DailyExp : A Tool for Collecting Cognitive Performance and Physiological Data in Daily Life with Engaging Behavioral Design

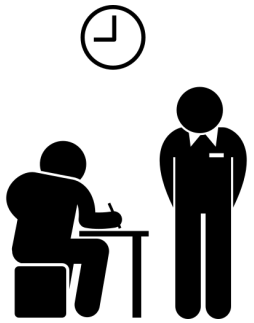
Xianyin Hu, Yuki Ban and Prof. Shin'ichi Warisawa

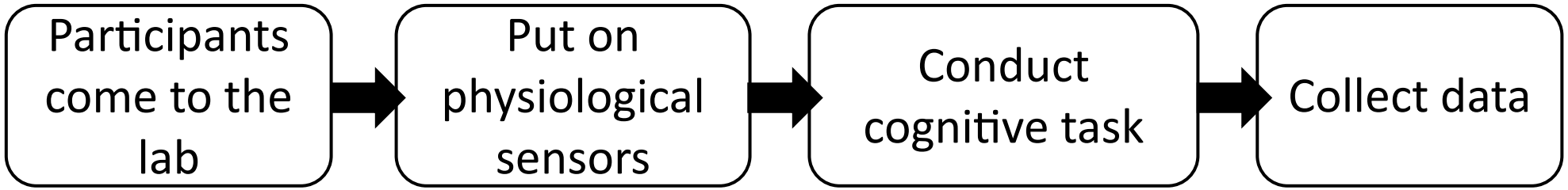
Human&Enviroment Informatics Lab. Graduated School of Frontier Science
The University of Tokyo
Tokyo, Japan

huxianyin@lelab.t.u-tokyo.ac.jp , {ban, warisawa}@edu.k.u-tokyo.ac.jp

Background

- Conventional laboratory-based experiment to study cognition and physiology:



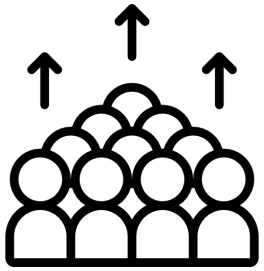


- Conducting conventional laboratory-based experiment has drawbacks:
  - High financial and temporal cost
  - Low ecological validity
  - Difficult to capture natural cognitive fluctuations over time

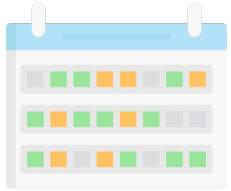
Objective

- **To present a practical tool for collecting cognitive performance data as well as physiological data in daily life settings.**

✓Cost and time efficiency.



✓Capturing diverse variety of human cognitive and physiological states.



Weekdays as well as weekends

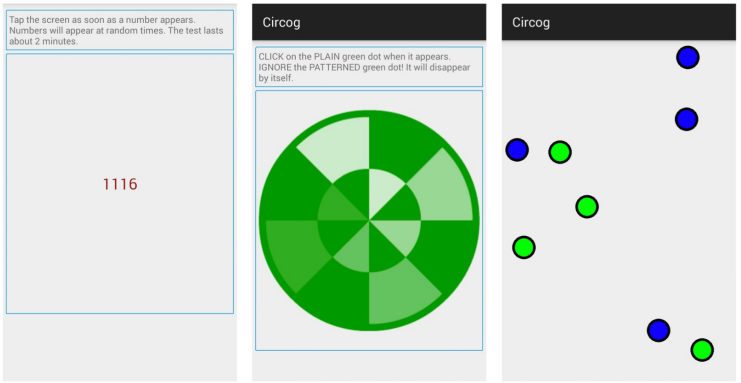
Energetic state as well as fatigued state

✓High ecological validity under a real-life context.

Related Works

- Smartphones and smartwatches had been adopted as assessment tools [1-5] showing their feasibiliy for evaluating cognitive function.
- However, a lack of user engagement throughout a prolonged experiment still exist in such experiment conducted in the wild that depends on participants' voluntary behaviors.

