Fighting Stress With AI, Positive Psychology, and Persuasive Technology

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LIST OF ABBREVIATIONS USED

AI	artificial intelligence
BMIS	Brief Mood Introspection Scale
CBT	Cognitive behavioural therapy
FIS	Future intention scale
HCI	Human-Computer Interaction
IDE	integrated development environment
IMI	Intrinsic Motivation Inventory
mHealth	Mobile Health
MIT	mentalization image therapy
OHQ	Oxford Happiness Scale
PANAS-SF	Positive and Negative Affect Schedule short form
PS	Persuasive Scale
PSD	persuasive system design
Q&A	question-and-answer
RQ	Research Question
SCS	Social Connectedness Scale
SD	Standard Deviation
SUS	system usability scale
UES-SF	User Engagement Scale
UI	user interface
UT	usability testing
WHO	World Health Organization

ABSTRACT

Over the past years, researchers in the field of Human-Computer Interaction (HCI) have dedicated their efforts to designing interactive systems that are both useful and usable across various domains. The health domain, in particular, has witnessed significant attention, leading to extensive research in Mobile Health (mHealth) and the development of diverse mHealth applications targeting various needs, such as stress management and the promotion of positive health habits, including smoking cessation.

Stress, being a universal problem, has prompted the development of various approaches aimed at managing and mitigating its effects. In this thesis, we designed, developed, and evaluated a mHealth mobile application called SmileApp to promote positive mood as a means of addressing stress. The application leverages artificial intelligence (AI) and persuasive technology, incorporating underlying psychological theories and models such as the Flow theory, PERMA Model, and PSD Model.

To evaluate the SmileApp, a two-week within-subject study involving 101 participants who utilized the app during the study period was conducted in a natural environment. Participants' emotional states and feelings of social connectedness were measured before and after the intervention. We determined this population based on other studies that promote positive behaviour change. Previous studies recruited 136 [1], 31 [2], and 84 [3]. This supports that a population size of 100 participants will be enough to achieve a reasonable result in our study.

The findings of this study reveal the effectiveness of SmileApp in positively impacting users' emotional well-being by fostering positive moods. These results offer valuable insights into innovative approaches for designing mHealth applications that promote positive mood. Moreover, the findings underscore the importance of utilizing technology to support individuals on their emotional well-being journey and lay the groundwork for further research and development in this area. The implications of this study mark a paradigm shift in mHealth app design by introducing a new approach of users reading supportive messages with Smile and playing mobile games with their smile instead of conventional keypads.

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Chapter 1 INTRODUCTION

1.1 The Problem

Mobile applications have witnessed widespread implementation across a range of domains, including education, e-commerce, banking, transportation, logistics, social media, real estate, and health. This thesis aims to delve into the utilization of mobile apps specifically in the context of mental wellbeing. While numerous mHealth applications have previously focused on addressing mental wellbeing concerns, the issue of high data entry burdens has emerged as a significant concern among users of health apps leading to slow adoption rates and subsequent attrition of users. Developing a solution that mitigates this burden, while incorporating elements of enjoyment and leveraging innate human capabilities, holds the potential to enhance adoption rates and sustain long-term engagement. By doing so, this solution can effectively address the pressing risks posed by mental health problems to the well-being of individuals and society as a whole [4]. According to the World Health Organization (WHO), depression is a significant contributor to global disability and is responsible for a substantial burden of disease worldwide [5]. The economic impact of depression is also noteworthy, with the American economy facing a yearly cost of $63 billion [6]. These statistics highlight the pressing need to address depression as a public health concern. While various factors contribute to the development of depression, extensive research indicates that stress plays a major role[7] The National Center for Complementary and Integrative Health defines stress as a physiological and emotional response that individuals experience when faced with life challenges [8]. Prolonged exposure to stress increases the vulnerability to depression, underscoring the importance of stress management strategies.

Research suggests that early-life stressors or chronic stress throughout adulthood can significantly impact emotional well-being and increase susceptibility to depression [9]. Moreover, stress has been classified as an epidemic by the WHO and is a significant contributor to mortality rates [10]. A study conducted at Yale University revealed that stress has the potential to accelerate ageing and shorten lifespan [11]. Thus, efforts to minimize or cope with stress can have positive effects on slowing down the ageing process. Gallup polls published by The Washington Post indicate that 60% of Americans experience daily stress [12]. Stress and its consequences are not limited to the United States alone; reports show that 91% of Australians and 86% of Chinese workers experience

stress [13], In Canada, about 74% of individuals report feeling the impact of personal and/or work-related stress [14].

Persistent and unaddressed stress can have severe health consequences, including premature death [15]. Consequently, stress can be regarded as a critical health condition that necessitates comprehensive intervention strategies. For example, a study has provided evidence indicating that stress exerts a substantial influence on professionals, ultimately resulting in a notable impact on their productivity levels [16]. Carmichael et al. [17] investigated the impact of maternal stress on unborn children. Maternal stress refers to the stress experienced by expectant mothers during pregnancy [18]. The study highlighted the association between stress during pregnancy and increased risks of certain birth defects, raising concerns about the potential intergenerational impact of stress.

The impact of stress extends beyond the individual, affecting their professional productivity as well. Studies have demonstrated that stress significantly influences professionals and impairs their work performance[19]. Increased job-related stress has been shown to decrease productivity regardless of gender [20]. This negative correlation between job stress and productivity has substantial economic implications globally. American employers reportedly spend approximately $300 billion annually on healthcare and workdays lost due to stress, while the United Kingdom experiences a loss of around 13.7 million workdays each year due to stress. Australia and the UK also face significant productivity losses of approximately $14.2 billion and $37 billion, respectively [13]. These findings emphasize the far-reaching consequences of stress on both individuals and societies, highlighting the urgent need for effective stress management and intervention measures.

