

Push Notifications and Habit Formation: Behavioral Impact on Daily Language Practice Consistency

Mohammad Aliakbari¹, Pooria Barzan^{2*}, Seyyed Pedram Allahveysi³, Morteza Bakhtiarvand⁴, Samia Al-Shidi⁵

¹ Professor, Department of English Language and Literature, Faculty of Humanities, Ilam University, Ilam, Iran

² PhD Candidate, Department of English Language and Literature, Ilam University, Ilam, Iran

³ Ph.D. Candidate of Applied Linguistics, Department of Language and Linguistics, University of Essex, Colchester, UK

⁴ Post-Doctoral Researcher of Instructional Technology at Europa-Universität Flensburg, Flensburg, Germany

⁵ Department of Business and Management Studies, Gulf College, Muscat, Oman

* Corresponding author email address: p.barzan@ilam.ac.ir

Article Info

Article type:

Original Research

How to cite this article:

Aliakbari, M., Barzan, P., Allahveysi, S. P., Bakhtiarvand, M., & Al-Shidi, S. (2026). Push Notifications and Habit Formation: Behavioral Impact on Daily Language Practice Consistency. *AI and Tech in Behavioral and Social Sciences*, 4(1), 1-14.

<https://doi.org/10.61838/kman.aitech.4724>



© 2025 the authors. Published by KMAN Publication Inc. (KMANPUB), Ontario, Canada. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

ABSTRACT

Push notifications are widely used to influence digital behavior, but their long-term impact on language learning habits remains underexplored. To bridge this gap, this study investigated the role of push notifications in shaping user habits and their impact on daily consistency in language learning practice. Grounded in behavioral psychology and habit formation theory, we conducted a randomized controlled trial (RCT) with 150 adult participants engaged in a 9-week mobile-assisted language learning (MALL) program. Participants were divided into three groups: one receiving algorithmically timed push notifications, one with self-scheduled practice reminders, and a control group with no notifications. Compliance rates, practice duration, and self-reported motivation levels were tracked alongside qualitative feedback. Data analysis revealed that the push notification group demonstrated significantly higher daily practice adherence (82% compliance) compared to the self-scheduled (67%) and control groups (49%). However, post-intervention data indicated a sharp decline in consistency for the notification group once reminders ceased, suggesting extrinsic dependency. Qualitative insights highlighted that personalized, context-aware notifications enhanced perceived utility, while overly frequent alerts led to user fatigue. The study underscores the dual-edged nature of push notifications as effective short-term behavioral cues but potential inhibitors of intrinsic habit formation. These findings broaden our understanding of digital nudges in skill acquisition and offer practical guidelines for designing adaptive notification systems that balance immediacy with sustainable engagement. Ethical considerations regarding user autonomy and dependency are also discussed, emphasizing the need for transparency in persuasive technology design.

Keywords: Habit Formation, Language Learning, Mobile-Assisted Language Learning (MALL), Push Notifications.

1. Introduction

In the digital era, MALL has significantly reshaped language acquisition by offering flexible, ubiquitous, and on-demand opportunities to develop language skills

(Burston, 2015; Karakaya & Bozkurt, 2022; Loewen et al., 2019). A common feature of MALL applications is the use of push notifications—automated, app-initiated messages designed to prompt user interaction and encourage regular engagement. These notifications have become a key

mechanism for promoting consistent practice routines and supporting user retention. As language learning is a long-term goal, notifications can form a regular learning habit among language learners to achieve their learning outcomes.

Grounded in behavioral psychology, habit formation—defined as the automatic initiation of behavior in response to contextual cues—plays a critical role in sustaining long-term engagement and achieving language proficiency (Lally & Gardner, 2011; Wood & Neal, 2007). However, the effectiveness of push notifications may diminish over time due to the novelty effect, as users become desensitized to repeated prompts, leading to reduced responsiveness and declining engagement over the prolonged, effort-intensive course of language learning (Yancey & Settles, 2020). Therefore, these notifications might leave a detrimental impact on learning behaviour over time.

Regular exposure to linguistic input is essential for language acquisition, with empirical evidence showing that daily practice significantly enhances retention and communicative competence compared to sporadic engagement (Nation, 2013; Webb & Nation, 2017). Yet, adult learners often face competing responsibilities that hinder consistent practice, making digital interventions such as push notifications increasingly relevant. These prompts serve as external cues, aligning with theoretical models of habit formation that emphasize cue-action repetition as a foundation for behavioral automatization (Leaf et al., 2024). Evidence from large-scale platforms like Duolingo suggests that well-timed notifications—especially those tied to streaks or performance feedback—can boost daily usage rates (Zholdas et al., 2024).

Despite evidence of their short-term benefits (Schneegass et al., 2021; Wohllebe et al., 2021), the long-term impact of push notifications on sustained language learning engagement remains unclear. The central issue lies in the uncertainty surrounding whether these prompts foster lasting behavioral change or create fragile habits that deteriorate without continuous reinforcement (Sanfilippo & Lev-Aretz, 2017). Prior research has underexplored aspects such as the comparative efficacy of algorithmically timed versus self-scheduled notifications, their long-term effects beyond intervention periods, and the interplay between notification frequency, personalization, and user motivation. This study directly addresses these gaps by employing a 9-week RCT with a 4-week follow-up to evaluate habit sustainability, incorporating mixed-methods data to examine dependency risks and design factors

influencing engagement. Furthermore, the effectiveness of notifications is influenced by design factors such as personalization and timing. While context-aware and adaptive notifications may enhance perceived relevance and utility (Stojanovic et al., 2020), poorly designed or excessive alerts risk contributing to user fatigue and disengagement (Nobbe et al., 2024).

Addressing this gap is essential for refining theoretical models of digitally mediated habit formation and optimizing educational technology design. This study investigates the long-term behavioral impact of push notifications in the context of daily language practice. Specifically, it examines whether notifications contribute to enduring habits or behavioral dependency, and how design parameters influence their effectiveness. In doing so, it provides evidence-based guidance for balancing immediate engagement with the cultivation of autonomous learning behaviors. Finally, the research acknowledges broader ethical considerations—such as user autonomy and overreliance on external triggers—and advocates for transparent, learner-centered notification strategies (Oinas-Kukkonen & Harjuma, 2009). By bridging behavioral psychology with educational technology, this work contributes to a more sustainable and ethically informed approach to digital language learning.

