The proliferation of smart devices and sensors has enabled **fine-grained tracking** of health and wellbeing behaviors, leading to **micro-interventions**.

- **Micro-interventions**: short, focused interventions for health and wellness objectives

Financial incentives are a commonly used intervention in commercial applications and policy–making[*]. Furthermore, they allow for personalized micro–interventions that are both quantifiable and amenable to systematic evaluation.

* Eat & Tell: A Randomized Trial of Random–Loss Incentive to Increase Dietary Self–Tracking Compliance (2018); Habit formation in children: Evidence from incentives for healthy eating (2015); Incentives to exercise (2009)
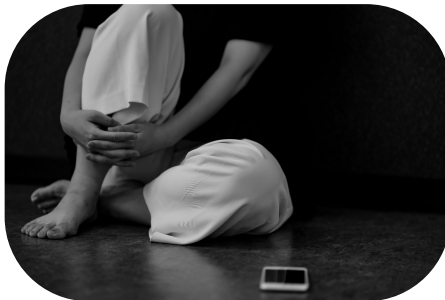
However, **implementing financial incentives** as interventions requires **careful consideration**.

Considerations for Financial Incentives

Finite financial resources

By program-hosting institutions

Unintended side effect

E.g., overjustification or crowding-out effect[*]

Complexity of financial incentives

E.g., gender, socioeconomic status[**]

[*] Effects of externally mediated rewards on intrinsic motivation (1971); On the relationship between intrinsic and extrinsic work motivation (1997); Motivation crowding theory (2001); [**] Personal financial incentives for changing habitual health-related behaviors: a systematic review and meta-analysis (2015); Financial incentives for exercise adherence in adults: systematic review and meta-analysis (2013)

To design financial incentives that can **sufficiently engage individuals** in behavior change **while simultaneously minimizing the total financial outlay**

Contributions

- We designed and implemented **WellbeingWallet**, a novel micro-intervention system for digital wellbeing that provided personalized financial incentives.

- We conducted a four-week, in-the-wild **user study** with 72 participants, comparing it to non-personalized incentive programs (i.e., programs employing random and fixed incentive amounts).

- We provided **design implications** for designing computerized behavior change programs based on our empirical findings.
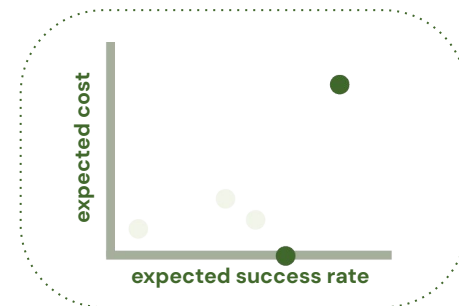
Design Rationale
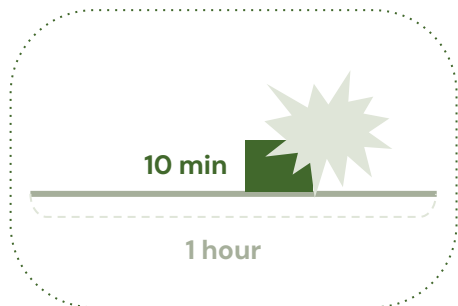
Timebox-Based Micro-Missions*

Using a smartphone
less than 10 minutes/hour
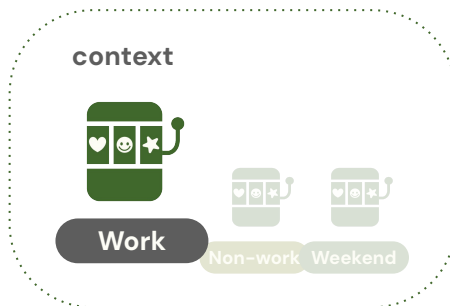
Context-Based Micro-Incentives

Temporal contexts –
*work, non-work, weekend*

Multi-Objective Personalization

Maximizing behavior change &
Minimizing costs

* Goldentime: Exploring system-driven timeboxing and micro-financial incentives for self-regulated phone use (2021)