1.2 Motivation

Growing up in a small city in Nigeria, I witnessed individuals experiencing stress due to various circumstances such as limited access to food, unemployment, and caring for sick family members. However, upon moving to a larger city, I observed that even the affluent population was not exempt from stress, as they faced social pressures and demanding job responsibilities. This realization led me to understand that stress affects individuals across diverse backgrounds and contexts. While many statistical studies on stress-related illnesses and their impact are primarily conducted in

Western countries, it is important to acknowledge that stressors exist in other parts of the world, including developing nations.

Regardless of geographical location or social class, stress is a ubiquitous phenomenon that affects individuals worldwide, spanning from developing nations to developed countries. For instance, in sub-Saharan Africa, socio-economic conditions have been identified as a significant contributor to chronic stress [21]. While it is impractical to address all socio-economic conditions comprehensively to improve mental well-being, leveraging technology presents a promising avenue for increasing the availability of evidence-based mental solutions, particularly for individuals with low resources [22]. This motivation underpins our work, as we strive to develop a solution that is accessible and beneficial to users from diverse backgrounds and demographics.

Both students and the working class can experience stress as a result of conflicts, life changes, and pressures in their respective domains [23]. Therefore, our motivation emanates from the objective of establishing a solution that is not limited to a specific user demographic but instead caters to the needs of a wide range of individuals, encompassing various socio-economic backgrounds and occupational roles.

Acknowledging the economic disparities and limited accessibility to medication and therapy, we recognize that not everyone can afford traditional stress-relief interventions. However, stress affects individuals universally. In pursuit of developing a solution that is affordable to everyone, we have harnessed the potential of artificial intelligence (AI), persuasive technology, and positive emotion. Our objective is to create a ubiquitous system that is affordable, accessible, and available to individuals worldwide, regardless of their geographical location.

Drawing upon the concept of persuasive technology, as defined by Fogg [24], our system utilizes persuasive technology to assist and empower people to manage their stress. Additionally, we leverage the power of positive emotions, which are inherently pleasurable experiences that individuals actively seek [25]. By providing a tool for experiencing and promoting a positive mood, I aim to empower individuals to lead healthier lives.

The culmination of these ideas, namely AI, persuasive technology, and positive emotion, is integrated within SmileApp. This mobile application has been specifically developed and evaluated within the context of this thesis to assess its effectiveness in promoting positive emotion.

Through our research, we aim to contribute to the field by offering a solution that could contribute to addressing the global need for accessible tools to enhance emotional well-being.

1.3 Solution

Previous research has explored diverse approaches to tackle the pervasive issue of stress [26]. While there is existing research evidence indicating that frequent smiling can contribute to stress reduction [27], there remains a limited number of technological solutions specifically designed to encourage individuals to smile more frequently. For instance, Moore et al. [28] proposed an application that solely served as a reminder for users to smile, without implementing the proposed study or exploring its potential efficacy.

The gap in technological solutions that actively promote and facilitate increased smiling presents an opportunity for further investigation and development. By leveraging innovative approaches and integrating psychological theories and models, such as those related to positive emotion and persuasive technology, there is potential to design interventions that effectively encourage individuals to adopt smiling often as a means of mitigating stress.

This thesis presents the design, development, and evaluation of the effectiveness of a persuasive mHealth app called SmileApp that was purposefully designed to promote smiling and elicit a positive mood. We explored other approaches for stress management other than medication, therapy, exercise, and mindfulness. Although these approaches can be helpful, they are not likely to fit into a user's day without much disruption and some of them may not be readily available or affordable by all, e.g., therapy and medication. For example, someone stressed at work cannot suddenly visit the gym in the middle of working hours especially when they do not have the luxury of time or gym within reach.

The development of SmileApp is grounded in prior studies that have highlighted the potential of positive psychology strategies as preventive and therapeutic measures for depression [29]. Research indicates that the act of mimicking a smile through facial muscle movement can deceive the brain into experiencing a more positive mood [30]. Additionally, smiling has been found to mitigate the intensity of the body's stress response [31], and the success of mobile applications in promoting happiness has been documented [28].

By capitalizing on these findings and leveraging the capabilities of mobile technology, SmileApp aims to provide users with an effective tool for integrating smiling practices into their daily lives, ultimately fostering a positive emotional state and mitigating stress. We chose smile among other approaches to reduce stress because every human being can smile irrespective of gender, culture, social class or education qualification.

The SmileApp encompasses three primary features, each with specific functionalities aimed at promoting frequent smiling and facilitating positive mood experiences. These features were developed based on established psychological theories and the Persuasive System Design (PSD) framework adapted from Oinas-Kukkonen et al. [32]. Psychological theories provide a foundation of principles that explain human thoughts, emotions, and behaviours, offering valuable insights into individual and group dynamics derived from research and observation. Rigorous testing has been conducted to ensure the validity and reliability of these theories [33].