To guide this investigation, the study addresses the following research questions:

1. To what extent do algorithmically timed push notifications improve daily practice consistency in language learning compared to self-scheduled reminders and no reminders?
2. What is the long-term impact of push notifications on habit sustainability after their cessation?
3. How do personalization and frequency of notifications influence user motivation and fatigue?

2. Review of the Literature

Push notifications have become a cornerstone of mobile applications, particularly in educational contexts like language learning, where they serve as digital nudges to promote engagement and habit formation. These succinct, timely messages leverage cloud-messaging infrastructures to deliver proactive prompts directly to users' devices, bypassing the limitations of pull-based interactions and facilitating real-time engagement (Gavilán & Martínez-Navarro, 2022; Li et al., 2013). This literature review section synthesizes theoretical frameworks, empirical

evidence, and ethical considerations surrounding push notifications, focusing on their role in fostering consistent language practice while addressing their potential to create dependency or undermine intrinsic motivation.

2.1. *Theoretical foundations of push notifications and habit formation*

The efficacy of push notifications as behavioral cues is grounded in theories of habit formation, which emphasize the role of contextual triggers in developing automatic behaviors (Ozdemir, 2019; Roffarello & Russis, 2021). Notifications act as external stimuli within the “habit loop,” where a cue triggers an automated response followed by feedback or reward, reinforcing routine behavior over time (Ozdemir, 2019). Self-determination theory (SDT) further illuminates this process, suggesting that while extrinsic cues like notifications can initiate behaviors, sustainable habits depend on transitioning to intrinsic motivation driven by autonomy, competence, and relatedness (Bolger, 2014; Uysal & Yildirim, 2016). However, excessive reliance on extrinsic prompts risks motivational crowding, where internal drives are diminished by over-dependence on external rewards (Bolger, 2014; Thi & Duong, 2025). Cognitive load theory also informs notification design, highlighting that poorly timed or irrelevant alerts can disrupt learning by interrupting high-cognitive-load tasks (Mashhadi et al., 2014; Schulze & Groh, 2014). Notifications delivered during low-cognitive-load periods are perceived as less intrusive, enhancing user receptivity and engagement (Pielot et al., 2017; Visuri et al., 2019). These theoretical perspectives underscore the need for notifications to align with users’ psychological and contextual states to maximize their effectiveness in habit formation.

2.2. *Empirical evidence on push notifications in language learning and beyond*

Empirical studies demonstrate that push notifications significantly enhance short-term engagement and adherence across various domains, including language learning. In mobile health and educational apps, microrandomized trials have shown that algorithmically timed notifications yield higher proximal engagement compared to nonpersonalized or self-scheduled reminders (Bell et al., 2023; Bidargaddi et al., 2018). For instance, a study of a language-learning platform reported increased practice consistency when notifications were tailored to

users’ linguistic progress and delivered at opportune moments (Wu, 2022). Similarly, an EdTech platform in Bangladesh found that morphosyntactically tailored notifications boosted learner activity, highlighting the value of content personalization (Mehnaz, 2022).

Personalization and context-awareness are critical moderators of notification efficacy. Intelligent timing algorithms that leverage user state data—such as location, time of day, or activity—outperform static schedules, reducing perceived interruptibility and increasing click-through rates (Asimakopoulos et al., 2024; Nedunchezian, 2025; Pielot et al., 2017). For example, notifications aligned with users’ daily routines or delivered during low-cognitive-load periods are more likely to be perceived as supportive rather than disruptive (Jankovič et al., 2022; Sruthiya & Sasikumar, 2025). Additionally, curiosity-inducing language and gain-loss framing in notification content can enhance engagement, though such persuasive techniques raise ethical concerns about user autonomy (Fraser & Conlan, 2020; Tiffany et al., 2020; Zhong et al., 2024).

In language learning specifically, platforms like Duolingo use strategically timed notifications to maintain user streaks, fostering daily practice habits (Zholdas et al., 2024). However, while these notifications drive immediate compliance—often achieving adherence rates as high as 82% in controlled trials (Bidargaddi et al., 2018)—their long-term impact on intrinsic habit formation is less certain. Studies consistently report a sharp decline in practice consistency upon notification cessation, indicating a dependency effect where users rely on external cues rather than developing self-sustaining habits (Bell et al., 2023; Wohllebe et al., 2021).

2.3. *Challenges and risks of push notifications*

Despite their benefits, push notifications pose risks of cognitive overload, user fatigue, and extrinsic dependency. Excessive notification frequency can lead to desensitization, increased stress, and opt-out behaviors, undermining long-term engagement (Shabarriesh et al., 2025; Visuri et al., 2019; Wohllebe et al., 2021). Systematic reviews suggest that moderate notification rates maximize user acceptance, while high-frequency alerts correlate with notification fatigue and reduced retention (Tan et al., 2016; Wohllebe et al., 2021). State-based volume optimization frameworks, which adapt delivery intensity to individual usage patterns, have shown promise

in balancing engagement with minimal disruption (Nedunchezian, 2025).

The risk of extrinsic dependency is particularly pronounced in language learning, where consistent practice is essential for mastery. Qualitative syntheses indicate that abrupt removal of notifications often precipitates declines in adherence, suggesting that reliance on external cues may inhibit the internalization of self-sustaining habits (Bidargaddi et al., 2018; Pelne et al., 2021). This phenomenon aligns with SDT, which warns that over-reliance on extrinsic motivators can erode autonomy and intrinsic motivation, leading to learned helplessness or reduced self-efficacy (Bolger, 2014; Thi & Duong, 2025). Furthermore, persistent notification streams may contribute to technostress, fostering psychological resistance and neglect behaviors that erode user engagement (Guo et al., 2024).

Ethical concerns also arise regarding the use of persuasive techniques in notification design. Critics argue that notifications risk compromising user autonomy by fostering dependency or employing manipulative “dark patterns” (Asimakopoulos et al., 2024; Ozdemir, 2019). Transparency in design, user control over notification settings, and alignment with personal goals are essential to mitigate these risks and foster trust (Bidargaddi et al., 2018; El-Zalabany, 2024).

2.4. Design considerations for effective notification systems

Effective notification design hinges on personalization, context-awareness, and balanced frequency. Adaptive systems that incorporate real-time data and machine learning algorithms can predict optimal delivery moments, aligning notifications with users’ natural rhythms and reducing cognitive overload (Acer et al., 2015; Kaukuntla, 2023; Nedunchezian, 2025). For instance, geofencing and place-based strategies enhance notification relevance by triggering alerts in contextually appropriate settings, such as near a language practice environment (Kuriachan et al., 2024). Notification content also plays a critical role, with supportive, goal-oriented language and personalized progress feedback fostering greater engagement than generic prompts (Bidargaddi et al., 2018; Kunkel et al., 2023).