[4]Cognitive kit(Smart phone based)



[5]UbiCAT (Smart watch based)

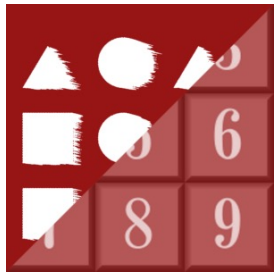
[1] Tschacher, et al. Dynamical Systems Approach To Cognition, The: Concepts And Empirical Paradigms Based On Self-organization, Embodiment, And Coordination Dynamics. Vol. 10. World Scientific, 2003.
[2] Jongstra S, et al. Cognitive testing in people at increased risk of dementia using a smartphone app: The iVitality proof-of-principle study. JMIR Mhealth Uhealth. 2017 May 25;5(5):e68.
[3] Tieges Z, et al. Development of a smartphone application for the objective detection of attentional deficits in delirium. Int Psychogeriatr. 2015 Aug;27(8):1251–1262.
[4] Dingler T, et al. Building cognition-aware systems: A mobile toolkit for extracting time-of-day fluctuations of cognitive performance. Proc ACM Interact Mob Wearable Ubiquitous Technol. 2017 Sep 11;1(3):1–15.
[5] Hafiz, et al. "The ubiquitous cognitive assessment tool for smartwatches: design, implementation, and evaluation study." JMIR mHealth and uHealth 8.6 (2020): e17506.

Proposal : The 「DailyExp」 Application

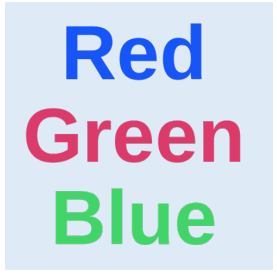
- An alpha version is readily available on major mobile platforms.
- Covering three classical cognitive paradigms (Stroop, N-back, FluidIQ).
- Ready to integrate with Fitbit account for collecting **physiological** data.

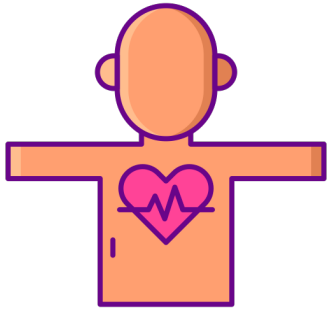
Fluid IQ Test

N-back Test



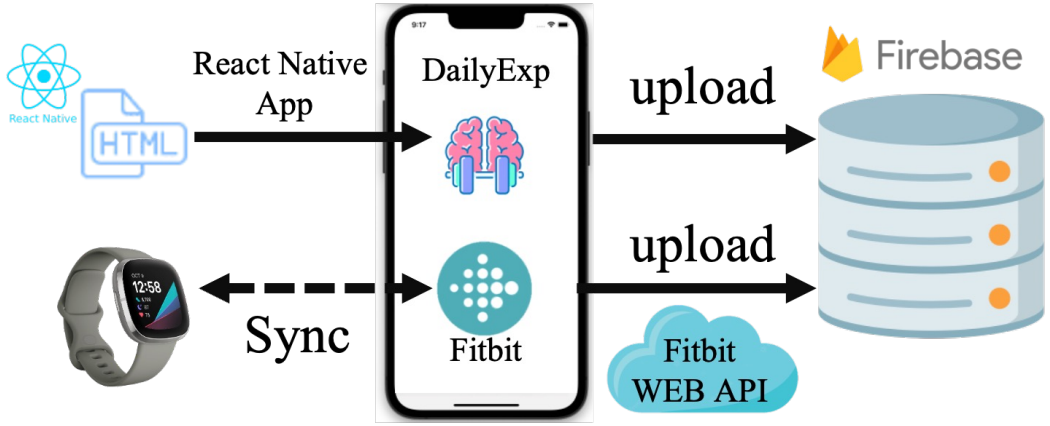
Stroop Test





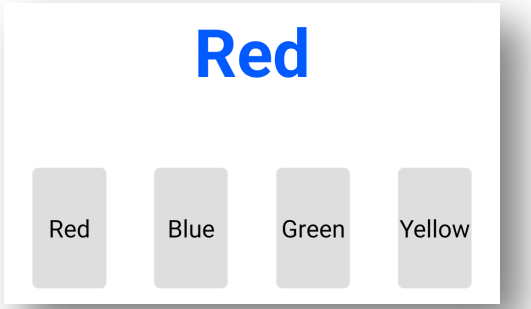
The 「DailyExp」 Application : Implementation