The three main features of the SmileApp are as follows:

1. SmileGram: This feature incorporates a game element where users interact with their smiles. Users can move icons around and align them with their smiles. With each successful alignment, a corresponding country map is painted green, and the user gains points. This process is repeated until the entire world map is filled with their smiles (painted green). The SmileGram feature includes sub-functionalities such as Syncfusion Map, Text-to-Voice Converter, Google ML Kit for Face Tracking, Countdown Timer, Leaderboard, and Font Awesome Animated Icons.
2. PocketBuddy: As the name suggests, PocketBuddy is a chatbot named Ada-Eze, designed to provide companionship to users. This chatbot employs a generative machine-learning model that generates responses with a level of human-like interaction. PocketBuddy serves as a virtual friend, aiming to reduce feelings of loneliness and enhance users' countenance as they engage with the AI-powered chatbot.
3. MyTribe: This feature establishes a closed community of supportive users. Participants in this community select their dominant emotion from a range of options, and other community members send anonymous supportive messages. The purpose of MyTribe is to create a supportive environment for emotionally vulnerable participants, providing them

with encouragement and uplifting messages. To ensure the messages shared in this community are positive, a two-level verification process is implemented:

i. At the composition stage, the system employs dark-sentiment analysis [34], specifically using the AFINN-Based sentiment analysis for the Dart programming language [35]. If the analysis detects negative sentiment in a composed message, it flags a notification and prevents the message from being sent. Only positive messages are transmitted.

ii. As an ethical requirement, researchers conduct a second level of content review and approval before the message is delivered anonymously to the intended user. When a message arrives, the recipient receives a notification and can unlock the message only with a smile. The functionalities associated with the MyTribe feature include sentiment analysis, an approval dashboard, Google ML Kit for Face Tracking, text-to-voice conversion, and notifications.

This study comprised two phases:

Phase 1: A system usability study was conducted after designing the beta version of the app. Participants were selected from the Persuasive Computing Lab at Dalhousie University, all of whom possessed knowledge of persuasive system design. Their feedback was collected and incorporated into refining the final version of the application used in the main study.

Phase 2: The main study was conducted under the approval of the Dalhousie Research Ethics Board (see Appendix-V). Participants were recruited from within and outside of Canada and were instructed to use the app in their natural environments for 14 days. Pre- and post-study surveys were administered to measure the impact of the application.

1.4 Contribution

The thesis presented in this study offers significant contributions to the field of Human-Computer Interaction (HCI) and mental mHealth apps. It addresses several research questions and provides empirical answers to the following research questions:

1. How effective is SmileApp for eliciting positive mood?

2. How engaging and Usable is the SmileApp for users to accomplish their goals of activating positive mood?
3. How effective is SmileApp in helping users find social support?
4. How effective is the Smile App for motivating continued use?
5. How persuasive and useful is the SmileApp in improving user's mood?

The measurement presented in this study holds valuable implications for future researchers, enabling them to adapt and refine our approach in addressing similar mental health problems. Additionally, industry partners can leverage the findings of this study to develop mental health products that align with evidence-based strategies and interventions. This thesis has made significant contributions to the field, introducing novel methodologies for designing health apps, fostering increased frequency of smiling behaviour, and expanding the repertoire of strategies for eliciting positive moods.

1.5 Overview of Thesis

This thesis provides a comprehensive account of the entire process undertaken for the design, development, and evaluation of the SmileApp, spanning eight additional chapters.

CHAPTER 1 INTRODUCTION: This chapter serves as an introductory section of the thesis, providing a comprehensive overview of the problem statement, the underlying motivations that drove the research, the proposed solution, and the significant contributions made by this study.

CHAPTER 2 RESEARCH BACKGROUND: This chapter presents a comprehensive review of existing research conducted within the field of human-computer interaction, specifically focusing on the promotion of positive mood. A thorough exploration of prior studies and findings is conducted to establish a solid foundation for the current research and to identify gaps in the existing literature.

CHAPTER 3 SMILEAPP DESIGN METHODOLOGY: This chapter offers a comprehensive overview of the design and development process of SmileApp, a mobile application aimed at promoting positive emotion. The chapter highlights the integration of underlying theories and models, the meticulous design and implementation strategies employed, the architectural structure of SmileApp, and an in-depth analysis of its various functionalities. The chapter serves as a

detailed account of the steps taken to create an effective and user-friendly app with a strong theoretical foundation.

CHAPTER 4 SMILEAPP EVALUATION: In this chapter, a rigorous evaluation of SmileApp is undertaken to determine its effectiveness and assess the impact it has on the participants enrolled in the study. The evaluation process encompasses a thorough analysis of various outcome measures and data collected from the participants, providing valuable insights into the app's efficacy in achieving its intended goals. The chapter presents a comprehensive evaluation methodology and statistical analyses to ensure a robust and reliable assessment of SmileApp's performance.

CHAPTER 5 STUDY RESULTS: In this chapter, an in-depth examination of the data collected during the study is conducted, employing rigorous analysis techniques to derive meaningful insights and present comprehensive results. The chapter presents a detailed exploration of the collected data, including descriptive statistics, inferential analyses, and visual representations, to provide a thorough understanding of the findings. The results are interpreted in light of the research objectives and contribute to the broader knowledge in the field.

CHAPTER 6 DISCUSSION: This chapter delves into a comprehensive discussion of the implications derived from the obtained results, elucidating the broader significance and potential ramifications of the study's findings. The findings are critically analyzed, and their implications are examined within the context of existing literature and theoretical frameworks. The chapter explores the practical implications of the results, highlighting their relevance to various stakeholders, including researchers and mHealth app developers. Additionally, the limitations of the study are addressed, and suggestions for future research avenues are provided to further advance the field's understanding in this area.

CHAPTER 7 LIMITATION AND FUTURE WORK AND CONCLUSION: This chapter serves as a concise summary of the work conducted, encapsulating the key findings and outcomes derived from the study. It presents a comprehensive overview of the main contributions and implications of the research. The chapter highlights the significance of the findings and their potential impact on the field of study. Moreover, it offers valuable recommendations for future research directions,

identifying areas that merit further investigation and exploration based on the study's results. These recommendations aim to guide future researchers in expanding upon the current study.

CHAPTER 8 CONCLUSION: This chapter encapsulates the overarching conclusion drawn from the entirety of the thesis, consolidating the key findings, insights, and implications discussed throughout the research.

