Balancing Notification Frequency and User Satisfaction in Task Management Tools

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Abstract. *This study examines the role of customizable notification intervals in task management applications. Tarefácil, an app designed to send task reminders, was used as the study tool. Participants were divided into three groups, each assigned different notification intervals: 3 hours (C1), 5 hours (C2), or a choice between the two (C3). The results show that users highly value the ability to personalize notification intervals, even though fixed intervals did not negatively affect their experience. This research suggests future studies in contexts such as work and education, contributing to interaction design, psychology, and technology. The findings emphasize the importance of customization in improving user experience.*
Keywords: *Notification customization, Task management applications, User experience, Human-computer interaction, Notification frequency.*

1. Introduction

The growing integration of technology in daily life has spurred advancements in areas focused on user well-being, privacy, and trust. Affective computing, a branch of artificial intelligence, has emerged as a key player in humanizing interactions between humans and machines, from applications to robots. These innovations aim to enhance technological interactions by providing more empathetic and personalized user experiences [Picard 2000].

However, as mobile applications adopt more sophisticated personalization and engagement features, concerns about privacy and user experience have also increased. One major issue is the potential misuse of personal data, leading users to be more cautious about installing and granting permissions to apps [Twomey 2016]. Another critical factor is how apps communicate through push notifications, as their frequency and relevance can significantly influence user perception and retention [Pielot et al. 2014, Mehrotra et al. 2016].

While notifications are essential for maintaining user engagement, excessive or poorly timed notifications can lead to negative experiences. Users may find frequent interruptions intrusive, resulting in frustration, notification disabling, or even app abandonment [Zendesk 2022]. Therefore, balancing notification frequency, content relevance, and personalization is crucial for improving user experience and fostering long-term engagement.

This study investigates how notification frequency affects users of planner-type apps, which keep users informed about events, appointments, and tasks. The analysis focuses on how notification frequency and type influence user engagement, satisfaction, and discomfort levels.

The study addresses the following research questions:

- **RQ1:** Can the notification interval influence the levels of anxiety, anger, and discomfort of the user? This question seeks to identify how different notification frequencies emotionally affect users.
- **RQ2:** Is the frequency of notifications a factor that leads the user to disable this feature? Understanding whether the frequency of notifications influences the decision to disable them can help adjust notification systems.
- **RQ3:** Is the personalization of the notification period a strategy valued by users? This question investigates whether the ability to personalize the notification frequency contributes to a better user experience.
- **RQ4:** Does the frequency of notifications affect the perceived usefulness of the application? The answer to this question can provide insights into how to optimize the effectiveness and perceived utility of the application.

These questions emphasize the importance of exploring the relationship between notification frequency and user experience, particularly in engagement and satisfaction. This study aims to fill a gap in the literature by examining how push notifications can be adjusted to enhance user experience in mobile apps.

2. Related Work

Push notifications are used by mobile applications to provide information or prompt user interaction, even when the app is inactive. Research on their impact has explored aspects such as stress, engagement, content personalization, and timing. This section reviews key findings, emphasizing the need to tailor notifications to users' preferences.

2.1. Notification Frequency and User Engagement

Affective computing has been increasingly applied to improve human-computer interaction, particularly in managing user stress caused by notification frequency. [Morrison et al. 2017] explored this aspect in the context of mental health applications, investigating how sensor-based adaptive notifications influence user stress levels. Their findings suggest that frequent notifications can enhance engagement without necessarily discouraging user participation. Additionally, [Wohllebe 2020] conducted a systematic review on notification frequency and found that excessive notifications often lead users to disable notifications or uninstall applications, reinforcing the need for a balance between engagement and intrusiveness. Recent studies further demonstrate the importance of personalized notification strategies to optimize engagement while minimizing stress [Zhong et al. 2024, Williamson et al. 2022].

2.2. Personalization and Adaptive Notification Systems

Personalization plays a crucial role in the efficacy of push notifications. [Bidargaddi et al. 2018] explored micro-randomization techniques in the Jool application, where notification content was adapted based on users' behavioral

patterns. Their results indicated that personalized notifications significantly enhance self-monitoring behaviors. Similarly, [Bell et al. 2020] showed that fixed-interval notifications may be insufficient for long-term engagement, whereas adaptive notifications—dynamically adjusted based on user activity—are more effective in sustaining interaction. The use of reinforcement learning techniques to refine notification delivery has also been proposed as a promising approach to improving user satisfaction [Wheatley and Ferrer-Conill 2021, Bell et al. 2023].

