LembreMe: The Effectiveness of Affective Micro-Interactions in Mobile JITAI-Style Reminder Systems – A Crossover Experimental Study

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Abstract. *This paper presents LembreMe, a Progressive Web App (PWA) designed to support individuals with executive function difficulties through personalized, just-in-time reminders on mobile devices. A crossover experimental study ($N = 10$) was conducted to compare affective reminders, incorporating empathetic language, personalization, emojis, and text-to-speech, with neutral reminders based on standard text and default notification sounds. The evaluated metrics included adherence rate, time to action, snooze frequency, user satisfaction (Likert scale), usability (System Usability Scale — SUS), and affective state measured using the Positive and Negative Affect Schedule. The results indicate that affective micro-interactions significantly increased task adherence, reduced task initiation latency, decreased snooze usage, improved user satisfaction, increased perceived usability, and enhanced positive affect. These findings suggest that incorporating affective elements into mobile reminder systems may enhance user engagement and contribute to the design of more effective JITAI-style interventions for executive function support.*

1. Introduction

Difficulties related to executive function, such as impairments in working memory, time management, and task initiation, are common among individuals with Attention Deficit Hyperactivity Disorder (ADHD), anxiety, or cognitive decline [Barkley 2012]. ADHD is estimated to affect approximately 5% of the adult population worldwide, significantly impacting individuals' ability to organize, plan, and adhere to daily routines [Faraone et al. 2024]. Failure to adhere to everyday tasks, such as taking medication, attending medical appointments, or performing self-care activities, may lead to important consequences for health and well-being.

Mobile and ubiquitous technologies have emerged as promising tools for cognitive support. Smartphones, wearable devices, and reminder applications are widely used to help users organize daily tasks and commitments in their everyday environments. However, many current notification systems still operate under a predominantly utilitarian paradigm, relying mainly on simple auditory alerts or textual messages and often

disregarding users' emotional or motivational states [Pielot et al. 2014]. Studies on digital interventions suggest that the way a message is presented can significantly influence users' behavioral responses [Perski and Short 2021].

This issue can be examined through the lens of Affective Computing, which proposes systems capable of recognizing, interpreting, and simulating emotional aspects of human interaction [Picard 1997]. This perspective is supported by the Computers as Social Actors (CASA) paradigm, according to which individuals tend to respond socially to computers when they display characteristics associated with human interaction [Reeves and Nass 1996]. In parallel, persuasive technology highlights that personalization, empathetic language, and appropriate triggers may increase engagement in digital systems [Fogg 2003, Fogg 2009, Torning and Oinas-Kukkonen 2009]. In mobile health, these ideas also relate to Just-in-Time Adaptive Interventions (JITAI), which aim to provide the appropriate support at the moment users need it most, often through mobile devices embedded in everyday contexts [Nahum-Shani et al. 2018, Klasnja et al. 2015].

Despite these advances, empirical evidence on the role of affective micro-interactions in mobile reminder systems designed to support executive function remains limited. In particular, it is still unclear whether incorporating empathetic language and affective elements into notifications can improve adherence and reduce task initiation latency. To address this gap, this study investigates the effect of affective notifications in a mobile reminder system. For this purpose, the *LembreMe* system was developed as a Progressive Web App (PWA), and a crossover experimental study was conducted comparing affective notifications with neutral notifications. This study contributes empirical evidence that affective micro-interactions can significantly influence adherence, task initiation latency, and user experience in mobile reminder systems designed to support executive function.

2. Related Work

Research on mobile notifications has shown that smartphone alerts play a central role in mediating everyday activities, influencing attention, interruptions, and behavioral responses. Pielot et al. [Pielot et al. 2014] demonstrated, through an *in situ* study, that mobile notifications are frequent and context-sensitive, directly affecting how users manage tasks and respond to device stimuli. These findings reinforce that notification design is not neutral and may either support or hinder engagement.

In digital health interventions, user acceptability and engagement are critical to system effectiveness. Perski and Short [Perski and Short 2021] argue that the acceptance of digital interventions involves subjective perception, contextual appropriateness, and emotional response. This suggests that the success of reminder systems depends not only on technical functionality but also on how the interaction is perceived by the user.