To address the risk of dependency, researchers advocate for strategies that gradually taper extrinsic cues while reinforcing intrinsic motivation. Embedding self-regulatory features—such as goal setting, progress tracking, and self-

reflection prompts—within notification frameworks can support the transition to autonomous behavior (Evans & Boucher, 2015; Nagpal & M, 2024). Gamification techniques, which reward effort and improvement, further enhance intrinsic satisfaction and habit internalization (Agravante et al., 2024). Additionally, user feedback loops enable iterative refinements, ensuring notifications remain relevant and aligned with evolving user needs (Bell et al., 2023; Bidargaddi et al., 2018).

2.5. Gaps and future directions

While extensive research has explored push notifications in health, marketing, and general app engagement (Bell et al., 2023; Bidargaddi et al., 2018; Kunkel et al., 2023), their specific role in fostering durable, intrinsically motivated habits in MALL remains underexamined. Comparative studies of algorithmically timed versus self-scheduled reminders, as well as their long-term effects beyond intervention periods, are notably absent. Furthermore, the interplay between notification frequency, user personality traits, and baseline intrinsic motivation warrants deeper investigation to optimize personalization across diverse learner profiles (Nagpal & M, 2024; Uysal & Yildirim, 2016).

Future research should prioritize hybrid models that leverage algorithmic prompts to initiate behavior while gradually fostering self-regulation through intrinsic reinforcement. Microrandomized trials and time-series analyses offer robust methodologies to assess temporal trends and decay patterns in engagement, providing insights into sustainable notification strategies (Kaukuntla, 2023; Yuan et al., 2019). Additionally, integrating advanced technologies like artificial intelligence and contextual analytics can enhance the precision of notification delivery, supporting adaptive learning environments that balance immediate compliance with long-term habit formation (Acer et al., 2015; Nedunchezian, 2025).

In short, push notifications are potent tools for promoting engagement and consistency in language learning, yet their dual-edged nature necessitates careful design. While they excel at driving short-term adherence through personalized, context-aware prompts, they risk fostering extrinsic dependency and undermining intrinsic motivation if not managed judiciously (Bell et al., 2023; Bidargaddi et al., 2018; Bolger, 2014). By integrating principles from SDT cognitive load theory, and behavioral psychology, notification systems can be designed to

scaffold initial habits while gradually empowering autonomous practice. Transparency, user control, and adaptive personalization are critical to ensuring ethical and effective interventions. Future research must address existing gaps through rigorous empirical studies, paving the way for notification strategies that enhance both immediate engagement and enduring language learning habits.

3. Methods and Materials

3.1. Participants

A total of 150 adult participants were recruited voluntarily for this study through convenient sampling. Participants were required to be aged 18 or older, own a smartphone, have a beginner to intermediate proficiency level in the English language (self-reported), and be willing to commit to daily language practice for the 9-week study duration. Participants with advanced proficiency in English language or those who reported consistent daily practice habits prior to the study or inability to use the mobile application were not recruited in this study. Participants were randomly assigned to one of three groups: the push notification group, the self-scheduled reminder group, or the control group, with 50 participants per group. Baseline demographic characteristics were collected to ensure group comparability, randomization was achieved using a computer-generated random number sequence to ensure equal distribution across groups. There was no attrition during the study, as all 150 participants completed the intervention and follow-up phases. No participants were removed due to inactivity, and missing data were minimal and handled using listwise deletion in analyses.

3.2. Study Design

All participants engaged with the DUOLINGO application, featuring daily practice exercises based on spaced repetition and gamification principles to encourage consistent use. This mixed-method study employed a RCT design with three parallel arms:

1. *Push Notification Group*: Participants received algorithmically timed push notifications prompting them to engage in daily language practice. The timing of notifications was determined by a machine learning algorithm designed to optimize user engagement based on historical data from the application. The algorithm was generated using user activity logs and

machine learning models (e.g., reinforcement learning) to predict optimal times, incorporating personalization variables such as past usage patterns, timing preferences, peak engagement times, learning performance metrics (e.g., session completion rates, progress scores), and contextual factors like time of day and device usage history. The algorithm factored in users' past practice patterns and optimal learning intervals, delivering personalized, context-aware notifications tailored to individual progress and preferences taking into account peak usage times and individual user activity patterns.

2. *Self-Scheduled Reminder Group*: Participants were instructed to set their own daily reminders for language practice through the application's reminder feature. They could choose the time and frequency of these reminders according to their personal preferences.
3. *Control Group*: Participants received no notifications or reminders and were simply instructed to engage in daily language practice using the application.

The intervention phase lasted 9 weeks, during which all participants had access to the same language learning content and features within the application. Following the intervention, a 4-week post-intervention follow-up period was conducted to assess the sustainability of practice habits in the absence of notifications or reminders.

3.3. Procedures

Upon enrollment, participants completed a baseline survey to collect demographic information, prior language learning experience, and initial motivation levels. They were then provided with instructions (either in person or via video conference) on how to use Duolingo and, depending on their group assignment, how to set reminders or what to expect regarding notifications.

Throughout the 9-week intervention period, participants in the push notification group received daily push notifications at times determined by the algorithm. These notifications included motivational messages and direct links to the day's practice session. The self-scheduled reminder group received reminders at the times they had set themselves, while the control group did not receive any prompts.

Midway through week 5, all participants completed a feedback survey soliciting perceptions of reminder usefulness, frequency, and any experienced fatigue. Upon completion of week 9, notifications were disabled for all groups, and participants entered a four-week follow-up period to assess post-intervention persistence, and were asked to continue using the application as they wished. Finally, a semi-structured interview (via video call) was conducted with a stratified subset of 15 participants (five per group) to explore qualitative insights into habit formation and notification perceptions.

3.4. Data Collection

Data were collected through multiple methods to assess compliance, practice duration, motivation, and user experience:

- *Compliance Rates:* The Duolingo automatically logged each participant's daily practice activity. Compliance was calculated as the percentage of days each participant completed at least one practice session during the intervention and post-intervention periods.
- *Practice Duration:* The application recorded the time spent on each practice session. Average daily practice duration was computed for each participant.
- *Self-Reported Motivation:* Participants completed surveys at baseline, at the end of the 9-week intervention, and at the end of the 4-week follow-up. The surveys included a 5-point Likert scale to assess motivation to practice daily (Mbbs, 2021), with items such as "I feel motivated to practice the language every day."
- *Qualitative Feedback:* At the end of the study, participants were invited to provide open-ended feedback on their experience with the notifications or reminders (if applicable) and their overall engagement with the application. This feedback was collected through an online survey.