2.3. Context-Aware Notifications and Receptivity

The timing and contextual relevance of notifications are key factors in determining user receptivity. [Mehrotra et al. 2016] found that notifications received in appropriate contexts were perceived more positively, whereas poorly timed notifications led to frustration. Similarly, [Pielot et al. 2014] conducted an in-situ study, demonstrating that notifications should be designed to align with users' activities and attention states. Ensuring that notifications are both contextually relevant and well-timed can foster user acceptance and improve the overall experience [Gavilan and Avello 2023].

These studies collectively illustrate the significance of balancing notification frequency, personalization, and contextual awareness to enhance user experience in mobile applications.

3. Methodology

3.1. Participants

Participants were recruited through invitations sent to specific WhatsApp groups. To organize data collection, three WhatsApp groups were created, corresponding to three distinct experimental conditions. Inclusion criteria for participants included owning a smartphone compatible with the developed application and being willing to use it regularly during the study period. All selected volunteers received detailed instructions on how to install the application, as well as the necessary files to perform the installation and start using it.

3.2. Materials

The application developed for this study, named Tarefácil, was designed to assist users in managing their daily tasks through automatic reminders. To achieve this, the development team chose to use React Native and Expo due to their efficiency in cross-platform mobile development.

React Native is a JavaScript-based framework that enables the creation of native applications for both iOS and Android from a single codebase, reducing development time and simplifying maintenance. Its "learn once, write anywhere" approach allows developers to build consistent and robust interfaces efficiently.

Expo, an open-source platform, complements React Native by streamlining development with pre-configured tools and libraries. It facilitates real-time testing on simulators and physical devices without complex setups, accelerating iteration cycles. Additionally, Expo offers seamless integration with APIs for push notifications, geolocation, and other essential functionalities, which were crucial for implementing Tarefácil's automatic task reminders and real-time data management.

For back-end services, Firebase was selected due to its scalability and ease of integration with React Native. Firebase provided key functionalities such as real-time data storage and user authentication, ensuring a seamless experience for task tracking and notifications.

Tarefácil was designed to assist users in managing daily tasks through automatic reminders. Its user-friendly interface allows users to register tasks and receive timely push notifications, implemented using Expo Notifications. Figure 1 presents the main screens of the application.

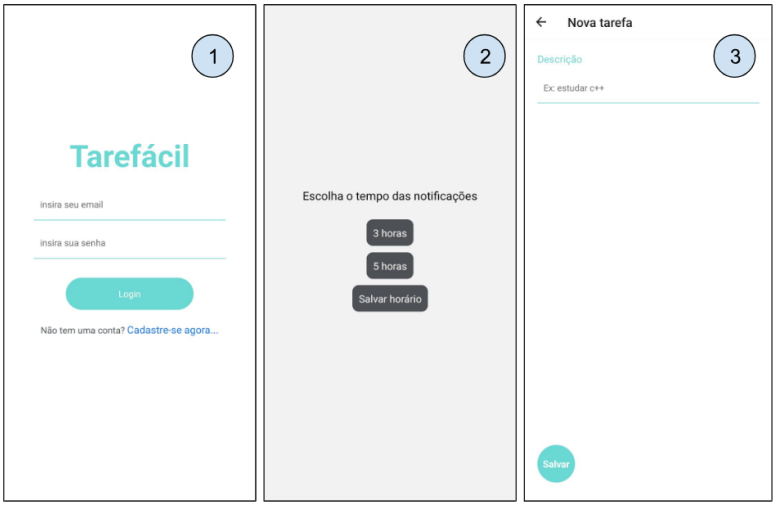

Figure 1. Screens of Tarefácil.

The notification system, shown in Figure 2, was implemented using Expo Notifications, ensuring reliable and efficient delivery across platforms.