Mobile Application

- **Hourly micro–missions**: Using a smartphone less than 10 minutes per hour, from 9 AM to 2 AM the following day

- **Timer**

- **Notification**

- **Statistics**

(b) Notification bar timer ↓

Internet >
Bluetooth >
Flashlight
Do Not Disturb
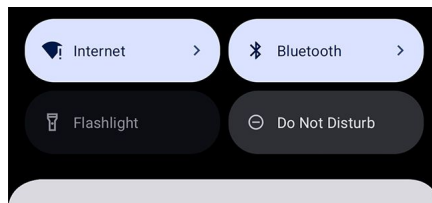
Silent

20-21 PM Usage Time: **14:07**
Mission Success Reward: **+ 75 KRW**

Manage

(c), (d) 9/10 min notifications ↓

9 min notification • now 🔔
1 minute left before timeout.

10 min notification • now 🔔
10 minutes used.

(a) Main screen of WellbeingWallet ↓

Day 2
On a mission

◀ **Aug 5th** ▶ 📅 (as of 20 o'clock)
3h 42m 15s used
6 successes, 5 failures
275 KRW earned

So far
11 successes, 17 failures
475 KRW earned in total

Mission Success Rate By Time

10am 12 14 16 18 20 22 0
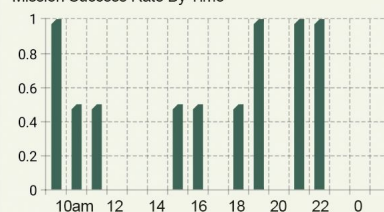
Average Smartphone Use By Time

9
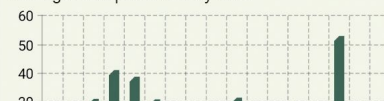
Personalization Algorithm

- **Dynamically explores & exploits different incentive amounts** to determine the optimal incentive for each user

- **Multi–Armed Bandit** using Thompson Sampling

- **Multi–Objective Optimization** using the Pareto front

Personalization Algorithm

- **Multi–Armed Bandit** using Thompson Sampling: **Each arm representing probability of successfully completing a micro–mission** for that specific incentive amount and context
  - **Arms (Incentive amounts)**: 0, 25, 50, 75, 100 KRW
                                                      (0, 0.02, 0.04, 0.06, 0.08 USD)
  - **Contexts**: work, non–work, weekend

Personalization Algorithm

- **Multi–Armed Bandit** using Thompson Sampling: **Each arm representing probability of successfully completing a micro–mission** for that specific incentive amount and context

probability distribution · probability distribution · probability distribution · probability distribution · probability distribution

context

Work

Non–work

Weekend

arm	arm	arm	arm	arm
₩ 0	₩ 25	₩ 50	₩ 75	₩ 100
$ 0.00	$ 0.02	$ 0.04	$ 0.06	$ 0.08
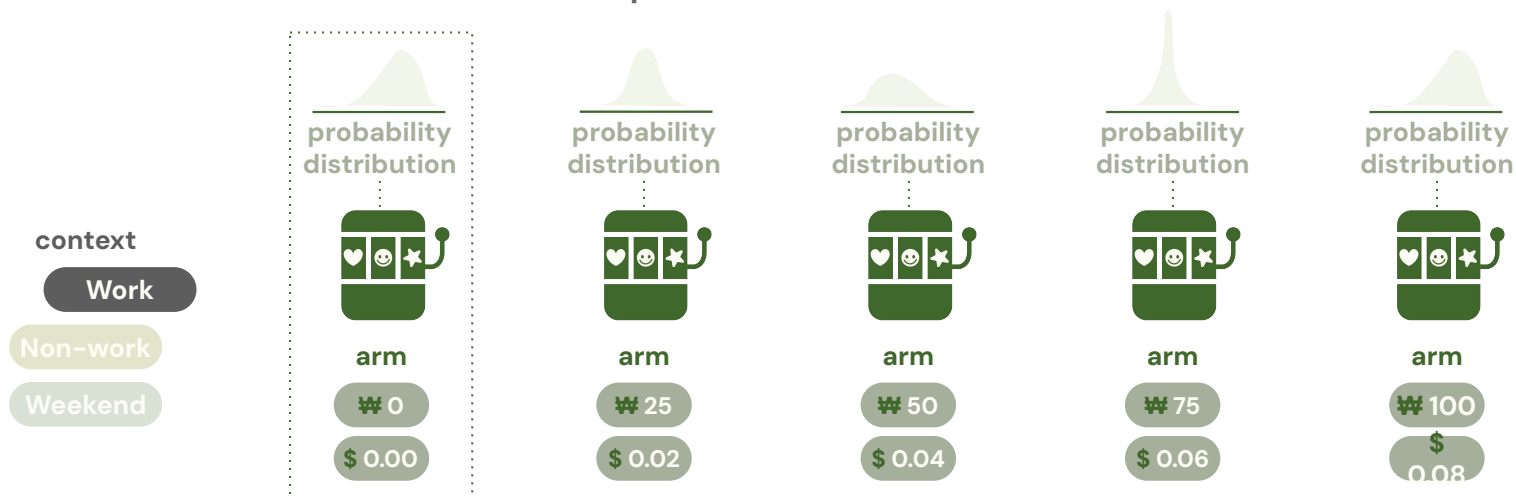
Personalization Algorithm