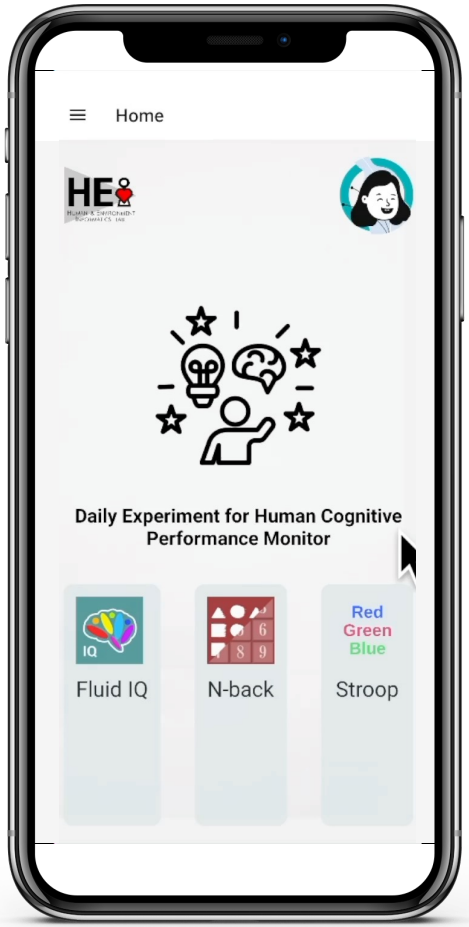
- Implemented using web-based open-source framework : React Native
- Physiological data including heart rate , sleep and activity was grabbed from the Fitbit server using Fitbit web API.
- Firebase's data storage service was utilized to store data.



The Stroop Test

A measure of **cognitive control** and **attention**.





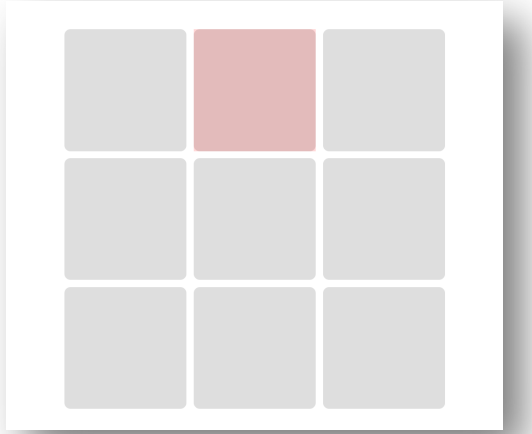
- Participants are presented with color words printed in ink colors and must indicate the color of the ink while ignoring the word itself.