Chapter 2 : BACKGROUND AND LITERATURE REVIEW

This section presents a comprehensive review of the existing literature about the application of computing technology in reducing stress, anxiety, and depression through the principles of positive psychology and mood regulation. Through a critical examination of the current literature, we identified gaps in the research and formulated research questions that drove the present study.

Stress and depression have garnered significant attention across various health research domains, including psychology, psychiatry, neuroscience, and public health. Researchers in the field of computer science have sought to explore the potential of leveraging computer technology to address anxiety, stress, and depression. To gain a comprehensive understanding of the current trends and state-of-the-art approaches employed by researchers in promoting mental well-being through mood regulation and positive psychology, we conducted a systematic review of the literature in the domain of human-computer interaction (HCI) applications in mobile health (mHealth) for emotional state intervention and regulation.

For our literature review, we extensively searched databases such as the ACM Digital Library, the IEEE Xplore Digital Library, PubMed, and the Journal of Medical Internet Research. These databases were chosen due to their wide coverage of publications and conferences in the HCI field, aligning with our research topic. Additionally, we also searched Google Scholar to ensure comprehensive coverage of relevant papers that may not have been captured by the aforementioned databases and journals. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model [36] was employed to guide our review process, and the findings were organized into thematic categories.

To search, we employed keywords such as "Regulate," "Improve," "Enhance," "Emotion," "Feeling," "Mood," "Mobile App," and "Mobile Application." Through crowdsourcing, we identified approximately 5,653 research articles, which were subsequently subjected to title filtering by reading through the title to ensure it was relevant to our study. This filtering process resulted in a selection of 106 which were subjected to further inclusion criteria, outlined as follows:

- Papers were written in the English language.
- The paper's objective had to be on promoting positive emotion and mood regulation (identified from the abstract)

- Not a theoretical, or conceptual article
- Developed an app (identified from full text)

The selected papers were thoroughly reviewed, and their findings contributed to the synthesis of the existing literature, informing the subsequent stages of our research.

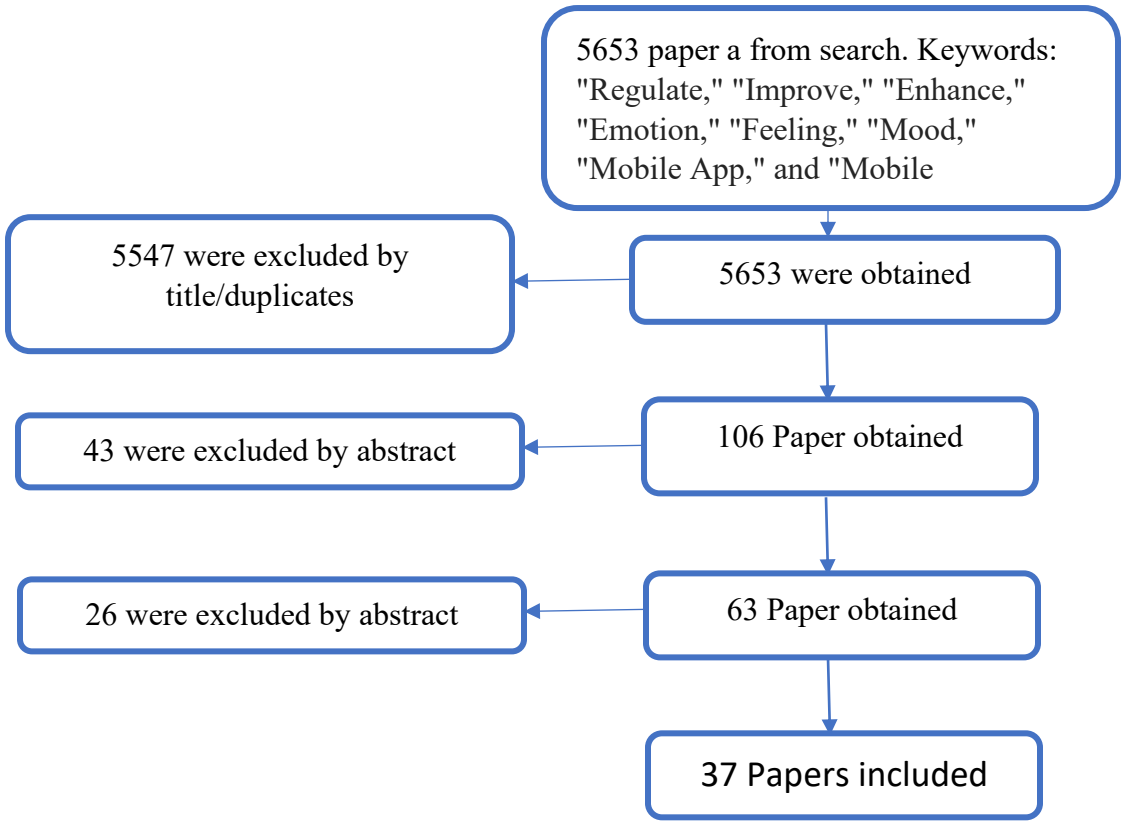


Figure 2.1 Study Identification Papers

Our analysis adopted the coding sheet from Orji et al. [37] for the paper organization. We organized the papers based on persuasive strategies employed, technologies used and the approach to promote positive psychology (for example diagnosis, Educating Users, Gamification, Guided Meditation, Journaling/Mood Tracking and Social Support).