- **Multi–Objective Optimization using the Pareto front**: Finding incentive amount that maximizes the expected success rate and minimizes the expected cost

Control Algorithms

	Group 1	Group 2	Group 3
	Fixed Incentive	**Random Incentive**	**Personalized Incentive** ⭐

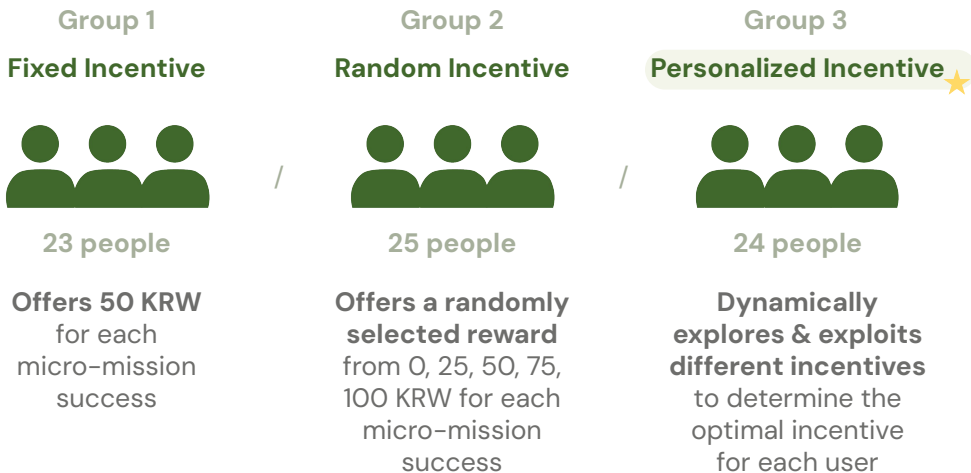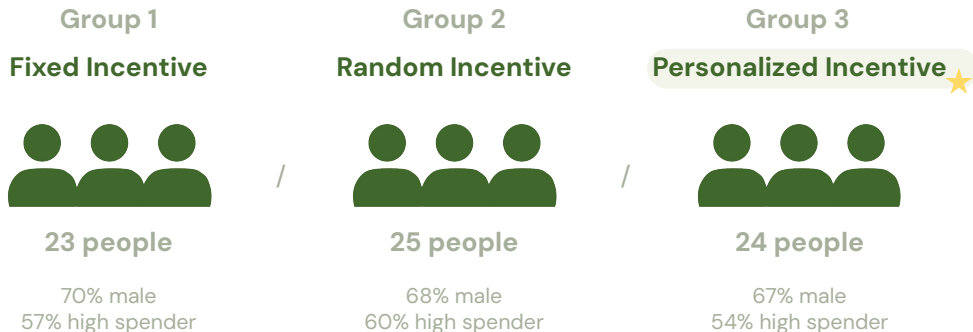|	Group 1	Group 2	Group 3
	23 people	**25 people**	**24 people**
	Offers 50 KRW for each micro-mission success	**Offers a randomly selected reward** from 0, 25, 50, 75, 100 KRW for each micro-mission success	**Dynamically explores & exploits different incentives** to determine the optimal incentive for each user
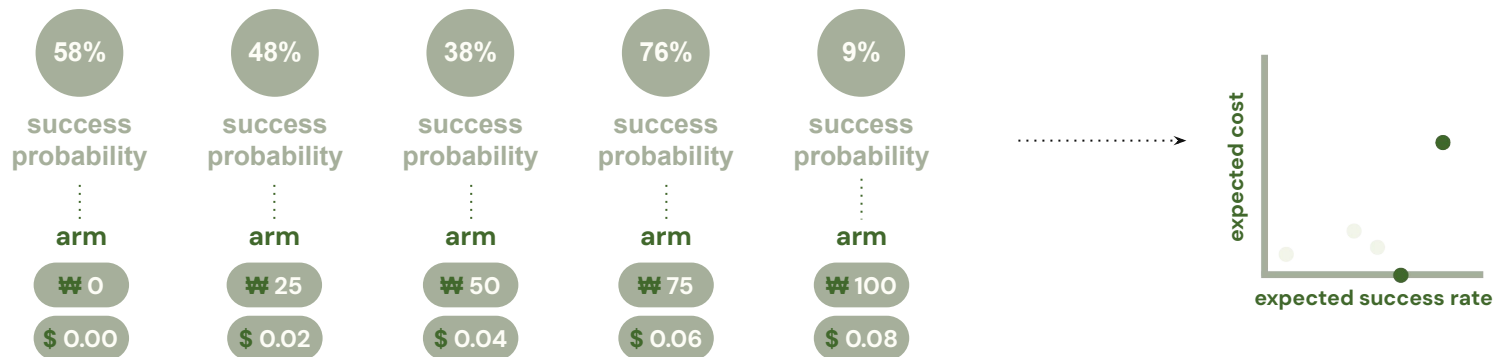
➜ **Same expected cost of 50 KRW** (0.04 USD) for each success