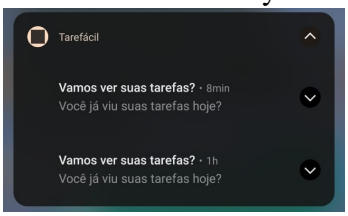

Figure 2. Notification tab of the app in the 1-hour test interval.

Thus, the combination of React Native, Expo, Firebase, and Expo Notifications provided a scalable and efficient foundation for Tarefácil, enabling a streamlined development process and an enhanced user experience.

3.3. Procedures

Participants were instructed to install Tarefácil on their smartphones and received an informed consent form with detailed information about the study. After agreeing to the informed consent, they configured the application according to their assigned test condition (C1, C2, or C3). They were then encouraged to use the application regularly for seven days, interacting with it naturally and using it to help manage their tasks.

To ensure the integrity of the experiment, participants were explicitly instructed not to disable notifications in their operating system settings during the study period. Additionally, during the initial instruction session, we verified that notification permissions

were properly configured on each device. Participants were also directed to report any technical issues that might interfere with receiving notifications.

At the end of the seven-day test period, participants were asked to provide feedback on their experience with the application through an online questionnaire. The questionnaire evaluated the usefulness of push notifications, the ease of use of the application, and the overall impact of the application on their task management.

3.4. Manipulation

The experimental manipulation allowed for the evaluation of the impact of different push notification frequencies on user behavior. For this, three distinct conditions were configured for sending notifications through the Tarefácil application.

In the first condition, called C1, participants received notifications every 3 hours. This condition was designed to evaluate the impact of frequent notifications on user engagement with the application. The 3-hour interval was chosen based on research suggesting that frequent reminders can help maintain user engagement and task completion rates, particularly in task management applications [Mehrotra et al. 2016].

In the second condition, called C2, participants received notifications every 5 hours. This condition allowed for the evaluation of whether a less frequent notification interval could result in a similar or higher level of user engagement. The 5-hour interval was selected to explore a balance between keeping users informed and avoiding notification fatigue, which can occur with overly frequent alerts [Pielot et al. 2014].

In the third condition, called C3, participants had the opportunity to personalize the notification interval between 3 and 5 hours. This condition was included to evaluate whether giving users the ability to personalize notification frequency could lead to greater engagement. Allowing users to choose their preferred notification interval acknowledges individual differences in notification preferences and aims to enhance user satisfaction and engagement by providing a sense of control [Bidargaddi et al. 2018].

Participants were randomly assigned to one of the experimental conditions at the beginning of the study. This random assignment approach ensured that each condition had an equitable distribution of participants, allowing for a fair comparison of results between the different conditions. Additionally, measures were taken to ensure that participants were not influenced by the experimental manipulation. Participants were informed that they were participating in a study on the use of task management applications and were not informed about the different experimental conditions. This helped ensure that their responses and behaviors reflected their natural reactions to the application, without being influenced by knowledge of the experimental conditions.

Throughout the study, researchers closely monitored participants' use of the application and their interaction with push notifications. This allowed for a detailed analysis of the impact of different notification frequencies on user behaviour, providing valuable insights for optimizing push notification design in applications.

3.5. Questionnaire

After the study period, participants received a structured questionnaire to evaluate their experience with Tarefácil. The first questions were developed based on a Likert

scale from 1 to 5, where participants could express their level of agreement or satisfaction with different aspects of the application. The questions addressed notification frequency, notification personalization, perceived notification usefulness, and the impact of notifications on application interaction.

Additionally, the questionnaire included binary and multiple-choice questions, where participants were asked about the adequacy of the time interval between notifications, the need for notification frequency personalization, and whether they had ever felt the need to disable notifications due to their frequency.

Finally, the questionnaire included an open-ended question where participants were invited to provide suggestions for improving the application's notifications. This question allowed participants to express their opinions and ideas more freely, providing suggestions for improving the application.

3.6. Generative AI

Generative AI contributed to application development by resolving technical issues with React Native and Expo, and optimizing the code structure. AI also assisted in questionnaire creation, suggesting relevant questions and key areas for evaluation.

In the article writing process, AI helped organize ideas, improve clarity, and review grammar, ensuring a cohesive and focused discussion on data analysis and results.