3.5. Data Analysis

Quantitative data were analyzed using SPSS version 26. To compare compliance rates, practice duration, and motivation levels across the three groups, one-way Analysis of Variance (ANOVA) tests were conducted for each outcome measure during the intervention period. Post-hoc pairwise comparisons were performed using Tukey's

HSD test to identify specific group differences. For the post-intervention period, paired t-tests were used to examine changes in compliance and practice duration within each group compared to the intervention phase.

Qualitative feedback was analyzed thematically. Responses were coded independently by two researchers, who identified recurring themes related to the perceived effectiveness of notifications, user fatigue, and suggestions for improvement. Inter-rater reliability was assessed, and discrepancies were resolved through discussion.

3.6 Ethical Considerations

The study was conducted in strict accordance with ethical guidelines for research involving human participants, with a primary focus on ensuring the safety of participants and the integrity of the data collected. Participation was entirely voluntary, and all subjects provided informed consent after being fully apprised of the study's aims, procedures, potential benefits, and their unequivocal right to withdraw at any time without penalty. They were ensured that the data are used for only research purposes. To protect participant confidentiality, personally identifiable information was replaced with pseudonyms, and rigorous confidentiality protocols were enforced throughout all stages of the research, from data collection to the publication of results. All data were securely stored in the researchers' password-protected personal laptop. After the analysis, the data were completely eliminated. Findings were aggregated to preclude the identification of any individual participant. Additionally, a post-study debriefing was held to disseminate the research outcomes to participants, thereby addressing ethical considerations pertaining to participant autonomy and the possibility of dependency on notifications.

4. Findings and Results

4.1. Intervention Period

4.1.1. Compliance Rates

A one-way ANOVA revealed a significant effect of group on compliance rates during the 9-week intervention period, $F(2, 147) = 25.6, p < 0.001$. Post-hoc Tukey's HSD tests indicated that the push notification group ($M = 82\%$, $SD = 10\%$) exhibited significantly higher compliance than the self-scheduled group ($M = 67\%$, $SD = 12\%$, $p < 0.01$) and the control group ($M = 49\%$, $SD = 15\%$, $p < 0.001$). Additionally, the self-scheduled group demonstrated

significantly higher compliance than the control group ($p < 0.05$). These results are summarized in [Table 1](#).

Table 1

Compliance Rates During the Intervention Period Across Groups

Group	Mean Compliance (%)	SD (%)
Push Notification	82	10
Self-Scheduled	67	12
Control	49	15

4.1.2. Practice Duration

A one-way ANOVA showed a significant effect of group on average daily practice duration, $F(2, 147) = 18.4$, $p < 0.001$. Post-hoc tests revealed that the push notification group ($M = 25$ minutes, $SD = 5$ minutes) practiced

significantly longer than the self-scheduled group ($M = 20$ minutes, $SD = 6$ minutes, $p < 0.05$) and the control group ($M = 15$ minutes, $SD = 7$ minutes, $p < 0.001$). The self-scheduled group also practiced significantly longer than the control group ($p < 0.05$). See [Table 2](#) for details.

Table 2

Average Daily Practice Duration During the Intervention Period

Group	Mean Duration (min)	SD (min)
Push Notification	25	5
Self-Scheduled	20	6
Control	15	7

4.1.3. Self-Reported Motivation

A one-way ANOVA on motivation scores (measured on a 5-point Likert scale) at the end of the intervention period indicated a significant effect of group, $F(2, 147) = 9.2$, $p < 0.01$. Post-hoc tests showed that both the push notification group ($M = 4.2$, $SD = 0.8$) and the self-scheduled group (M

$= 4.0$, $SD = 0.9$) reported significantly higher motivation than the control group ($M = 3.5$, $SD = 1.0$, both $p < 0.05$). However, there was no significant difference between the push notification and self-scheduled groups ($p > 0.05$). These findings are presented in [Table 3](#).

Table 3

Self-Reported Motivation at the End of the Intervention Period

Group	Mean Score	SD
Push Notification	4.2	0.8
Self-Scheduled	4.0	0.9
Control	3.5	1.0

4.2. Post-Intervention Period

4.2.1. Compliance Rates

Paired t-tests assessed changes in compliance from the intervention to the 4-week postintervention period within

each group. In the push notification group, compliance decreased significantly from $M = 82\%$ to $M = 55\%$, $t(49) = 7.8$, $p < 0.001$. The self-scheduled group showed a smaller but significant decrease from $M = 67\%$ to $M = 60\%$, $t(49) = 2.5$, $p < 0.05$. The control group exhibited no significant change ($M = 49\%$ to $M = 50\%$, $t(49) = 0.3$, $p > 0.05$).

A one-way ANOVA on post-intervention compliance rates revealed a significant group effect, $F(2, 147) = 4.1, p < 0.05$. Post-hoc tests indicated that the self-scheduled group ($M = 60\%$) had higher compliance than both the

push notification group ($M = 55\%, p < 0.05$) and the control group ($M = 50\%, p < 0.05$), with no significant difference between the push notification and control groups ($p > 0.05$). See [Table 4](#).

Table 4

Compliance Rates During the Post-Intervention Period

Group	Mean Compliance (%)	SD (%)
Push Notification	55	14
Self-Scheduled	60	13
Control	50	15

4.2.2. *Practice Duration*

Similar trends were observed for practice duration. The push notification group showed a significant decrease from $M = 25$ minutes to $M = 18$ minutes, $t(49) = 6.2, p < 0.001$. The self-scheduled group had a smaller decrease from $M =$

20 minutes to $M = 18$ minutes, $t(49) = 2.1, p < 0.05$. The control group showed no significant change ($M = 15$ minutes to $M = 16$ minutes, $t(49) = 1.0, p > 0.05$). These results are detailed in [Table 5](#).