2.1 Persuasive Strategies

Persuasion can be defined in simple terms as an attempt by a human being or organizational authority to motivate a target audience (human being) manually [38]. Within the field of human-computer interaction (HCI), researchers have demonstrated creativity in implementing persuasive

techniques, guided by underlying models. Fogg's FBM (Behavior Model) [39] posits that for a desired behaviour to occur, there must be sufficient motivation, ability, and an effective trigger. These three fundamental components of persuasion should align concurrently to achieve significant impact. In general, the persuasive design aims to enhance motivation, simplify tasks to improve ability, and effectively trigger behaviour change.

Building upon Fogg's work, Oinas-Kukkonen and Harjumaa [32]categorized persuasive techniques for developing system contents and functionalities into four main groups: primary task support, dialogue support, system credibility support, and social support. Primary task support techniques include a reduction (simplifying tasks), tunnelling (guiding users through a specific path), tailoring (customizing content), personalization, self-monitoring, simulation, and rehearsal. Dialogue support techniques involve elements such as praise, rewards, reminders, suggestions, similarity, liking, and social role. System credibility support techniques focus on establishing trustworthiness, expertise, surface credibility, a real-world feel, authority, third-party endorsements, and verifiability. Lastly, social support techniques encompass social learning, social comparison, normative influence, social facilitation, cooperation, competition, and recognition. These techniques were identified and highlighted in the papers reviewed.

Figure 2.2 illustrates the utilization of persuasive strategies in the reviewed papers. Tunneling emerged as the most frequently employed technique, accounting for 26% of the cases, followed by self-monitoring (13%) and tailoring (12%). Praise, rehearsal, social learning, rewards, social comparison, normative influence, recognition, and social facilitation were each utilized in 1% of the cases. The distribution of these techniques provides insights into their respective prevalence and potential effectiveness in influencing user behaviour.

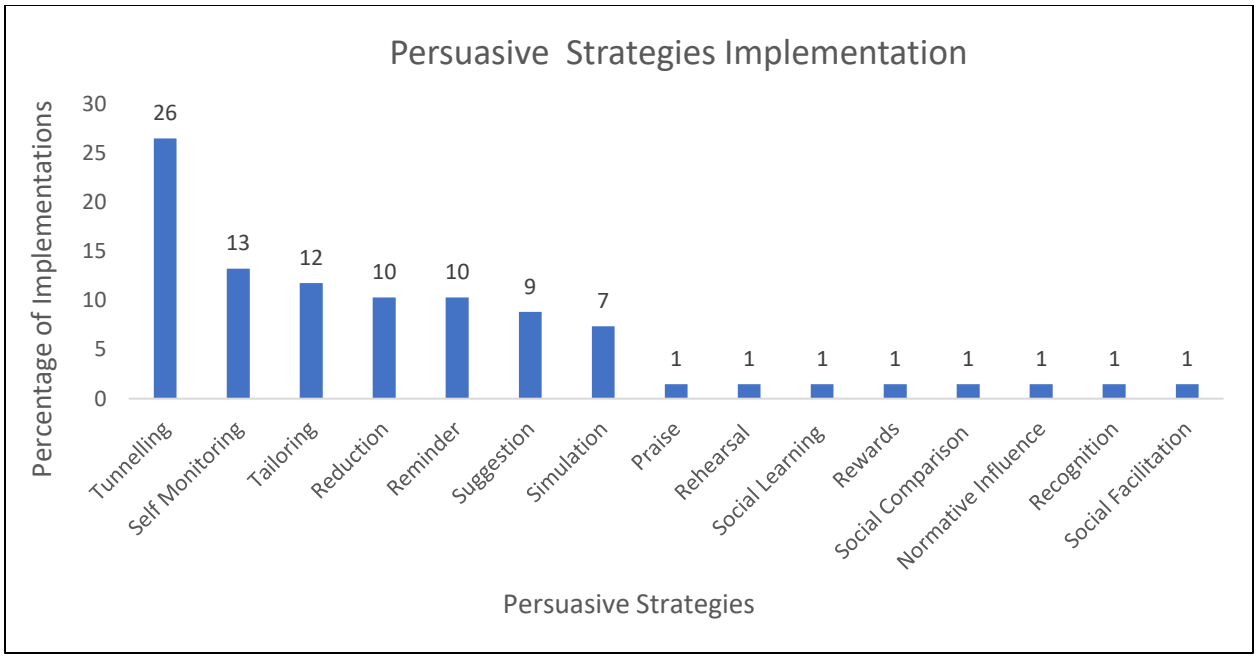


Figure 2.2 Percentage of Persuasive Strategies employed in mood regulation studies from the literature reviewed (N =37).

2.2 Technologies

During our review, we examined the platforms utilized by researchers to deploy their interventions. From the analyzed papers, we identified three primary platforms: (1) web, (2) chatbots, and (3) mobile applications. Among these platforms, mobile emerged as the most commonly employed platform for the reviewed interventions. Figure 2.3 provides a visual representation of the distribution of platforms across the reviewed papers.

Considering the wide usage of mobile applications in the domain of mental health systems, as well as the promising outcomes demonstrated in studies, we opted to design SmileApp as a mobile application. Numerous studies have indicated that smartphone apps have yielded positive results in addressing mental health concerns, particularly for individuals experiencing mild to moderate depression [40]. Taking into account the prevalence and effectiveness of mobile platforms in mental health interventions, we believe that SmileApp's mobile design holds great potential for promoting emotional well-being and enhancing users' mental health outcomes.