3.7. Ethical Considerations

This study adhered to ethical guidelines for research involving human participants. Before participating, all users were provided with a detailed informed consent form, explaining the purpose of the study, the procedures involved, and their right to withdraw at any time without any consequences. Participants were informed that their responses and usage data would be treated confidentially and anonymously, ensuring no personally identifiable information would be collected or stored.

3.8. Statistical Analysis

Data analysis was conducted using IBM SPSS (v28.0.1) and Microsoft Excel. The Shapiro-Wilk test indicated that most data were not normally distributed ($p < .05$), leading to the use of non-parametric methods. The Kruskal-Wallis test assessed differences among study conditions, while the Mann-Whitney test compared pairs of conditions ($p \leq 0.05$).

4. Results

A total of 30 participants were selected, equally distributed across three experimental conditions. All volunteers used the application for 7 days and completed the questionnaire at the end of the period.

4.1. RQ1: Influence of Notification Interval on Anxiety, Anger, and Discomfort

Initially, we calculated the average responses provided by participants to the following questions:

(Q1) "Upon receiving the app notifications, what level of anxiety did you feel?" with an average of 1.93 (SD=1.172);

(Q2) “Upon receiving the notifications, what level of anger did you feel?” with an average of 1.53 (SD=0.973);

(Q3) “What level of discomfort did you feel from the notifications received?” with an average of 1.93 (SD=1.388).

When separating the responses by study condition, the highest averages were obtained in C2, followed by C3, with the lowest averages in C1, as shown in Table 1.

Table 1. Mean and standard deviation of volunteer responses by condition.

Question	C1	C2	C3
Q1	1.4 (0.699)	2.3 (1.418)	2.1 (1.197)
Q2	1.2 (0.422)	2.1 (1.370)	1.3 (0.675)
Q3	1.3 (0.483)	2.7 (1.767)	1.8 (1.317)

4.2. RQ2: Impact of Notification Frequency on Behavior

To address this research question, we counted the responses to the question (Q4) about whether the user felt the need to disable notifications due to their frequency. Of the volunteers, 18 did not find it necessary to disable them, while 12 felt the need to do so.

When analyzing the data by condition, in C1, 8 participants responded no and 2 yes. In C2, 6 responded no and 4 yes. In C3, 4 responded no and 6 yes.

4.3. RQ3: Customization of Notification Frequency

For this research question, we asked two questions: the first was whether the volunteers would like to have the option to customize the notification frequency (Q5) and the second was how they would rate the importance of being able to customize notifications (Q6). For Q5, 25 participants said yes, 1 said no, and 4 were indifferent. For Q6, the average rating was 4.53 (SD=0.776).

For Q5, in C1, 8 responded that they would like to customize the notification frequency and 2 were indifferent. In C2, 7 responded yes, 2 indifferent, and 1 no. In C3, all 10 volunteers responded yes.

For Q6, in C1 the average rating was 4.5 (SD=0.850). In C2, the average was 4.2 (SD=0.919). In C3, the average was 4.9 (SD=0.316).

4.4. RQ4: Influence of Notification Frequency on Perception and Utility

When asked about the usefulness of the notifications (Q7), the average rating was 3.23 (SD=1.165). Regarding the question about whether the notifications increased interaction with the application (Q8), the average rating was 3.70 (SD=1.119). Finally, we asked whether they considered the notification frequency adequate to their needs (Q9), obtaining an average of 3.70 (SD=1.236).

When separated by condition, the highest averages for Q7 and Q8 were obtained in C2, while for Q9, the highest average was in C3, as shown in Table 2.

It is important to note that the Kruskal-Wallis statistical test was applied to all questions, and no statistically significant differences were found ($p > .05$). Additionally, the Mann-Whitney test was applied between each pair of study conditions, and no statistical differences were found

Table 2. Mean and standard deviation of volunteer responses by condition.