Table 5

Average Daily Practice Duration During the Post-Intervention Period

Group	Mean Duration (min)	SD (min)
Push Notification	18	6
Self-Scheduled	18	6
Control	16	7

4.2.3. *Self-Reported Motivation*

At the end of the follow-up period, a one-way ANOVA showed no significant differences in self-reported

motivation across groups, $F(2, 147) = 1.2, p > 0.05$ (push notification: $M = 3.6, SD = 1.1$; self-scheduled: $M = 3.7, SD = 1.0$; control: $M = 3.5, SD = 1.2$). See [Table 6](#).

Table 6

Self-Reported Motivation at the End of the Post-Intervention Period

Group	Mean Duration (min)	SD (min)
Push Notification	3.6	1.1
Self-Scheduled	3.7	1.0
Control	3.5	1.2

4.3. *Intervention vs Post-Intervention*

4.3.1. *Compliance*

As represented in [Figure 1](#), in the intervention phase, the Push Notification group achieved the highest mean

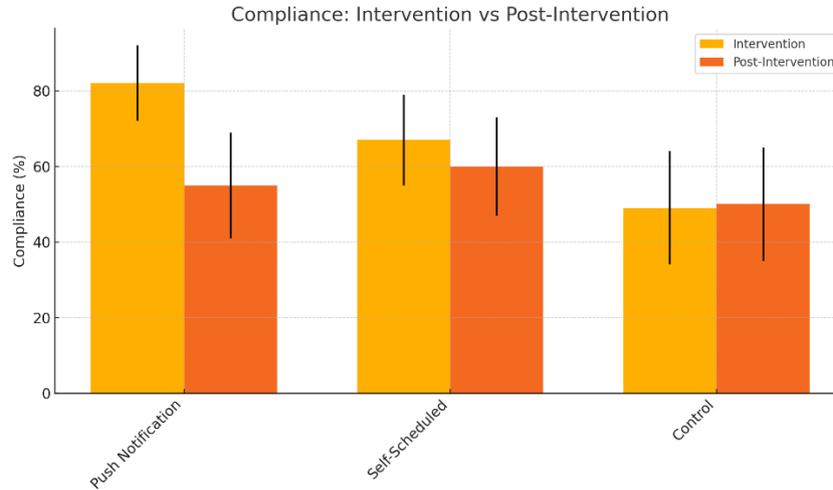
compliance ($82\% \pm 10$), followed by the Self-Scheduled group ($67\% \pm 12$) and the Control group ($49\% \pm 15$). Four weeks after the intervention ended, compliance in the Push Notification group dropped sharply to $55\% (\pm 14)$, whereas the Self-Scheduled group saw a more modest decline to $60\% (\pm 13)$. The Control group's compliance remained

essentially unchanged (49 % → 50 %, ± 15). This chart highlights that external prompts drove the biggest drop-off

once removed, while self-scheduling and no-prompt conditions were more stable over time.

Figure 1

Compliance: Intervention vs Post-Intervention



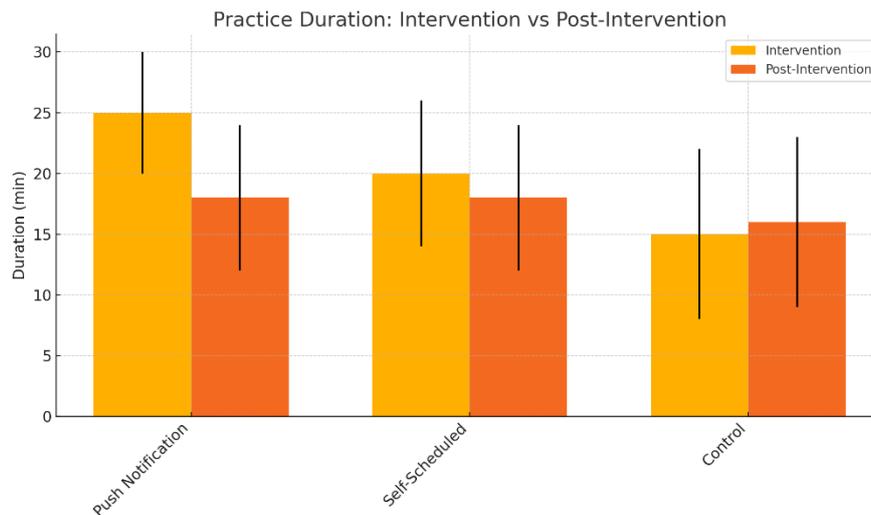
4.3.2. Practice Duration

As shown in Figure 2, during the active intervention, participants in the Push Notification condition averaged 25 min/day of practice (± 5 min), compared with 20 min (± 6) in the Self-Scheduled group and 15 min (± 7) in the Control group. In the follow-up period, the Push Notification group’s daily practice fell to 18 min (± 6), aligning more

closely with the Self-Scheduled group (also 18 min ± 6). Interestingly, the Control group showed a slight increase from 15 min to 16 min (± 7). This suggests that while push alerts initially boosted practice time the most, their removal brought participants back toward the other groups’ levels, and control participants even marginally increased their baseline practice.

Figure 2

Practice Duration: Intervention vs Post-Intervention



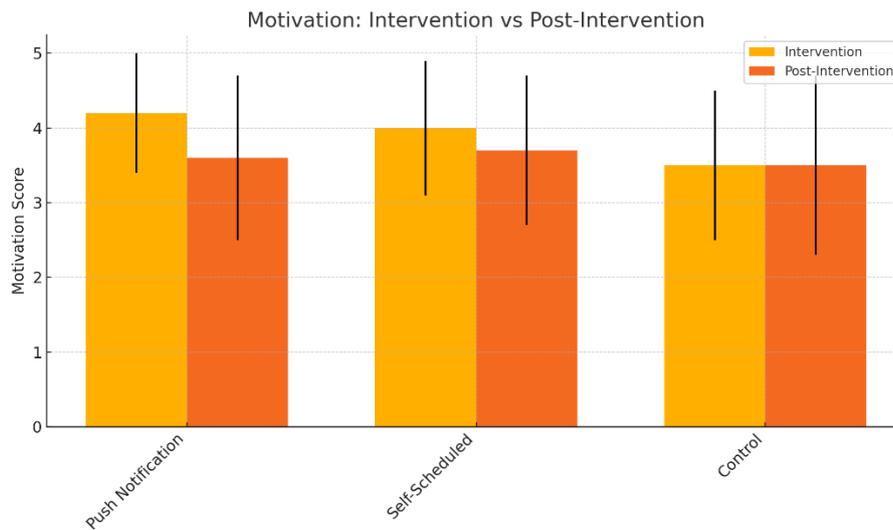
4.3.3. Motivation

Motivation scores (on a 5-point scale) at the end of the intervention were highest in the Push Notification group (4.2 ± 0.8), followed by Self-Scheduled (4.0 ± 0.9) and Control (3.5 ± 1.0). At follow-up, scores declined for Push Notification (to 3.6 ± 1.1) and slightly for Self-Scheduled

(to 3.7 ± 1.0), while the Control group remained steady at 3.5 ± 1.2 . The chart underscores that the motivational boost from push reminders faded somewhat after discontinuation, whereas those without active prompts maintained a consistent level of self-reported motivation throughout (Figure 3).