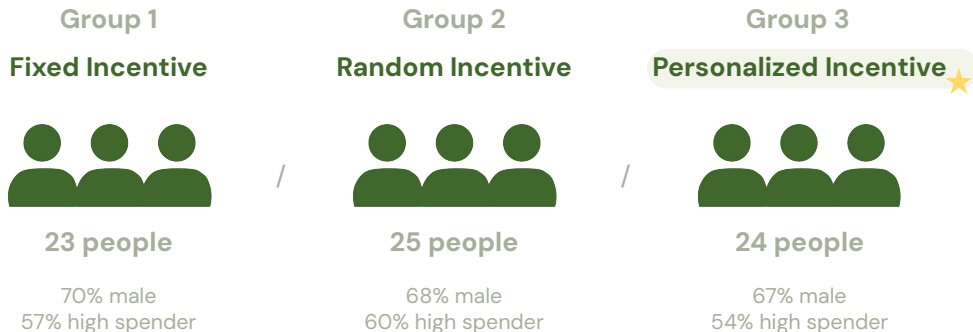To assess effects of different micro–financial incentive strategies in terms of:

- **cost-effectiveness** (RQ1) → smartphone usage log
- **behavior change outcomes** (RQ2) → smartphone usage log
- **motivational changes** (RQ3) → pre-/post-survey
- **user experiences** (RQ4) → semi-structured interview

Randomized Controlled Experiment

Group 1	Group 2	Group 3
Fixed Incentive	**Random Incentive**	**Personalized Incentive** ⭐
23 people	25 people	24 people
70% male	68% male	67% male
57% high spender	60% high spender	54% high spender

- Participants were informed that their compensation would be contingent on their mission performance.

- Details about group differences and the underlying algorithm mechanisms were not disclosed.