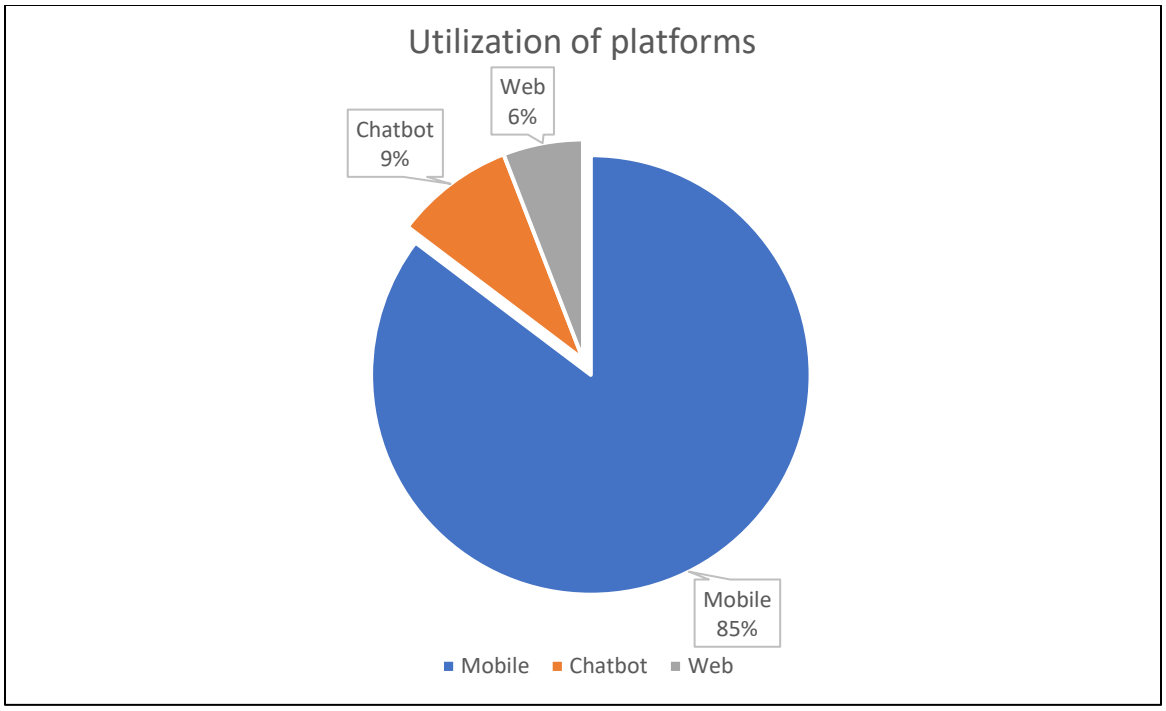


Figure 2.3 Percentage of technology used from the literature reviewed (N =37).

2.3 Approach employed to promote positive feeling.

Positive psychology, as defined by scholars, involves the study of conditions and processes that contribute to the flourishing and optimal functioning of individuals, groups, and institutions [41]. Within this framework, happiness is considered a significant aspect and is widely regarded as a valuable personal pursuit. It is believed that happiness not only leads to personal fulfilment but also contributes to the achievement of life successes [42]. Positive psychology primarily aims to enhance well-being and optimal functioning, rather than focusing solely on alleviating symptoms. It is considered complementary to traditional psychology, working in tandem to promote holistic mental health [43].

Numerous researchers have developed persuasive systems intending to promote positive emotions and mental well-being [44], [45][46], [47]. In the case of our system, SmileApp, we drew upon the principles of positive psychology to address stress by encouraging users to smile, providing social support, and simulating companionship. In the subsequent sections, we delve into the specific approaches employed by the papers we reviewed, highlighting their contributions to the field of promoting positive feelings and mental well-being.

2.3.1 Diagnosis

Diagnosis, in the context of health, refers to the process of identifying or determining the underlying cause or nature of a disease or condition [48]. Within the realm of mental health, researchers have utilized technology to detect the possibility or presence of stress and depression. Various mobile applications have been developed to contribute to mood regulation by detecting user moods and providing recommendations. However, these applications typically do not actively guide or influence the process of mood regulation itself.

In contrast, our design approach aimed to not just detect and monitor user moods but also actively reduce the intensity of negative moods and enhance the intensity of positive moods. By incorporating strategies from positive psychology, such as promoting smiling, providing social support, and simulating companionship, our design sought to actively influence and improve users' mood regulation processes.

Denecke et al. [49] conducted a study where they designed an emotion regulation app called SERMO. This app utilized a chatbot functionality that allowed users to regulate their emotions. The chatbot employed emotion detection techniques to identify the user's current emotional state and provided recommendations for activities based on the detected emotion. Additionally, the SERMO app incorporated a Diary feature that enabled users to engage in journaling as a means of self-reflection. The app also offered Cognitive Behavioral Therapy (CBT) content and emotional advice to further support users in managing their emotions. In another study, Kinderman et al. [50] developed a smartphone app that applied basic CBT principles. The app guided users through three key processes: (1) "Catch it," (2) "Check it," and (3) "Change it." These processes aimed to help users identify their thoughts and thinking styles associated with mood shifts or specific emotions, reflect on the helpfulness of these thoughts, and generate alternative ways of thinking, respectively. The outcomes of the study indicated a statistically significant reduction in the intensity of negative moods and an increase in the intensity of positive moods among the app users. These results demonstrate the potential effectiveness of incorporating CBT principles and emotion regulation techniques into smartphone apps as a means of promoting emotional well-being and enhancing mood regulation skills.

Mehta et al. [51] evaluated to assess the acceptability and effectiveness of "Youper," an AI-powered therapy app designed for the treatment of anxiety and depression. Youper offers users

emotional support and guidance through personalized conversations, enabling the app to extract and understand the user's mood. During these interactive conversations, Youper utilizes emotion detection techniques and provides therapeutic support accordingly. It is important to note that while Youper serves as an initial point of contact and offers valuable support, it does not replace the need for a therapist in certain cases. The app is designed to complement traditional therapy and provide users with additional resources and tools for managing their anxiety and depression. The study aimed to determine the acceptability and effectiveness of Youper as an adjunct to therapy, highlighting its potential as a convenient and accessible mental health support option.