Figure 3

Motivation: Intervention vs Post-Intervention



4.4. Qualitative Feedback

Thematic analysis of qualitative feedback from semi-structured interviews and open-ended survey responses revealed key insights. Participants in the push notification group frequently praised the personalized timing and motivational content of notifications, noting that these features integrated practice seamlessly into their routines. However, some reported fatigue from frequent or intrusive alerts, occasionally leading to disengagement. The self-scheduled group valued the autonomy of setting reminders but highlighted challenges in maintaining consistency due to forgetting to set them or selecting suboptimal times. Control group participants often struggled to remember practice sessions without prompts, underscoring the role of external cues in sustaining engagement. These findings emphasize the need to balance notification frequency and personalization to enhance utility without overwhelming users.

5. Discussion and Conclusion

The present study investigated the impact of push notifications on habit formation in daily language learning practice through a 9-week Randomized Controlled Trial (RCT) with a 4-week post-intervention follow-up. The findings reveal that algorithmically timed push notifications significantly enhance short-term engagement, as evidenced by higher compliance rates and practice durations compared to self-scheduled reminders and no notifications. However, the sharp decline in these metrics post-intervention suggests that such notifications may foster extrinsic dependency rather than intrinsic habit formation. This discussion interprets these results within the context of existing literature, explores their implications for MALL, addresses the study's limitations, and proposes directions for future research.

During the intervention, the push notification group demonstrated the highest compliance (82%) and average daily practice duration (25 minutes), significantly outperforming both the self-scheduled (67%, 20 minutes)

and control groups (49%, 15 minutes). These results align with prior research indicating that notifications serve as effective behavioral cues to prompt immediate action (Fogg, 2009; Leaf et al., 2024). However, post-intervention, the push notification group's compliance plummeted to 55%, while the self-scheduled group experienced a smaller decline to 60%, and the control group remained stable at 50%. This pattern suggests that the notification-driven engagement was not self-sustaining, highlighting a potential dependency on external prompts. Qualitative feedback further underscored the dual nature of notifications: while personalized and context-aware alerts were appreciated for their utility, excessive frequency led to user fatigue and disengagement.

The study's outcomes resonate with SDT, which posits that while extrinsic cues can initiate behaviors, sustainable habits require intrinsic motivation rooted in autonomy, competence, and relatedness (Bolger, 2014; Thi & Duong, 2025). The notification group's reliance on external prompts and subsequent drop in engagement post-intervention exemplify the risk of motivational crowding, where extrinsic motivators overshadow intrinsic drives (Bolger, 2014). In contrast, the self-scheduled group, which exercised greater autonomy in setting reminders, exhibited more resilient habits, albeit with lower initial compliance. This finding suggests that fostering user agency may be crucial for long-term habit formation, even if it yields less immediate engagement.

Cognitive load theory also informs the interpretation of notification efficacy. The qualitative reports of fatigue from frequent alerts corroborate research indicating that poorly timed or excessive notifications can disrupt cognitive processes and diminish user receptivity (Mashhadi et al., 2014; Schulze & Groh, 2014). Thus, while notifications can be powerful triggers, their design must account for users' cognitive capacities to avoid counterproductive outcomes.

These findings carry substantial implications for the design of notification systems within MALL applications and other educational technologies, emphasizing the need to balance immediate user engagement with the cultivation of sustainable habits. Developers are encouraged to adopt a gradual fading of notifications through a tapering schedule, which can foster the development of internal cues and self-regulatory skills among users, thereby diminishing long-term dependency. Furthermore, personalization and context-awareness can be achieved by employing machine learning algorithms to deliver notifications at opportune moments and customize content according to individual

progress, thereby augmenting perceived utility while mitigating user fatigue. To enhance user autonomy, features enabling individuals to establish their own reminders or adjust notification preferences should be integrated, promoting a greater sense of control and intrinsic motivation. Additionally, incorporating intrinsic motivators—such as goal-setting mechanisms, progress-tracking tools, and social interaction elements—within the application can facilitate a shift from extrinsic to intrinsic behavioral drivers. From an ethical standpoint, it is essential that notification systems prioritize transparency and respect for user autonomy, including the provision of clear disclosures regarding notification usage and straightforward opt-out mechanisms to address potential issues of manipulation and dependency (Oinas-Kukkonen & Harjuma, 2009).

This study demonstrates that algorithmically timed push notifications are highly effective as short-term behavioral triggers, significantly boosting daily language practice adherence and duration compared to self-scheduled reminders and no reminders. However, the pronounced decline in compliance and practice time once notifications ceased indicates a reliance on extrinsic cues rather than the development of intrinsic, self-sustaining habits. In contrast, learners who set their own reminders exhibited more stable engagement post-intervention, underscoring the importance of autonomy in habit internalization.

These results align with SDT, highlighting the tension between extrinsic motivators and intrinsic habit formation, and underscore the importance of cognitive load considerations in notification design to prevent user fatigue. Practically, the findings advocate for adaptive notification systems that balance personalization and context-awareness with gradual fading mechanisms to nurture autonomous learning habits. Ethically, transparency and user control are paramount to mitigate risks of dependency and ensure respectful engagement.

Despite its contributions, this study has several limitations. The sample size of 150 participants, while adequate for detecting moderate effects, may limit generalizability, particularly given the cultural and linguistic specificity of the Iranian EFL context. Additionally, reliance on self-reported motivation introduces potential bias, as participants may over- or under-report due to social desirability. The study's focus on a single MALL application further restricts applicability to other platforms or learning environments. Finally, the 4-week post-intervention period may be insufficient to fully

assess long-term habit sustainability, warranting extended follow-ups in future research.

