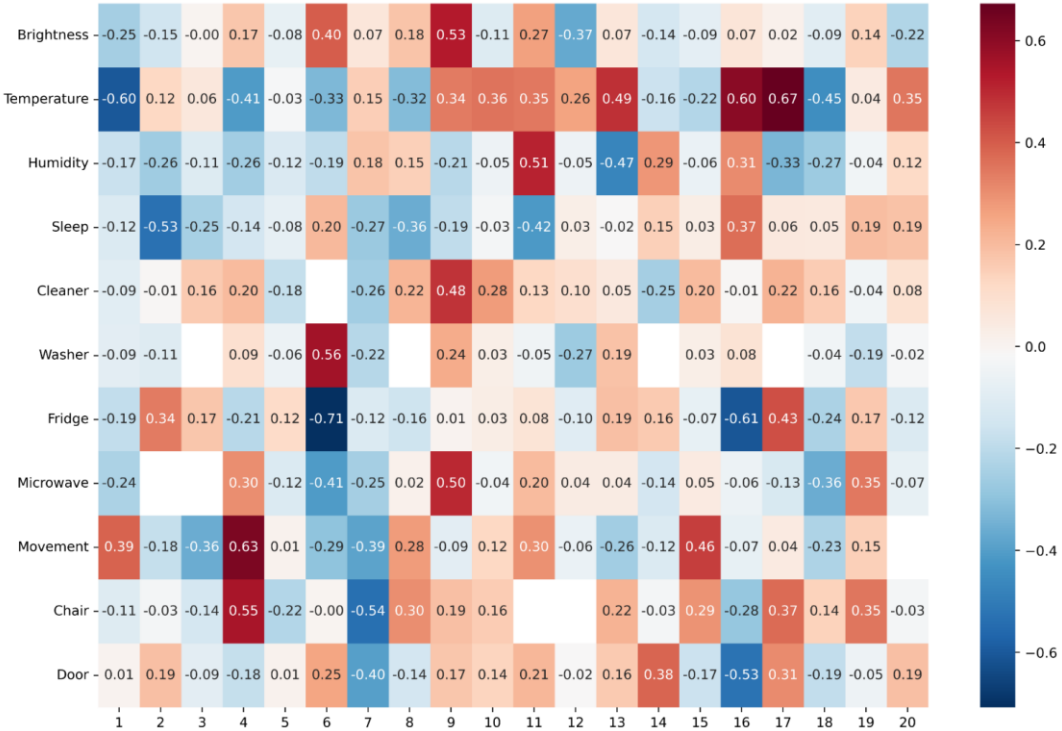
### Multilevel Logistic Regression Analysis Results:
**Reduced sleep duration** and **higher indoor temperature** predicted **worse mental health**

| Data Types | Depression | Anxiety | Stress | Emotional Valence | Emotional Arousal |
|---|---|---|---|---|---|
| **Sleep duration** | ↓ (β = –0.21***) | ↓ (β = –0.33***) | ↓ (β = –0.12*) | ↑ (β = +0.11*) | — |
| **Temperature** | ↑ (β = +0.77***) | ↑ (β = +0.74***) | — | — | — |
| **Washer usage** | ↑ (β = +0.22*) | — | — | — | ↑ (β = +0.17**) |
| **Door open/close** | — | — | ↑ (β = +0.10**) | — | — |
| **Message counts** | — | — | ↑ (β = +0.08*) | — | — |
| **Other features*** | — | — | — | — | — |

*Other features include call frequency, step count, brightness, humidity, and appliance or furniture usage (e.g., cleaner, fridge, microwave, chair)

Blue: Negative association (Higher value = Lower emotional score)
Red: Positive association (Higher value = Higher emotional score)
— : non-significant (p ≥ .05)

# Findings for RQ1. Exploring Home IoT Data Associated with Emotional Wellbeing



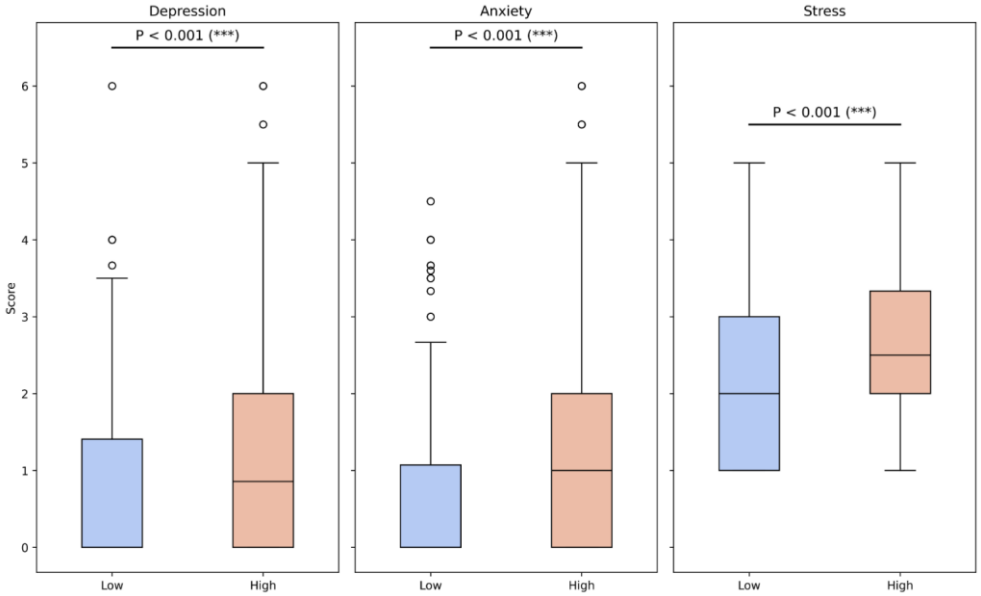

However, the relationship between emotional wellbeing risk scores (depression, anxiety, stress) and home IoT data **varied widely across individuals**