Randomized Controlled Experiment

Group 1	Group 2	Group 3
Fixed Incentive	**Random Incentive**	**Personalized Incentive** ⭐

/	/

23 people / **25 people** / **24 people**

70% male
57% high spender

68% male
60% high spender

67% male
54% high spender

- **Stratified random sampling** based on gender & socioeconomic status

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A Four–Week Field Study

baseline	intervention	follow–up
1 week	2 weeks	1 week

pre–survey

post–survey   interview

Intrinsic Motivation Inventory (IMI)
Self–Regulation Questionnaire (SRQ)

Intrinsic Motivation Inventory (IMI)
Self–Regulation Questionnaire (SRQ)
Reinforcement Sensitivity Theory of Personality (RST–PQ)

- **Baseline**: Collecting smartphone usage data without any intervention

- **Intervention**: Actively delivering micro–missions & incentives

- **Follow–up**: Collecting data after removing interventions (including incentives) to investigate sustained effects after incentive removal

RQ1. Total Costs

- **The personalized incentive strategy significantly reduced the total cost** as intended through the algorithm design.

- Personalized vs. Random (p < .001)

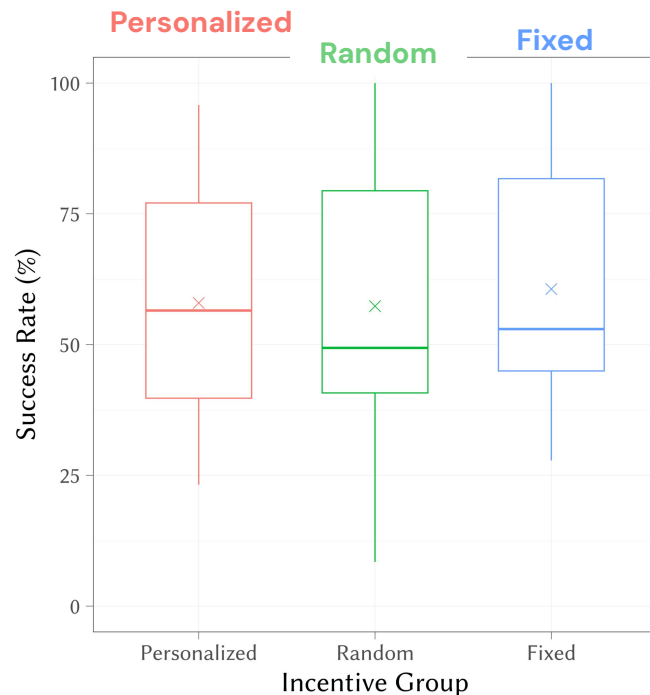- Personalized vs. Fixed (p < .001)