Question	C1	C2	C3
Q7	2.8 (1.135)	3.7 (1.418)	3.23 (1.165)
Q8	3.3 (1.059)	3.9 (1.287)	3.9 (0.994)
Q9	3.7 (1.059)	3.4 (1.350)	4.0 (1.333)

5. Discussion

RQ1: Influence of Notification Interval on Anxiety, Anger, and Discomfort

The results indicate that the frequency of notifications can significantly impact users' emotions. Condition C2, which involved notifications every 5 hours, resulted in the highest averages for anxiety, anger, and discomfort. This suggests that a longer notification interval may lead to increased anxiety and discomfort, possibly due to a sense of anticipation or forgetting tasks. This finding aligns with previous research, which suggests that less frequent notifications can sometimes lead to increased stress due to the unpredictability and anticipation of the next notification [Mehrotra et al. 2016]. On the other hand, Condition C1, with notifications every 3 hours, resulted in the lowest averages, indicating that a higher notification frequency may be less disruptive for users. This could be because more frequent notifications help users stay on top of their tasks, reducing anxiety and stress [Pielot et al. 2014].

RQ2: Impact of Notification Frequency on Behavior

The data analysis reveals that a portion of participants felt the need to disable notifications, likely due to their frequency. This result indicates that notification frequency can affect user behavior, leading some to consider disabling notifications to reduce annoyance. This is consistent with findings from other studies, which have shown that excessive notifications can lead to notification fatigue, causing users to disable notifications or even uninstall the application [Wohllebe 2020].

RQ3: Customization of Notification Frequency

The results demonstrate a preference among participants for customizing the notification frequency. Most participants expressed interest in having the option to adjust the notification frequency according to their individual preferences. Additionally, the high average rating for the importance of notification customization indicates that this functionality is valued by users. This preference for customization is supported by previous research, which has found that providing users with control over their notification settings can enhance user satisfaction and engagement [Bidargaddi et al. 2018].

RQ4: Influence of Notification Frequency on Perception and Utility

Participants' responses indicate a generally positive perception of the usefulness of notifications and an increase in interaction with the application. However, the evaluation of the adequacy of notification frequency for participants' individual needs showed a more balanced distribution of responses. This suggests that the perception of the adequacy of notification frequency may vary among users. This variation in perception highlights the importance of personalized notification strategies to cater to different user needs and preferences [Zhong et al. 2024].

Note that while the data indicate trends in user preferences and reactions, no

statistically significant differences emerged among the experimental conditions. This outcome likely stems from factors such as the sample size, inherent variability in individual preferences, and the study's brief seven-day span. Despite this statistical constraint, the findings are not undermined, but rather they call for prudent interpretation and cautious extrapolation to larger groups.

The study's duration of one week was a balance aimed at gathering pertinent data while keeping participants engaged. Although this timeframe enabled the observation of initial usage patterns and responses to notifications, it might not have been long enough to detect more nuanced behavioral changes, like adapting to notifications or developing coping strategies. In real-life scenarios, users engage with apps over much longer periods, during which their behaviors and preferences can evolve substantially.

Feedback from the open-ended questions underscored the demand for enhanced app functionalities. Participants advocated for features allowing them to schedule notifications at specific times and enable daily event reminders, such as for hydration. This feedback implies that rigid alert timings could diminish the app's practical value. Reports of receiving notifications at inopportune moments stress the need for timely and pertinent delivery. Moreover, suggestions for a customizable settings area to adjust notification frequency by priority indicate a desire for finer control over notification management. Such tailored options promise to enhance user interaction and the utility of notifications. These qualitative perspectives enrich the quantitative data, offering a deeper understanding of user experiences with the app's notification features.

6. Conclusion

This study highlights the importance of customization and adaptability in task management applications, demonstrating that more flexible notification settings can improve user engagement while reducing negative reactions to reminders. The results indicate that allowing users to customize notification intervals and access functions tailored to their needs improves interaction with the application, reinforcing the need for customization in the design of task management tools.

Although we did not find statistically significant differences between experimental conditions, the qualitative data and strong preferences expressed by participants offer valuable insights for the design of notification systems. The consistent valuation of personalization, regardless of experimental condition, suggests that this is a fundamental feature for user satisfaction.

The study has limitations, including sample size and the relatively short duration of the testing period, which may have influenced the lack of statistical significance in the results. However, the insights gained about user preferences and their reactions to different notification frequencies contribute to the field of human-computer interaction and user experience design.

Future research could explore different notification strategies in contexts such as work, health, and education, refining application design and improving the user experience. By incorporating greater flexibility and personalization, task management tools can become more intuitive and effective, better aligning with user preferences and their daily routines.

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