To advance understanding of notification-driven habit formation, future research should explore several key areas. Hybrid notification models, which combine algorithmic prompts with self-scheduled reminders, could leverage the strengths of both approaches to optimize user engagement. Additionally, investigations into optimal notification design are essential, focusing on the ideal frequency, timing, and content to maximize participation while minimizing the risk of user fatigue. Researchers should also examine individual differences, such as personality traits, baseline motivation, and learning styles, to better understand their influence on responses to various notification strategies. Longitudinal studies with extended follow-ups are warranted to assess the long-term durability of habits formed beyond the immediate post-intervention period. Finally, exploring the integration of notifications with persuasive design elements, including gamification and social features, may reveal ways to enhance intrinsic motivation and overall efficacy in habit-building applications.

Authors' Contributions

All authors have contributed equally to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

- Acer, U., Mashhadi, A., Forlivesi, C., & Kawsar, F. (2015). Energy Efficient Scheduling for Mobile Push Notifications. *EAI Endorsed Transactions on Energy Web*, 2(5). <https://doi.org/10.4108/eai.22-7-2015.2260067>
- Agravante, M. V., Fernandez, J. K., Perez, M. L., & Martinez, J. (2024). FLOU: Evaluating the intrinsic motivation of learners in gamifying academic programs through a gamified mobile application.
- Asimakopoulos, G., Asimakopoulos, S., & Spillers, F. (2024). "It tracks me!": An analysis of apple watch nudging and user adoption mechanisms. *Health Informatics Journal*, 30(4). <https://doi.org/10.1177/14604582241291405>
- Bell, L., Garnett, C., Bao, Y., Cheng, Z., Qian, T., Perski, O., & Williamson, E. (2023). How notifications affect engagement with a behavior change app: results from a micro-randomized trial. *JMIR mHealth and uHealth*, 11, e38342. <https://doi.org/10.2196/38342>
- Bidargaddi, N., Almirall, D., Murphy, S., Nahum-Shani, I., Kovalcik, M., Pituch, T., & Strecher, V. (2018). To prompt or not to prompt? a microrandomized trial of time-varying push notifications to increase proximal engagement with a mobile health app. *JMIR mHealth and uHealth*, 6(11), e10123. <https://doi.org/10.2196/10123>
- Bolger, M. (2014). Servant Leadership as an enhancer of intrinsic motivation in MOOCs.
- Burston, J. (2015). Twenty years of MALL project implementation: A meta-analysis of learning outcomes. *ReCALL*, 27(1), 4-20. <https://doi.org/10.1017/S0958344014000159>
- El-Zalabany, H. (2024). Mobile notifications as an information medium: an ethnographic study of mobile human-information interaction attitudes of Egyptian and German higher education students. *Cybrarians Journal*, 71, 1-33. <https://doi.org/10.70000/cj.2024.71.585>
- Evans, M., & Boucher, A. (2015). Optimizing the power of choice: supporting student autonomy to foster motivation and engagement in learning. *Mind, Brain and Education*, 9(2), 87-91. <https://doi.org/10.1111/mbe.12073>
- Fogg, B. (2009). A behavior model for persuasive design.
- Fraser, K., & Conlan, O. (2020). Enticing notification text & the impact on engagement.
- Gavilán, D., & Martínez-Navarro, G. (2022). Exploring user's experience of push notifications: a grounded theory approach. *Qualitative Market Research: An International Journal*, 25(2), 233-255. <https://doi.org/10.1108/qmr-05-2021-0061>
- Guo, Z., Liu, Y., Gao, J., Adams, M., & Kalinowska-Żeleźnik, A. (2024). Push, overload, and exhaustion. *International Journal of Cyber Behavior, Psychology and Learning*, 14(1), 1-17. <https://doi.org/10.4018/ijcbpl.362809>
- Jankovič, A., Kolenik, T., & Pejović, V. (2022). Can personalization persuade? Study of Notification Adaptation in Mobile Behavior Change Intervention Application. *Behavioral Sciences*, 12(5), 116. <https://doi.org/10.3390/bs12050116>