Studies on persuasive technology indicate that personalization, feedback, and dialogue can increase adherence to desired behaviors [Fogg 2003, Torning and Oinas-Kukkonen 2009, Oinas-Kukkonen and Harjumaa 2009]. In the mobile health domain, JITAI has been used to guide interventions that deliver adaptive support at opportune moments [Nahum-Shani et al. 2018]. Klasnja et al. [Klasnja et al. 2015] also highlight the importance of appropriate experimental designs for evaluating adaptive interventions in real time. However, the literature

has focused primarily on physical activity, medication adherence, and broader health behaviors, with less attention to affective micro-interactions in reminder systems aimed at task initiation and daily organization, particularly for individuals with executive function difficulties.

Therefore, although the literature provides important foundations regarding affective computing, mobile notifications, persuasive technology, and JITAI, empirical evidence combining these specific elements (affective micro-interactions, mobile reminder systems, and executive function support in everyday contexts) remains notably limited. The present work addresses this critical gap by experimentally investigating affective notifications, incorporating empathetic language and personalization, compared to neutral notifications in a crossover study using a mobile reminder application. This study specifically contributes by providing empirical insights into how subtle affective cues in notifications can impact behavioral outcomes and user experience in the context of executive function support, representing an innovative exploration in an area where existing JITAI and persuasive technology applications often overlook the emotional dimension of reminders and lack direct empirical investigation into this specific combination of factors.

3. Theoretical Background

This section lays the theoretical groundwork for understanding the design and evaluation of affective micro-interactions in mobile reminder systems. We delve into the core concepts of executive function, affective computing, and persuasive technology, which collectively inform our approach to supporting users with daily task management and, specifically, the rationale behind the LembreMe system's design.

3.1. Executive Function and Adherence Difficulties

Executive function comprises cognitive processes related to planning, inhibitory control, working memory, organization, and task initiation [Barkley 2012]. Impairments in these processes may impair daily routines, time management, and adherence to essential activities such as medical appointments, self-care, and medication use [Faraone et al. 2024]. These difficulties are prevalent in conditions like ADHD, anxiety, and cognitive decline, making effective support crucial for daily well-being.

In this context, digital tools such as reminder applications can act as external aids for behavioral regulation. However, simply providing alerts does not guarantee adherence, especially when users struggle with task initiation or procrastination. Thus, it is important to investigate not only the presence of reminders but also how they are presented to the user, considering their potential to influence motivation and engagement. This highlights the need for reminder systems that go beyond mere informational delivery, aiming to actively facilitate task initiation and reduce procrastination.

3.2. Affective Computing and the CASA Paradigm

Affective Computing proposes the development of systems capable of recognizing, interpreting, and expressing emotional aspects during human-computer interaction [Picard 1997]. Rather than operating solely in a functional manner, such systems seek to incorporate signals that make interactions more empathetic, human-like, and socially meaningful. This field is particularly relevant for designing interfaces that can adapt to

or evoke specific emotional states, thereby enhancing user experience and effectiveness. In the context of mobile reminders, Affective Computing principles suggest that infusing notifications with emotional cues could transform a utilitarian alert into a more engaging and persuasive interaction.

This perspective is reinforced by the *Computers as Social Actors* (CASA) paradigm, which suggests that users tend to apply social norms to computers when these display typically human characteristics, such as personalized language, voice, emotional cues, or cooperative behaviors [Reeves and Nass 1996]. Studies in human–computer interaction also indicate that interfaces sensitive to affective aspects can improve user experience and foster greater engagement with digital systems [Calvo and D'Mello 2010]. The application of CASA principles to notification design suggests that even subtle affective cues can elicit social responses, making reminders more impactful. Our experimental design directly leverages the CASA paradigm by integrating personalized and empathetic language, emojis, and text-to-speech to evoke a more social and less purely functional interaction with the LembreMe system.