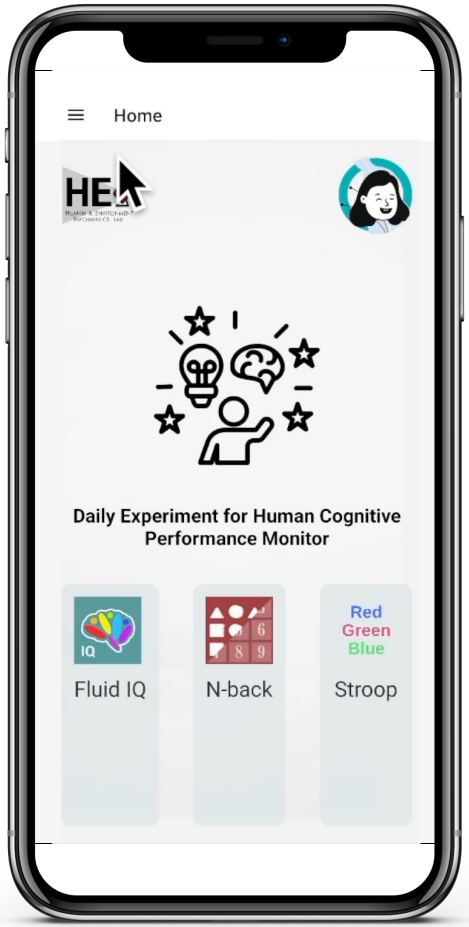
➢ **In 「DailyExp」：**

- Only the incongruent condition where color word and ink color are always different.
- Present interval = 3 sec, retention interval = 2 sec.

The N-back Test

A measure of **working memory**.





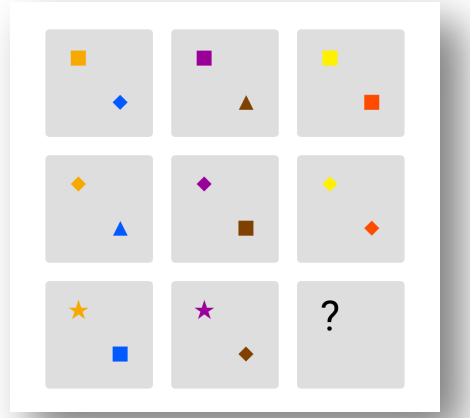
- Participants are presented with a series of stimuli and must indicate the stimulus presented N steps back.

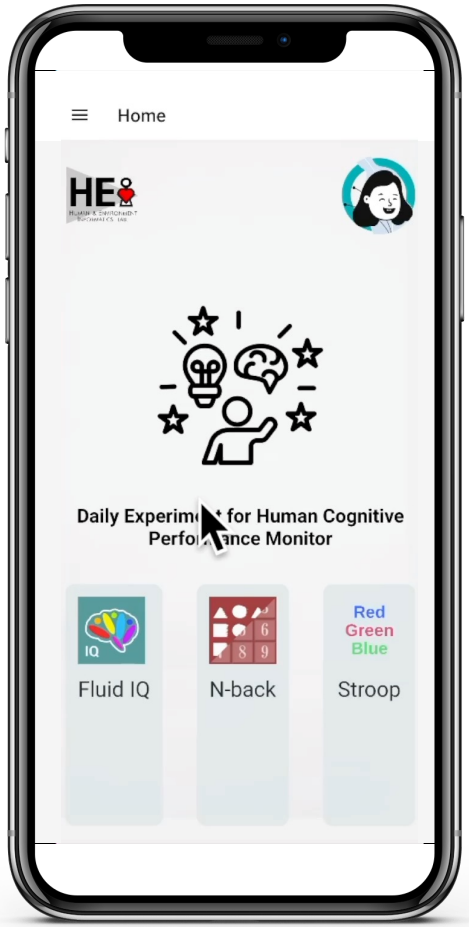
➢ **In 「DailyExp」：**

- A modified version with a continuous input manner.
- Specifically, N=2 and the stimulus are visual locations.
- Present interval = 2 sec.

The FluidIQ Test (RAPM-Raven's Advanced Progressive Matrices Test)

A measure of **fluid intelligence** and **problem-solving abilities.**





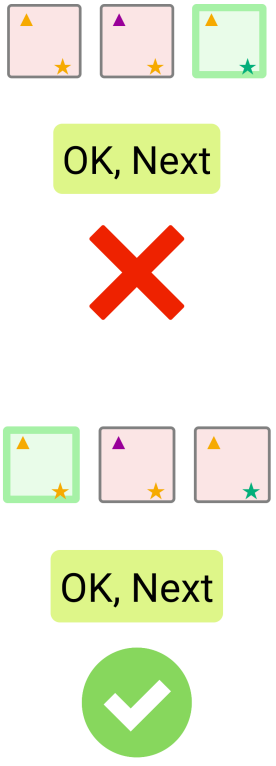
- Participants are asked to Identify the underlying rule and select the correct option after presented with a series of abstract visual patterns.