Kim et al. [52] developed a mobile video-conferencing app “Hello MindCare” to improve the efficiency of the process of therapy. The "Hello MindCare" application has been developed with features such as session booking, document sharing, and videoconferencing, aimed at enhancing the operational efficiency of therapists in managing their schedules and engaging in therapy sessions. While the app may have contributed to improvements in stress reduction and therapist resilience, it is important to note that its effectiveness relies on the presence of a therapist within the therapeutic process. Consequently, the scalability of the app is hindered by the limited availability of therapists, thus imposing constraints on its widespread implementation.

Roy et al. [53]conducted a study where they developed a Mindfulness Training (MT) app specifically designed for individuals with generalized anxiety disorder (GAD). The purpose of this app was to deliver a digital therapeutic program that aimed to identify and address habitual worrying and thinking patterns through the use of reinforcement learning techniques. By breaking this cycle of negative thought patterns, the app aimed to reduce anxiety and worry while promoting the development of mindfulness skills.

The efficacy of the MT app was evaluated, and the results indicated a significant reduction in anxiety and worry symptoms among the participants. Additionally, there was an observed increase in mindfulness levels, suggesting that the app's intervention approach was effective in fostering positive changes in individuals with GAD. These findings highlight the potential of digital therapeutic interventions, such as the MT app, in providing targeted support for individuals struggling with anxiety disorders.

Jungmann et al. [54] used chatbots (Ada) to diagnose a broad spectrum of mental disorders and their dependency on expert knowledge. The chatbot (Ada) is based on a medical database which is constantly updated with research findings. The researchers investigated the diagnostic quality of this chatbot and how is depends on an expert's knowledge. The result of their finding suggests that the accuracy of the chatbots is user-dependent. This outcome makes the chatbots subjective and may not be very reliable in mental health diagnosis.

So far, interventions that have been presented in this section are focused on diagnosing stress. Although many of them are effective for managing stress they are not optimized for emotion regulation. Helping people improve their emotions is an important aspect and is the primary objective of our work. In our work, our focus is on bringing the user out of negative emotions. For example, the chatbot (Ada) by Jungmann et al [54], relies on expert knowledge, interacting with it can only detect mental disorders but is not an intervention to change the mental health challenge.

2.3.2 Educating Users

Some researchers have taken the approach of training users on simple techniques aimed at enhancing their emotional well-being as a means of promoting mental health. This involves providing users with knowledge and recommendations for activities that can regulate their emotions, decrease the intensity of negative moods, and increase the intensity of positive moods. In this section, we present several studies that primarily focus on educating users about approaches to improve their mood and enhance the intensity of positive emotions. These studies contribute valuable insights into the effectiveness of such interventions in promoting mental well-being and fostering positive emotional states.

In a study conducted by Luo et al. [55], the effectiveness of a mobile device-based multimedia training program, incorporating text, pictures, and short videos, was evaluated for its impact on reducing depressive symptoms and enhancing quality of life. The study utilized the popularity and reach of social media, specifically Twitter, as a platform for intervention delivery. Participants engaged in assessments that were subsequently evaluated by a psychological consultant, highlighting the involvement of human expertise in the feedback process. While this approach demonstrated promising results, it is important to note that the reliance on psychological consultants for feedback may present scalability limitations in broader implementation. Further

exploration is warranted to develop automated or scalable feedback mechanisms for similar interventions in the future.

Coelhoso et al. [56] designed a dedicated mental health app specifically targeting the reduction of stress among working women. The app implemented an 8-week program, consisting of four classes per week, aimed at providing effective stress management techniques. The study's findings demonstrated that the app successfully reduced stress levels and enhanced overall well-being among the targeted group of working women. It is worth noting, however, that the app's efficacy may be limited to individuals who can benefit from the specific teachings and interventions provided in the program. Specialized training and tailored content may be necessary for optimal outcomes, which could present challenges in terms of scalability and generalizability to a wider range of individuals experiencing stress. Further research and refinement of the intervention approach may be required to address these limitations and ensure broader applicability in diverse populations.

Sikder et al. [57] delivered mentalization image therapy (MIT) through a mobile app targeted at family caregivers. The app incorporates exercises to help participants mindfully observe themselves and understand the interconnectedness of self and others. The app consists of audio recordings of MIT practices and 4 essays (1 per week) explaining the concept underlying each recording and supportive information. The study showed that the app was able to improve a user’s mental health by reducing depression and incrementally increasing the user’s mood in a positive direction.

In a different study, Mendes-Santos et al. [58] developed Innov Breast Cancer (iNNOVBC), which is a mental health app designed to treat mild to moderate anxiety and depression in breast cancer patients. iNNOVBC consists of 10 modules (5 compulsory). The program adopts a transdiagnostic structure that features psychoeducation, acceptance, cognitive diffusion, connecting with values, committed action and exposure, behavioural activation, and relaxation as central components. Sleep management, energy conservation, problem-solving, and sensate focusing techniques are complementary components of the program. The app employed tunnelling and tailoring persuasive strategies.

McCallum et al. [59]studied the feasibility, acceptability and preliminary outcome of “Nood Mood”. Nood-Mood is a commercially available mobile app that handles cognitive behavioural therapy and mindfulness-based programs. The app delivered about 15 psychoeducation articles and journal features for users to log their thought processes as an approach to tackling mental health issues. The result of this study showed potential for “Nood Mood”, however, the authors recommended that more tests on the app with a rigorous design should be implemented.