3.3. Persuasive Technology and JITAI

Persuasive technology investigates how computational systems can be designed to influence human attitudes and behaviors [Fogg 2003]. Among the most relevant mechanisms in this context are personalization, feedback, reinforcement, and the use of triggers appropriate to the user's context. The *Fogg Behavior Model* proposes that a behavior occurs when motivation, ability, and a trigger converge at the same moment [Fogg 2009]. In reminder systems, this suggests that simply delivering a notification is not sufficient; it must also be timely and motivating, aligning with the user's current state and needs. This model provides a theoretical lens through which we analyze how affective elements in notifications might enhance motivation, making the reminder trigger more effective for task initiation.

Approaches based on *Persuasive Systems Design* highlight that user support, credibility, dialogue, and personalization can make digital systems more effective in promoting desired behaviors [Oinas-Kukkonen and Harjumaa 2009, Torning and Oinas-Kukkonen 2009]. This reasoning converges with the concept of *Just-in-Time Adaptive Interventions* (JITAI), which describes interventions capable of providing appropriate support when the user needs it most [Nahum-Shani et al. 2018]. In mobile health, JITAIs have been explored as a promising approach to support routines and self-regulation, although there is still a need to better understand how affective elements, such as empathetic language, voice, and personalization, may influence the effectiveness of mobile reminder systems [Klasnja et al. 2015]. Our study aims to contribute to this understanding by empirically evaluating the integration of affective micro-interactions within a JITAI-style reminder system. By focusing on the "how" a reminder is delivered, our work extends the JITAI framework to include the communicative quality of interventions as a critical factor for effectiveness.

4. Methodology

4.1. Participants

The study included 10 volunteers ($N = 10$), recruited through convenience sampling. This approach meant participants were selected based on their accessibility and willing-

ness to participate, rather than through random selection. All participants reported everyday difficulties related to executive function, such as forgetting appointments, difficulty initiating tasks, and problems organizing daily routines. Basic familiarity with smartphones and regular internet access were minimum requirements for using the system.

4.2. System and Experimental Conditions

The experiment was conducted using the *LembreMe* system, a Progressive Web App (PWA) designed to support the execution of everyday activities through personalized, just-in-time reminders on mobile devices. The system's architecture is client-server based, with the front-end implemented using React, providing a responsive and cross-platform user interface. For data persistence and management, Supabase was utilized, offering a robust backend-as-a-service solution that allowed for automatic logging of user interactions throughout the study, including notification triggers, user responses, and task completion status. This design ensures that the system is lightweight, easily deployable, and capable of operating reliably across various mobile devices.

Two experimental conditions were defined. In the neutral condition, used as the control, notifications contained only objective information such as the task title and scheduled time, accompanied by the system's default notification sound. In the affective condition, considered the experimental condition, notifications incorporated elements of personalization and emotional support, including empathetic language, the participant's first name, emojis, and text-to-speech output. Thus, the difference between conditions was limited to the communicational tone of the notification, while the same reminder functionality was maintained in both cases.

4.3. Procedures

The study lasted a total of 6 days of active intervention for each participant. Initially, an *onboarding* process was conducted, during which volunteers received detailed instructions on how to use the system and formally agreed to participate by signing an informed consent form. Participants were then assigned to two groups in order to balance the order of exposure to the experimental conditions and reduce potential sequence effects.

In Group A, participants first used the affective version of the system for three days, followed by a 12-hour *washout* period and then the neutral condition for three days. In Group B, the order was reversed: participants first experienced the neutral condition for three days, followed by the same 12-hour *washout* period and finally the affective condition for three days. This procedure aimed to minimize residual effects such as learning, habituation, or preference from the first condition.

Throughout the experiment, participants used the system in their everyday environments, and the system automatically logged interaction data, including the time elapsed between the notification trigger and the user's response, as well as the actions performed after each reminder.

4.4. Metrics and Data Analysis

The evaluation of the system included both objective behavioral metrics and subjective measures of user perception. Among the behavioral metrics considered were: (i) adherence rate, corresponding to the percentage of reminders that were effectively completed;

(ii) time to action, measured in seconds from the moment the notification was issued; and (iii) the number of postponements (*snooze*) performed by participants. In addition, established instruments from the literature were used to assess user perception and affective response. Usability was measured using the System Usability Scale (SUS) [Brooke 1996], which provides a standardized usability score ranging from 0 to 100. Participants completed the SUS questionnaire after interacting with each experimental condition.