- Random vs. Fixed (ns)
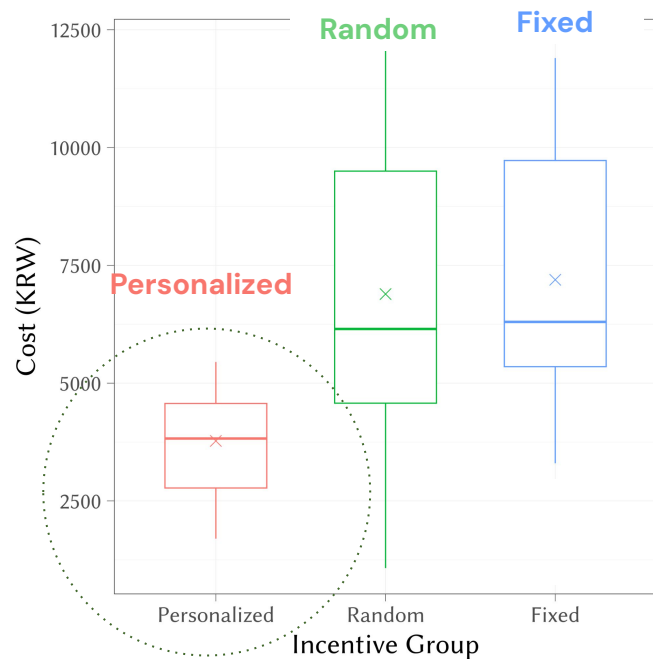
RQ2. Behavioral Change
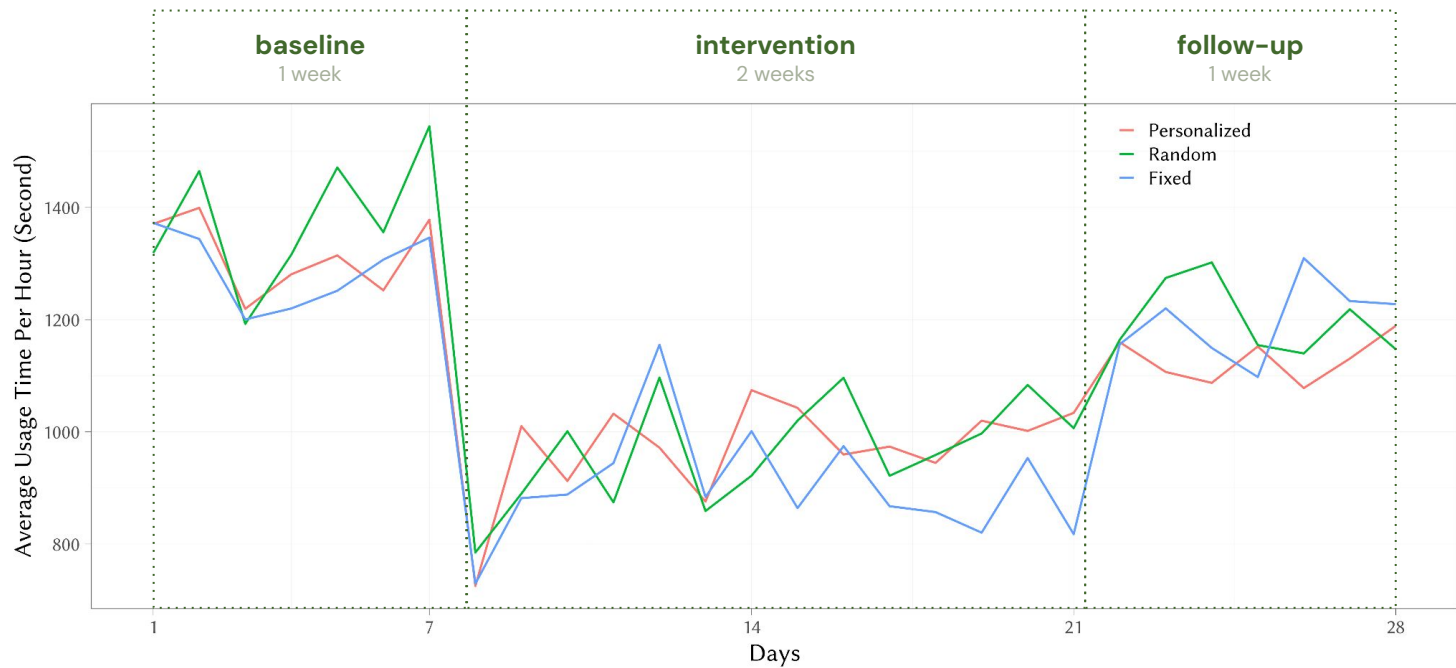
RQ2. Behavioral Change

- **No significant main effect of *incentive strategy* on micro–mission success rate** (ns)

- No significant interaction effect between *incentive strategy* and *time period* (ns)

RQ2. Behavioral Change

- **A statistically significant main effect of *time period* on success rate** (p < .001)

- Baseline vs. Intervention (p < .001)

- Baseline vs. Follow–up (ns)