➢ **In 「DailyExp」：**

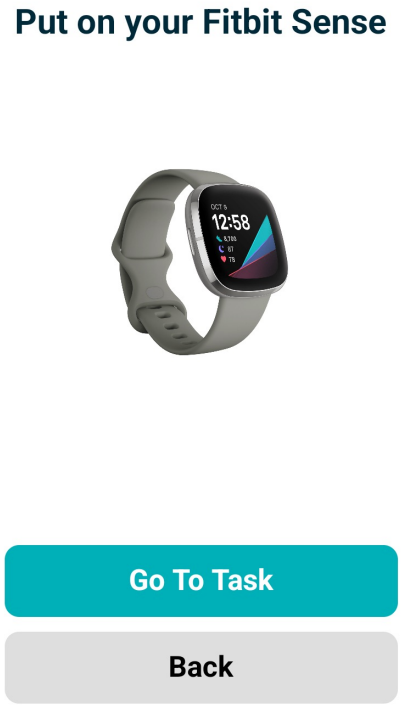
- A generative response manner was implemented to avoid strategy variation.

Dealing with Unexpected User Behavior

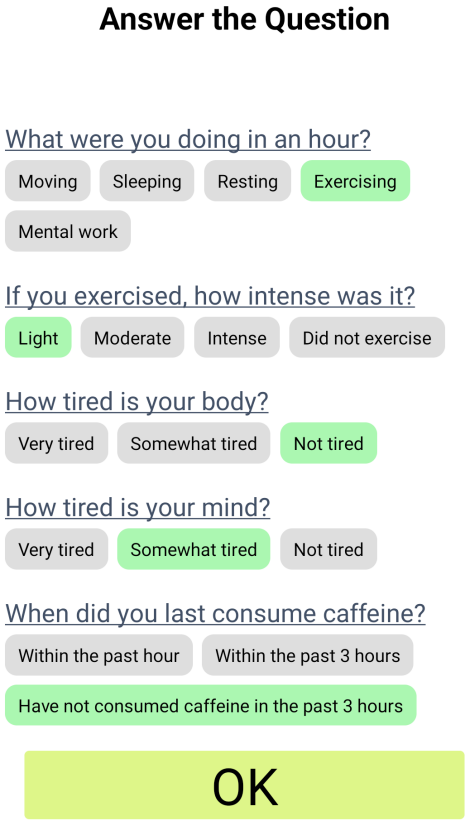
- Practice Mode



- Reminder

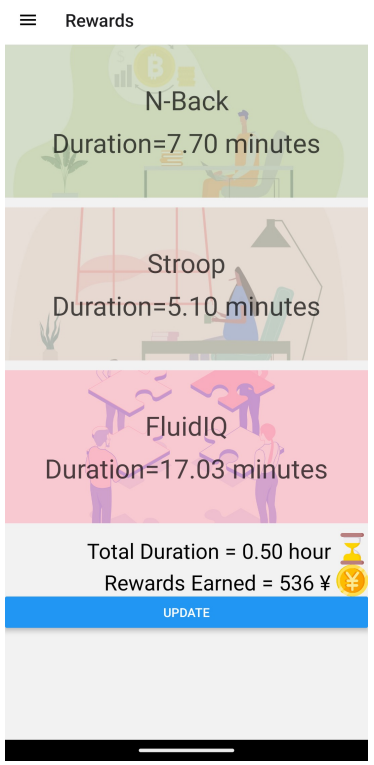


- After-task Questionnaire

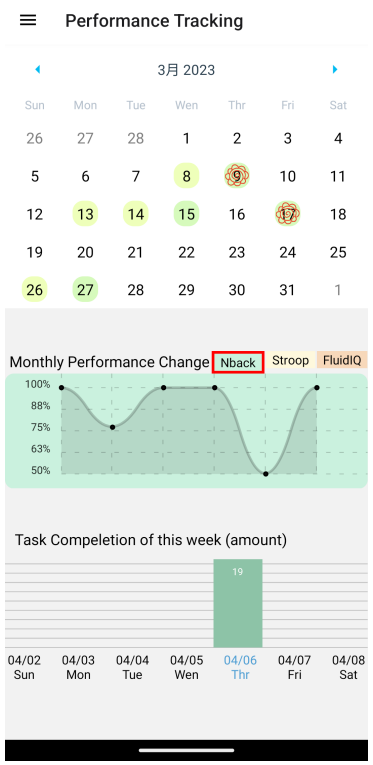


Encouraging Behaviral design

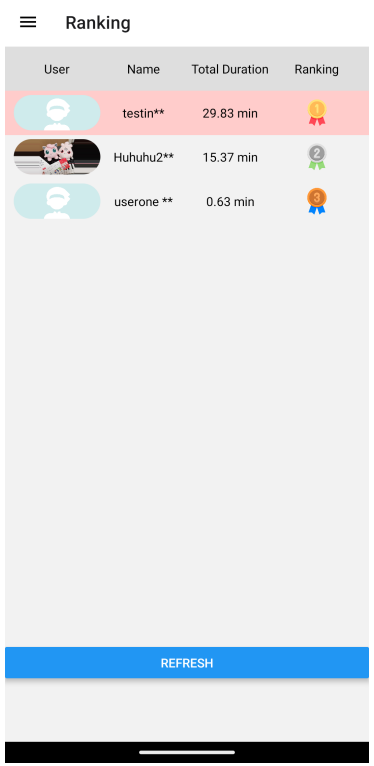
1. Monetary motivation