To assess affective response, the Positive and Negative Affect Schedule (PANAS) [Watson et al. 1988] was applied, focusing on the positive affect dimension in order to observe emotional responses associated with the interaction with the reminder notifications.

Statistical analysis was conducted in Python using the SciPy library. Initially, the distribution of the data was assessed using the Shapiro–Wilk normality test. Once normality was confirmed, paired t-tests were performed to compare the two experimental conditions, since each participant was evaluated under both conditions. In addition to statistical significance, effect sizes were calculated using Cohen's d [Cohen 1988] in order to estimate the magnitude of the differences observed between neutral and affective notifications.

5. Results

The collected data revealed statistically significant differences between the two experimental conditions. Table 1 presents the comparison between affective and neutral notifications for the main behavioral metrics observed in the experiment. The results include descriptive statistics (mean and standard deviation), mean difference between conditions (Δ), p value, and effect size calculated using Cohen's d coefficient. For adherence, time to action, snooze frequency, and Likert satisfaction, paired t-tests were used to compare the two experimental conditions. SUS and PANAS results are reported descriptively with corresponding effect sizes and significance values obtained from the original study analysis.

Table 1. Comparison between affective and neutral notifications ($N = 10$).

Metric	Affective	Neutral	Δ	t	p	d
Adherence (%)	83.57 ± 4.82	70.00 ± 6.56	$+13.57$	10.58	< 0.001	3.35
Time to action (s)	30.69 ± 5.75	47.00 ± 6.51	-16.31	-34.39	< 0.001	10.88
Snooze usage (count)	0.62 ± 0.71	2.21 ± 1.06	-1.59	-6.92	< 0.001	2.19
Likert (1–5)	4.50 ± 0.53	3.10 ± 0.74	$+1.40$	8.57	< 0.001	2.71
SUS (0–100)	79.80 ± 5.88	66.60 ± 5.72	$+13.20$	–	< 0.001	2.27
PANAS Positive	36.60 ± 4.50	28.10 ± 3.25	$+8.50$	–	< 0.001	2.18

Overall, the affective condition showed superior performance across all evaluated metrics. A significant increase in task adherence was observed, along with a reduction in the time required to initiate the task after receiving the notification and a lower use of the *snooze* function. In addition, participants reported greater satisfaction with the user experience when exposed to affective notifications.

To promote transparency and reproducibility, the data used in this study have been made publicly available. The anonymized dataset and analysis files can be accessed in the Open Science Framework (OSF) repository: `https://osf.io/7ntk9/overview`.

5.1. Adherence and Efficiency

Task adherence increased substantially in the affective condition. On average, participants completed 83.57% of reminders in this condition, compared to 70.00% in the neutral condition, representing a mean increase of 13.57 percentage points. The difference was statistically significant ($t = 10.58$, $p < 0.001$), with a large effect size ($d = 3.35$), indicating a strong impact of the affective tone of notifications on participant engagement.

In addition to the higher task completion rate, a reduction in the time required to initiate an action after receiving a notification was observed. The mean response time decreased from 47.00 seconds in the neutral condition to 30.69 seconds in the affective condition, representing an average reduction of 16.31 seconds. This difference was also statistically significant ($t = -34.39$, $p < 0.001$), with a very large effect size ($d = 10.88$), suggesting that affective messages can substantially reduce task initiation latency.

Figure 1 illustrates the difference in mean adherence rates between the two experimental conditions.

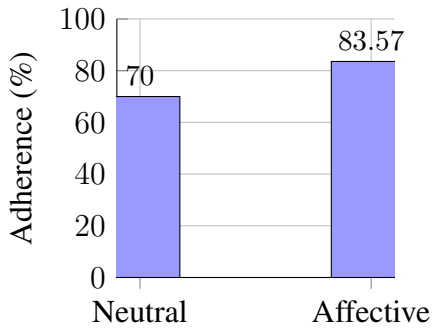

Figure 1. Mean adherence rate in the Neutral and Affective conditions.