- Intervention vs. Follow–up (p < .001)
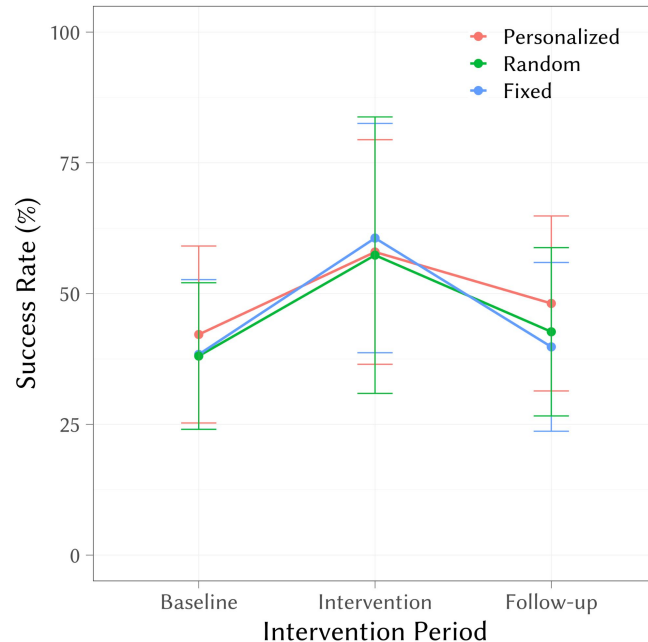
RQ3. Motivational Change

- **No significant changes in Intrinsic Motivation Inventory (IMI)* scores** after intervention

  - Interest/Enjoyment →
  - Perceived Competence
  - Perceived Choice
  - Pressure/Tension
  - Effort/Importance
  - Value/Usefulness
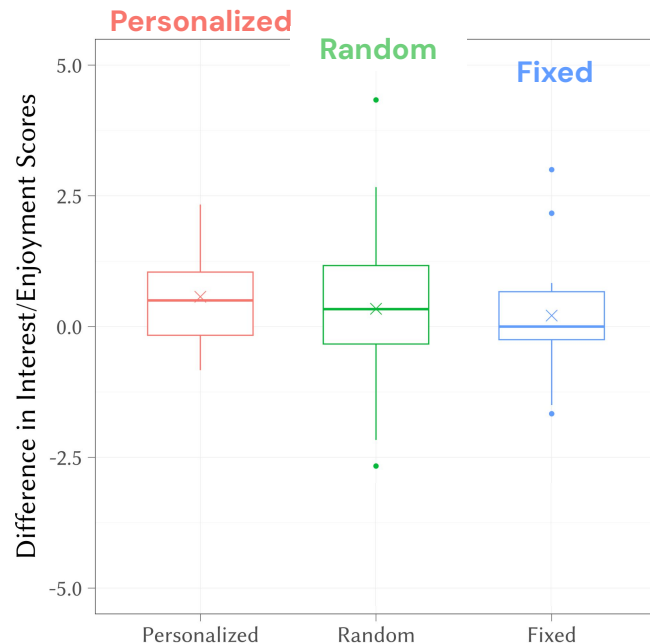
* Intrinsic motivation inventory: Psychometric properties in the context of first language and mathematics learning (2015)

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RQ3. Motivational Change

- **No significant changes in Self–Regulation Questionnaires (SRQ)* scores** after intervention
  - Autonomous motivation →
  - Introjected regulation
  - External regulation
  - Amotivation
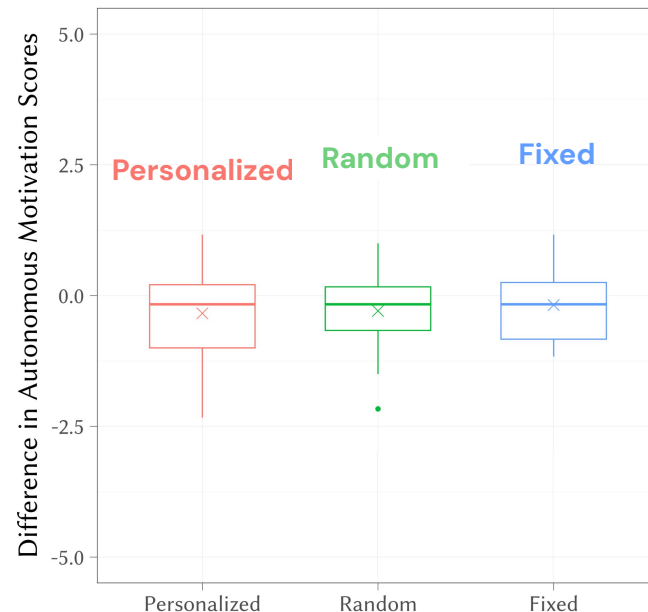
* Self–determination theory and the facilitation of intrinsic motivation, social development, and well–being (2000)