- Karakaya, K., & Bozkurt, A. (2022). Mobile-assisted language learning (MALL) research trends and patterns through bibliometric analysis: Empowering language learners through ubiquitous educational technologies. *System, 110*, 102925. <https://www.sciencedirect.com/science/article/pii/S0346251X2200207X>
- Kaukuntla, P. R. (2023). Quantifying the effectiveness of push notifications on user conversion and retention in digital communities using Time-Series analysis and A/B testing. *International Journal for Multidisciplinary Research, 5*(6). <https://doi.org/10.36948/ijfmr.2023.v05i06.38183>
- Kunkel, T., Hayduk, T., & Lock, D. (2023). Push it real good: the effects of push notifications promoting motivational affordances on consumer behavior in a gamified mobile app. *European Journal of Marketing, 57*(9), 2592-2618. <https://doi.org/10.1108/ejm-06-2021-0388>
- Kuriachan, A., Thomas, R. R., & Sukanya, R. (2024). Place-Based strategies, multichannel merger, and Context-Driven alerts for engagement with mobile marketing.
- Lally, P., & Gardner, B. (2011). Promoting habit formation. *Health Psychology Review, 7*(Sup1), S137-S158. <https://doi.org/10.1080/17437199.2011.603640>
- Leaf, C., Wasserman, C., Leaf, A., Kopooshian, N., Turner, R., & Paulson, R. (2024). Habit formation and automaticity: psychoneurobiological correlates of gamma activity. *Neuroregulation, 11*(1), 2-24. <https://doi.org/10.15540/nr.11.1.2>
- Li, N., Du, Y., & Chen, G. (2013). Survey of cloud messaging push notification service. *2013 International Conference on Information Science and Cloud Computing Companion, 273-279*. <https://doi.org/10.1109/ISCC-C.2013.132>
- Loewen, S., Crowther, D., Isbell, D. R., Kim, K. M., Maloney, J., Miller, Z. F., & Rawal, H. (2019). Mobile-assisted language learning: A Duolingo case study. *ReCALL, 31*(3), 293-311. <https://doi.org/10.1017/S0958344019000065>
- Mashhadi, A., Mathur, A., & Kawsar, F. (2014). The myth of subtle notifications. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct publication*, 111-114. <https://doi.org/10.1145/2638728.2638759>
- Mbbs, A. (2021). Understanding the study habits of Saudi residents in a psychiatry programme. *Journal of Taibah University Medical Sciences, 16*(1), 34-42. <https://doi.org/10.1016/j.jtumed.2020.10.011>
- Mehnaz, M. (2022). *Developing push-notifications to enhance user engagement in an EdTech platform in Bangladesh: A morphosyntactic study* [Bachelor's thesis, University of Liberal Arts Bangladesh].
- Nagpal, P., & M, R. (2024). Investigating the nexus of intrinsic motivation, learner engagement, and satisfaction in the completion of MOOC courses. *SPAST Reports, 1*(2). <https://doi.org/10.69848/sreports.v1i2.4959>
- Nation, I. S. P. (2013). *Learning vocabulary in another language*. Cambridge University Press. <https://doi.org/10.1017/CBO9781139858656>
- Nedunchezian, A. (2025). User state-based notification volume optimization: a novel approach. *World Journal of Advanced Engineering Technology and Sciences, 15*(1), 65-71. <https://doi.org/10.30574/wjaets.2025.15.1.0182>
- Nobbe, L., Breitwieser, J., Biedermann, D., & Brod, G. (2024). Smartphone-based study reminders can be a double-edged sword. *Npj Science of Learning, 9*(1). <https://doi.org/10.1038/s41539-024-00253-7>
- Oinas-Kukkonen, H., & Harjumaa, M. (2009). Persuasive Systems design: key issues, process model, and system features. *Communications of the Association for Information Systems, 24*, 486-500. <https://doi.org/10.17705/1cais.02428>
- Ozdemir, Ş. (2019). Digital nudges and dark patterns: the angels and the archfiends of digital communication. *Digital Scholarship in the Humanities, 35*(2), 417-428. <https://doi.org/10.1093/llc/fqz014>
- Pelne, L., Kale, S., Kubde, R., Bhusari, V., & Choubey, V. (2021). Neglect application for block the unwanted notification. *International Journal of Computational and Electronic Aspects in Engineering, 2*(2). <https://doi.org/10.26706/ijceae.2.2.20210409>
- Pielot, M., Cardoso, B., Katevas, K., Serrà, J., Matic, A., & Oliver, N. (2017). Beyond interruptibility. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 1*(3), 1-25. <https://doi.org/10.1145/3130956>
- Roffarello, A., & Russis, L. (2021). Understanding, discovering, and mitigating habitual smartphone use in young adults. *ACM Transactions on Interactive Intelligent Systems, 11*(2), 1-34. <https://doi.org/10.1145/3447991>
- Sanfilippo, M. R., & Lev-Aretz, Y. (2017). Breaking news: How push notifications alter the fourth estate. *First Monday, 22*(11). <https://doi.org/10.5210/fm.v22i11.8068>
- Schneegass, C., Sigethy, S., Eiband, M., & Buschek, D. (2021). Comparing concepts for embedding second-language vocabulary acquisition into everyday smartphone interactions.
- Schulze, F., & Groh, G. (2014). Studying how character of conversation affects personal receptivity to mobile notifications.
- Shabarriesh, A., Reddy, M., Kumar, A., & K, D. (2025). Reduce the amount of push notifications for e-commerce apps. *International Journal of Scientific Research in Engineering and Management, 9*(1), 1-9. <https://doi.org/10.55041/ijssrem40482>
- Sruthiya, V., & Sasikumar, A. (2025). Consumer perception and app loyalty through personalized push notifications. *International Journal of Research in Commerce and Management Studies, 7*(2), 16-25. <https://doi.org/10.38193/ijrcms.2025.7202>
- Stojanovic, M., Grund, A., & Fries, S. (2020). App-based habit building reduces motivational impairments during studying – an event sampling study. *Frontiers in Psychology, 11*. <https://doi.org/10.3389/fpsyg.2020.00167>
- Tan, L., Roegiest, A., Clarke, C. L., & Lin, J. (2016). Simple dynamic emission strategies for microblog filtering.
- Thi, T. D. P., & Duong, N. T. (2025). Intrinsic motivations in health and fitness app engagement: A mediation model of entertainment. *Digital Health, 11*. <https://doi.org/10.1177/20552076251326151>
- Tiffany, P., Pinem, A., Hidayanto, A., & Kurnia, S. (2020). Gain-loss framing: comparing the push notification message to increase purchase intention in e-marketplace mobile application. *IEEE Access, 8*, 182550-182563. <https://doi.org/10.1109/access.2020.3029112>
- Uysal, A., & Yildirim, I. G. (2016). *Self-Determination Theory in Digital Games*. *International series on computer entertainment and media technology*. Springer, Cham. https://doi.org/10.1007/978-3-319-29904-4_8
- Visuri, A., Berkel, N., Okoshi, T., Gonçalves, J., & Kostakos, V. (2019). Understanding smartphone notifications' user interactions and content importance. *International Journal of Human-Computer Studies, 128*, 72-85. <https://doi.org/10.1016/j.ijhcs.2019.03.001>

- Webb, S., & Nation, P. (2017). *How vocabulary is learned*. Oxford University Press.
<https://doi.org/10.25170/ijelt.v12i1.1458>
- Wohllebe, A., Hübner, D., Radtke, U., & Podrutzsik, S. (2021). Mobile apps in retail: effect of push notification frequency on app user behavior. *Innovative Marketing*, 17(2), 102-111.
[https://doi.org/10.21511/im.17\(2\).2021.10](https://doi.org/10.21511/im.17(2).2021.10)
- Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological Review*, 114(4), 843-863.
<https://doi.org/10.1037/0033-295X.114.4.843>
- Wu, H. (2022). Establish a digital real-time learning system with push notifications. *Frontiers in Psychology*, 13.
<https://doi.org/10.3389/fpsyg.2022.767389>
- Yancey, K. P., & Settles, B. (2020). A Sleeping, Recovering Bandit Algorithm for Optimizing Recurring Notifications.
- Yuan, Y., Zhang, J., Chatterjee, S., Yu, S., & Rosales, R. (2019). A state transition model for mobile notifications via survival analysis.
- Zholdas, S., Koshkimbayeva, R., Bekisheva, A., Yelmuratova, B., & Kaliyeva, A. (2024). Effectiveness of Duolingo in foreign language learning. *Bulletin of Toraighyrov University Pedagogics Series*, 3, 53-61.
<https://doi.org/10.48081/hckh9551>
- Zhong, J., Zhang, Z., Zhao, Z., Peng, L., Zhang, Y., Zhang, B., & Wu, Y. (2024). Relating caregiver experiences to personalized “push” content in mobile applications among caregivers of pediatric patients with oncology conditions. *Pediatric Blood & Cancer*, 71(10).
<https://doi.org/10.1002/pbc.31198>