The consistency of this effect can also be observed in Figure 2, which presents the within-subject variation in reaction time. All participants exhibited lower latency when exposed to the affective condition, indicating that the effect was not restricted to a few individuals but occurred consistently across the sample.

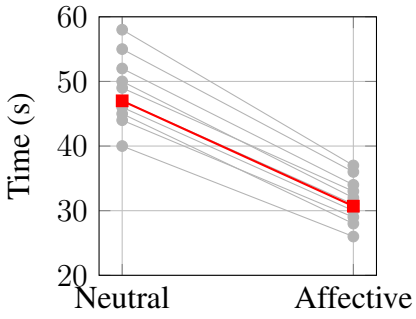

Figure 2. Within-subject reaction time in the Neutral and Affective conditions. The red line represents the mean across participants.

Another relevant result was the reduction in the use of the *snooze* function. While participants used an average of 2.21 postponements per task in the neutral condition, this value decreased to 0.62 in the affective condition. The difference was statistically

significant ($t = -6.92$, $p < 0.001$), with a large effect size ($d = 2.19$), indicating a lower tendency toward procrastination when reminders incorporated affective elements.

5.2. User Experience

The subjective evaluation of the user experience also showed consistent differences between the experimental conditions. On the Likert satisfaction scale (1–5), the affective condition achieved a mean score of 4.50, whereas the neutral condition obtained a mean score of 3.10. This difference was statistically significant ($t = 8.57$, $p < 0.001$), suggesting that participants perceived affective notifications as more motivating, pleasant, and appropriate for the usage context.

Figure 3 presents the distribution of usability scores obtained with the System Usability Scale (SUS). The affective condition achieved a mean score of 79.80, while the neutral condition obtained 66.60, remaining below the industry reference value of 68 points. This result indicates that participants perceived the system as easier and more pleasant to use when affective notifications were employed.

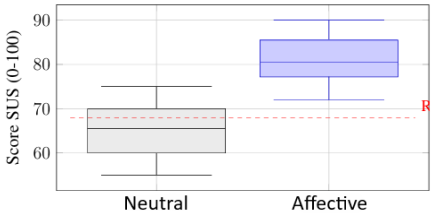

Figure 3. Distribution of usability scores in the Neutral and Affective conditions.

Similarly, positive affect scores measured through PANAS were higher in the affective condition (36.60) than in the neutral condition (28.10), suggesting that emotionally expressive notifications may contribute not only to behavioral engagement but also to users' affective responses during interaction.

Overall, the results suggest that incorporating affective micro-interactions into reminder systems can simultaneously improve objective behavioral metrics—such as adherence, response time, and snooze usage—and subjective metrics related to user experience.

6. Discussion

The results obtained in this study provide empirical evidence that the design of affective micro-interactions in mobile reminder systems can significantly influence user behavior in everyday contexts. Consistently, the affective condition outperformed the neutral condition across all evaluated metrics, including task adherence rate, reaction time to notifications, frequency of postponements (snooze), and the subjective evaluation of user experience.

From a behavioral perspective, the findings suggest that notifications incorporating empathetic language and personalization can reduce task initiation latency and increase the likelihood of task completion. This result is particularly relevant in contexts associated with executive function difficulties, where task initiation and routine management often represent central challenges. The observed reduction in the number of postponements also indicates a lower tendency toward procrastination when reminders are presented in a more supportive and personalized manner.

From a theoretical perspective, these findings are consistent with the principles of Affective Computing, which propose that systems capable of recognizing or simulating emotional aspects of human interaction can foster greater user engagement and cooperation [Picard 1997]. By incorporating elements such as empathetic language, personalization, and text-to-speech output, the *LembreMe* system introduced social cues that may have contributed to making the interaction more meaningful and motivating.

These results also align with the *Computers as Social Actors* (CASA) paradigm, which suggests that individuals tend to apply social norms to their interactions with computers when these systems exhibit characteristics associated with human behavior [Reeves and Nass 1996]. In this sense, the use of empathetic language and personalized references may have triggered automatic social responses from participants, leading them to interpret the notification not merely as a technical alert but as a socially meaningful stimulus.