RQ4. Perceived Experience

- **Diverse Reactions to Micro–Financial Incentives**:
  - Micro–financial incentives **as an add–on** (N = 23) vs. Micro–financial incentives **as a motivator** (N = 14)
  - Depending on the **tasks at hand** or one's **pre-existing attitude**

- **Diverse Mental Models for Personalization Algorithm**:
  - E.g., offering more rewards after spending a lot of time on phone, offering more rewards when people normally use it more

RQ4. Perceived Experience

- **Perceived Behavioral Change**:
  - Formation of a positive confirmatory cycle
  - Rebound of smartphone use after removal of incentives

- **Perceived Motivational Change**:
  - Interpreting motivation score changes in different ways
    - E.g., perceived challenges → decreased competence score vs. raised awareness by challenges → increased score
  - Multi-dimensional nature of motivation

Role of Micro-Financial Incentives in Reinforcing Awareness

- Diverse roles of micro-financial incentives for different individuals

  - Micro-financial incentives **as a motivator** (N = 14) vs. Micro-financial incentives **as an add-on** (N = 23)

    - **As an "*added bonus*" for individuals already intending to modify their health behaviors**[*] – *Presence* of monetary incentives enhanced engagement in smartphone use regulation.

* Why are financial incentives not effective at influencing some smokers to quit? Results of a process evaluation of a worksite trial assessing the efficacy of financial incentives for smoking cessation (2011); The effectiveness of financial incentives for smoking cessation during pregnancy: is it from being paid or from the extra aid? (2012); When do financial incentives reduce intrinsic motivation? comparing behaviors studied in psychological and economic literatures (2013)

Effectiveness of Multi–Armed Bandit–Based Personalization Algorithm

- **Multi–armed bandit–based personalization algorithm reduced costs while achieving comparable behavioral change outcomes.**

- **Dynamic incentive amounts** stimulated curiosity about upcoming incentives & fostered continued engagement.

- **Personalized incentive amounts** effectively minimized costs by identifying the smallest yet still effective incentive amount for each individual.

Design Considerations for Personalized Micro–Financial Incentives

- Extending the personalization algorithm by **varying incentive amounts, forms, contexts, and personalization objectives**

- Respecting user control & agency by balancing *system–initiated personalization* with *user–initiated personalization*

- Presenting micro–financial incentives by understanding users' mental model of personalization algorithm & micro–financial incentives

Micro-Financial Incentives and Motivation

- No *crowding-out* effect observed in our study

  - Potential of ***crowding-in* effect**[*] – development of new preferences favoring the incentivized behavior

- Multi-dimensional nature of motivation

  - **Nuanced understanding of motivational changes**

* When do financial incentives reduce intrinsic motivation? comparing behaviors studied in psychological and economic literatures (2013)

Limitations

- No control group without micro–financial incentives

- Study conducted in South Korea (cultural influences)

- Simplified assumptions in intervention design

- Insufficient study duration to fully capture formation of habits or longer–term effects

Paper ↓

Like Adding a Small Weight to a Scale About to Tip: Personalizing Micro-Financial Incentives for Digital Wellbeing

Sueun Jang, Youngseok Seo, Woohyeok Choi, Uichin Lee

Key idea:

To design **personalized financial incentives that can sufficiently engage individuals** in behavior change **while simultaneously minimizing the total financial outlay**

Takeaways:

- Multi-armed bandit-based personalization algorithm reduced costs while achieving comparable behavioral change outcomes.
- Role of Micro-Financial Incentives in Reinforcing Awareness as an *"added bonus"* – *"Like Adding a Small Weight to a Scale About to Tip"*
- Potential for a *crowding-in effect* – new preferences favoring the incentivized behavior

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