*The correlation heatmap of **users (X-axis, user ID)** and **sensor data (Y-axis)** and for emotional wellbeing risk scores

# Findings for RQ1. Exploring Home IoT Data Associated with Emotional Wellbeing

Despite individual differences, **behavioral variability** emerged as a key indicator of emotional wellbeing

**Greater day-to-day variability** in routines was consistently associated with higher depression, anxiety, and stress levels, indicating **poorer mental health**




Note: *** p < .001, ** p < .01, * p < .05.

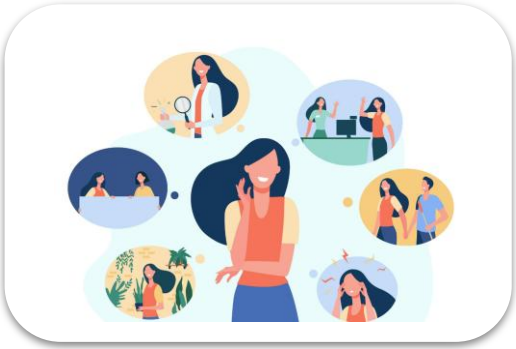
## Findings for RQ2. User Perceptions of Home IoT Data for Emotional Wellbeing

Participants replied that **the process of understanding their data** with the system was **straightforward** and **clear**

Explored **familiar or intuitive data** first, such as sleep and eating

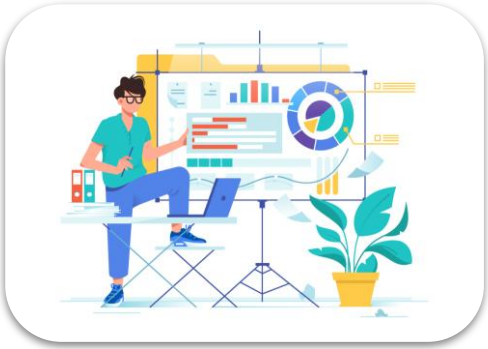
***"I already know that sleep affects my mood and mental health,*** *so I took a look at it first"*

Contextualized data patterns with **personal experience**



***"...Looking back, I stayed up all night studying during exams,*** *which added more stress..."*

**Integrated multiple data** to understand emotional wellbeing

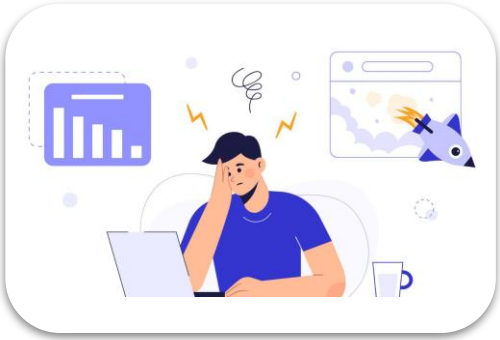


***"...Seeing vacuum, motion, and washer usage data together*** *revealed how my cleaning routines were tied to my stress..."*

# Findings for RQ2. User Perceptions of Home IoT Data for Emotional Wellbeing

However, participants sometimes **struggled to link sensor data with emotions**

**Ambiguous activities** and **confounding factors** made interpretation difficult



*"...But **I often open the microwave just to clean it, and it's still counted as usage**, even though it wasn't actually used for cooking"*

Some lacked a **clear mental model** for linking **environmental data** to emotions

*"Knowing that higher humidity is associated with my stress is interesting, but **I'm not sure what I'm supposed to do with that information**..."*

# Findings for RQ3. Privacy Concerns of Home IoT Data for Self-Tracking Emotional Wellbeing

After viewing their data, participants became more comfortable with Home IoT data collection. Especially, **Sleep** and **Indoor Movement** showed significant increases in acceptability ($p < .01$)

## Higher perceived benefits lead to lower privacy

*"At first, I questioned **why sleep data was needed**, but later I saw **how it reflected my mental health**"*

## Understanding how data are collected reduces privacy concerns

*"I was worried about motion data at first, but **seeing it only showed movement, not location**, made me comfortable"*

# Design Implications

Based on these findings, we highlight three **design implications**:

## Personalized Wellbeing Modeling

**Tailor** emotional insights to **individual lifestyles and routines**

## Context-Aware Reflection Support

Help users **interpret abstract data** through **relatable context**

## Trust-Building Privacy Design

Foster **transparency** and **control** to reduce privacy concerns

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## Takeaways

- Home IoT data revealed strong **individual differences** in emotional patterns
- **Behavioral variability** emerged as a key indicator of emotional wellbeing risk
- Participants became more **open to data collection** by understanding its value and collection

**Paper QR code**

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