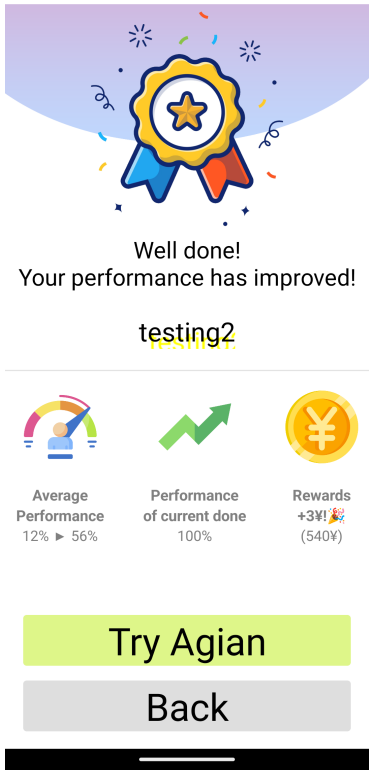
2. Self-control motivation



3. Social motivation

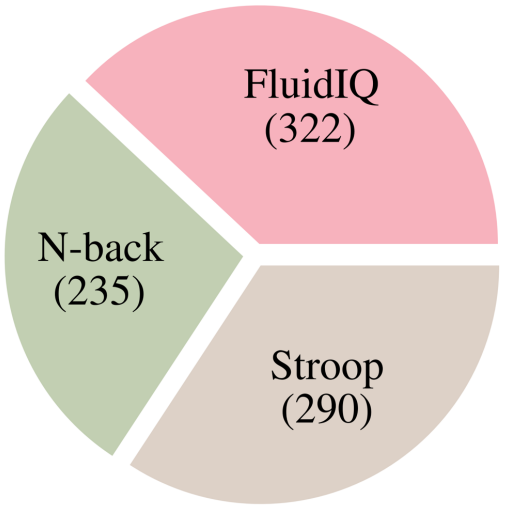


4. Action-reward link leads to habituation



Preliminary User Study : Data Collection Efficiency

- Ten users (6 male and 4 female) administrated to test 「DailyExp」
- Period: 1 month
- Data collected in total : 833 rounds (each round last for 5 minutes).
  - FluidIQ : 322 (38%)
  - N-back : 235 (28%)
  - Stroop : 290 (34%)