Furthermore, the results can be interpreted in light of the literature on persuasive technology. Models such as the *Fogg Behavior Model* suggest that a behavior occurs when motivation, ability, and an appropriate trigger converge [Fogg 2009]. In the context of this study, notifications function as behavioral triggers. The presence of affective elements may have increased the perceived motivation to perform the task, thereby making the trigger more effective.

Another relevant aspect is the convergence between the observed results and the concept of *Just-in-Time Adaptive Interventions* (JITAI) [Nahum-Shani et al. 2018]. Such interventions aim to provide support precisely when the user needs it most, maximizing the likelihood of a behavioral response. Although the system evaluated in this study did not implement dynamic contextual adaptation, the results suggest that the communicational quality of the intervention—that is, how the reminder is presented—may be an important factor in the effectiveness of this type of system.

Finally, the findings reinforce that seemingly simple micro-interactions, such as the choice of language used in notifications, can produce meaningful behavioral effects. In applications designed to support executive function, small changes in interaction design may represent substantial differences in task adherence and perceived usefulness of the system.

Finally, it is important to acknowledge the potential for a novelty effect in our findings. While the observed improvements were significant, the relatively short duration of the experiment does not fully account for potential long-term user adaptation or habituation to affective notifications. This aspect is further discussed as a limitation and direction for future work in the Conclusion.

Taken together, these findings contribute to understanding how affective elements can be integrated into the design of mobile reminder systems. The results suggest that combining personalization, empathy, and contextualized communication may increase engagement and improve the effectiveness of digital interventions aimed at supporting everyday organization.

The improvements observed in usability (SUS) and positive affect (PANAS) further reinforce the role of affective interaction design as a mechanism for promoting engagement and improving user experience in mobile reminder systems.

7. Conclusion

This study investigated the effect of affective micro-interactions in notifications of mobile reminder systems designed to support executive function. To this end, the *LembreMe* system was developed, and an experimental study with a crossover design was conducted, comparing affective notifications with neutral notifications.

The results indicate that the affective condition outperformed the neutral condition across all evaluated metrics. An increase was observed in task adherence rates, along with a reduction in the time required to initiate actions after receiving a notification and a lower use of the *snooze* function. Furthermore, participants reported better user experience, higher perceived usability, and higher positive affect when exposed to affective notifications. These findings suggest that affective micro-interactions may represent a relevant component in the design of digital systems aimed at supporting executive function.

From a practical perspective, the results indicate that replacing strictly functional notifications with messages that incorporate empathetic language and personalization may help reduce procrastination and improve user engagement with daily routines. Thus, the communicational design of notifications should be considered a functional component of the system rather than merely an aesthetic aspect of the interface.

Despite the promising results, this study presents some limitations that warrant careful consideration. First, the sample size was relatively small ($N = 10$). This choice was primarily driven by the inherent challenges in recruiting participants willing to commit to a multi-day experimental study involving daily interactions with a novel system. In addition, participants were recruited through convenience sampling, which means they were selected based on their accessibility and willingness to participate. This approach, while practical, may introduce selection bias, as the characteristics of our participants might not fully represent the diversity of individuals experiencing executive function difficulties.

Another factor to consider is the relatively short duration of the experiment. The study involved 6 days of active intervention for each participant (3 days per condition), a design chosen to focus on the immediate impact of micro-interactions and to minimize participant fatigue and dropout in a crossover setup. However, this duration does not allow for the evaluation of potential long-term effects, such as habituation to notifications over extended periods or the sustained behavioral changes that might occur with prolonged use. Future research should address these aspects to understand the long-term efficacy and user adaptation.

As directions for future research, studies with larger and more diverse samples may help validate and extend the findings observed in this work, enhancing their generalizability. Additionally, longitudinal investigations could evaluate the persistence of the effects of affective notifications over time, particularly concerning habituation and sustained behavioral change. Another possibility is the integration of the system with contextual or physiological sensors, enabling the implementation of more sophisticated adaptive interventions within the framework of *Just-in-Time Adaptive Interventions* (JITAI). Finally, future research may explore different affective communication strategies, such as variations in tone of voice, emotional intensity, or dynamic adaptation of messages to the user profile.

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