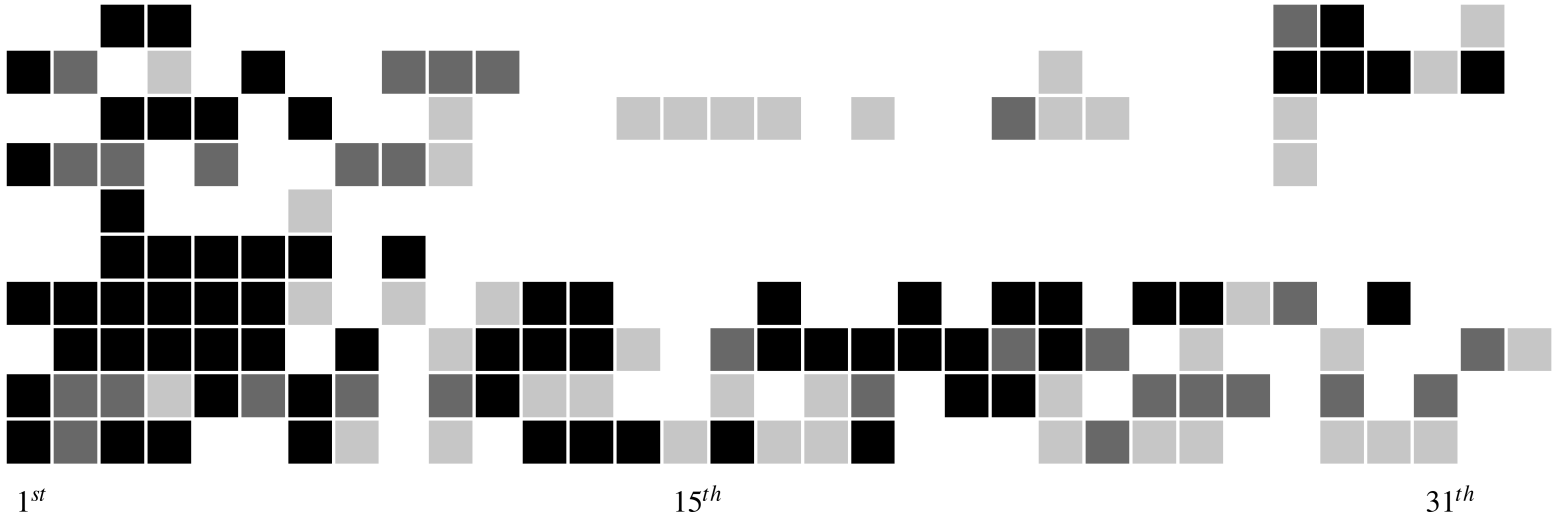


Preliminary User Study : Data Collection Efficiency

- Six users (user 2, 3, 7, 8, 9, and 10) : actively engaged with DailyExp.
- Four users (user 1,4,5 and 6) : less engaged, three reported being occupied with other commitments during the experiment period.

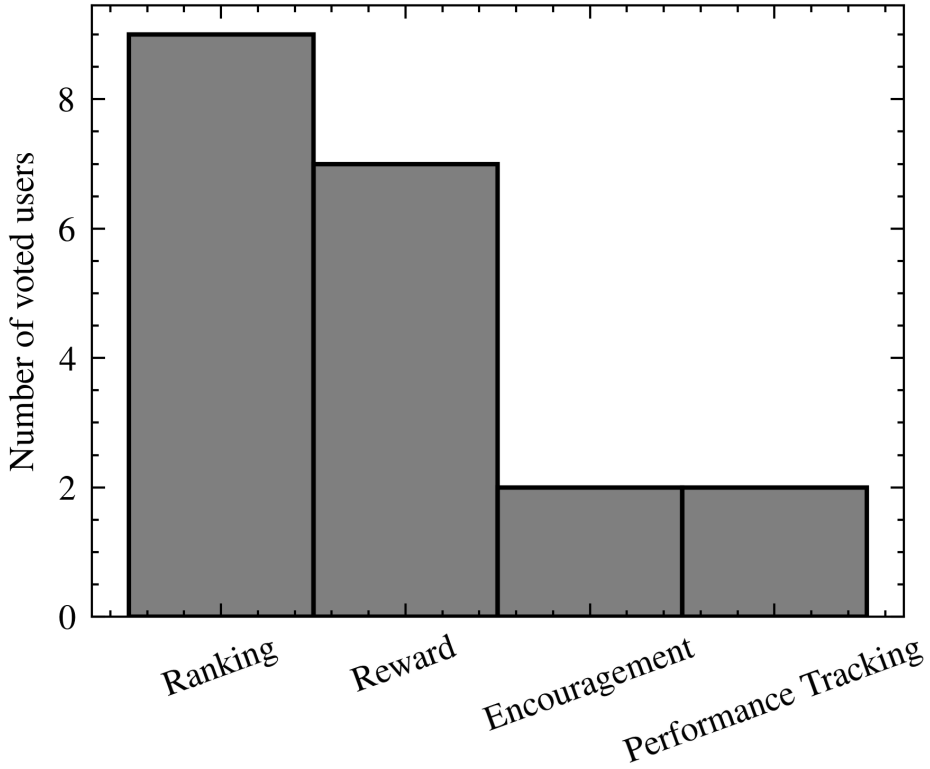
User	Busyness	N_{days}
1	busy	5
2	as usual	13
3	busy	14
4	busy	8
5	busy	2
6	as usual	6
7	as usual	20
8	as usual	24
9	busy	23
10	Very busy	22

Task Conduction over a month



Preliminary User Study : Engaging features

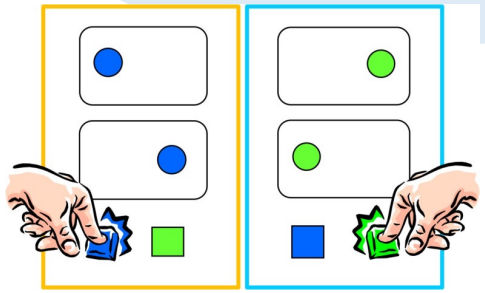
- Users reported engaging features:
  - **Ranking** > Reward > Encouragement > Performance Traking
- Fostering a sense of **social competition** could be a highly effective strategy for promoting user engagement within such a study.



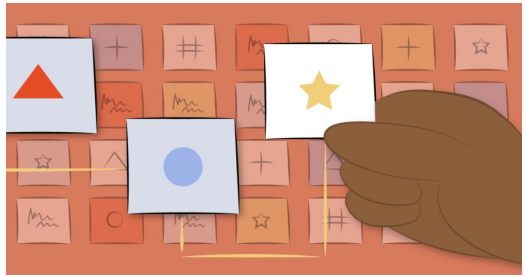
Future Work

- More cognitive batteires.

Simon test



Card sorting test



Operation Span test

(3x2-1)=2 ? Sweets

(3x3-1)=4 ? World

- A Dashboard to adjust system factors for researchers to design their experiment to align with research objective more easily.

Conclusion

- In this work, we demonstrated 「**DailyExp**」 as a data collection tool for both cognitive performance and physiological data in everyday life settings.

- The tool was evaluated by 10 users for one-month usage.

- The results demonstrated its usefulness as a practical smartphone application for conveniently collecting data in daily life settings.

Thank you for your attention!

For further information, please contact:

Xianyin Hu

huxianyin@lelab.t.u-tokyo.ac.jp

HUMAN & ENVIRONMENT INFORMATICS LAB.

THE UNIVERSITY OF TOKYO

Japan

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