Laird et al. [60] evaluated the feasibility of a consumer-based meditation app, called “Calm”. Calm is targeted to reduce stress among middle-aged adults. The Calm app guides users to do daily meditation and education podcasts. Similar to many other existing solutions, the Calm app helps users in daily meditation and educates them via podcasts which showed a significant improvement in perceived stress and stress-related health behaviours.

Borosund et al. [61] developed StressProffen an evidence-based stress management intervention for patients living with cancer. This app has educational material that promotes knowledge of stress, thoughts and feelings, anger management, health behaviour and setting goals. The app contains a variety of exercises such as thought challenges, positive self-talk, diaphragmatic breathing, progressive muscle relaxation, guided imagery, mindfulness, and meditation. The StressProffen also offers a video visualizing and explaining the flight-or-flight concept. The study showed that cancer survivors (who are the primary target audience) found the app useful, easy to access and user-friendly. However, the extent to which it managed stress was not clearly stated. Kawadler et al. [62] evaluated the effectiveness of a smartphone app called “BioBase” for reducing anxiety and increasing mental well-being. The app was found potentially effective for decreasing anxiety and increasing well-being by providing psycho-educational modules, and real-time feedback on physiological data.

Austin et al. [63] evaluated the experience of participants while using a mobile app targeted at enhancing and supporting dialectical behaviour therapy for persons with personality disorders. The app offers psychoeducation, a journaling feature for users to note their experience in situ. This information stored in the app is helpful for recall during therapy sessions.

El Morr et al. [64] deployed a web-based mindfulness community to administer mindfulness and CBT programs in an attempt to reduce symptoms of depression, anxiety, and stress and to increase mindfulness among university students. This web platform consisted of 12 video-based modules with psychology education, an anonymous peer-to-peer discussion forum, and anonymous group-based professionally guided 20-minute live videoconferencing. Results suggest that the web platform was an effective intervention for reducing symptoms of depression and anxiety among college students. In our study, we aim to deliver a peer-to-peer anonymous emotional support group unlike the discussion and video conference approach adopted by El Morr et al. [64].

Emmerik et al. [65] evaluated the immediate and long-term efficacy of an MBI app (the VGZ Mindfulness Coach) in a waiting-list controlled randomized trial for mindfulness without any form of therapeutic guidance in addition to the self-help app. the app offers 40 audio exercises, including but not limited to breathing exercises, attention exercises, body scan exercises, guided meditation exercises, visualization exercises, mantra exercises, and yoga exercises. It also offers the possibility of a 5-week program of 25 preselected audio exercises, as well as background information on meditation and mindfulness and the various exercises. The VGZ Mindfulness Coach is a self-help intervention without any form of automated or therapist-provided guidance or feedback. The study revealed that a positive effect on mindfulness is achievable with low costs apps like VGZ Mindfulness Coach.

Lozano-Lozano et al. [66] blended traditional learning materials and mobile app design for knowledge dissemination on motivation, mood state, and satisfaction among undergraduates. The app interface gives users access to different game modes and allows them to complete different activities and find platform-related information. The researchers examined the short-term (i.e., 2 weeks) effects of this blended learning method, the outcome shows a significant improvement in motivation, mood state, and satisfaction compared to traditional teaching.

Providing a form of training and psychology education to users using digital technology is effective in improving wellbeing. How these solutions can fit into the users' everyday lives without being intrusive is under-researched. How existing approaches can intervene and regulate the mood of users and fight off stress when needed is also unclear. To address some of these limitations, our solution focused on eliciting positive mood by promoting companionship which helps to improve

a user's emotional wellbeing [67] and leads an individual to experience positive feelings [68], social support and smiles. Smiles have been shown to fight stress by triggering the body to release neuropeptides [69], [70]. We propose an approach to regulate mood and improve wellbeing instantaneously through imbibing positive psychology in the design of our app.

2.3.3 Gamification

Gamification, the incorporation of game design elements into non-game environments, has gained significant popularity in the field of mHealth apps [71]. This trend is evident from the growing number of gamified apps available on platforms like the Apple Store and Play Store. However, studies indicate that many of these apps exhibit low adherence to professional guidelines and industry principles [72]. Despite this, the increasing popularity of gamification can be attributed to its potential for enhancing user experience and promoting higher levels of engagement [73]. Numerous researchers have recognized the value of gamification in promoting emotion regulation and improving mental well-being, leading to the development of systems that integrate gamification into their design. In this section, we provide a review and summary of selected apps that have successfully incorporated gamification as a means to motivate behaviour change and support individuals in their journey towards better mental health.

Christoforou et al. [74] evaluated the effectiveness of a self-guided game-based interactive intervention targeted at agoraphobic symptoms. The app simulates the real-life environments of a character that has agoraphobia. The user will guide this character through the help of a virtual therapist. In so doing, the user completes several tasks which would have made the user go through different therapeutic tasks. However, the outcome of this study showed that agoraphobic-focused apps compared to other generic anxiety apps had no difference in their effectiveness. This further amplifies the reason that our intervention was not defined for a specific population. Rather our intervention was made as a convenient tool for everyone to regulate their emotions.

In an attempt to improve emotional regulation in children, Moltrecht et al. [75] investigated the use of a new app-based intervention designed to support children's emotion regulation. The app has four modules a user can explore: (1) play (including four games with rewards), (2) relax (includes mindfulness and relaxation exercises), (3) watch (including psycho-education animations) and (4) tools (includes a list of emotion regulation strategies). These modules provide users with the opportunity to learn, practice, and develop new emotion regulation skills. An

evaluation of the app showed the possibility of its effectiveness as revealed by 67% of the participants who reported the app as helpful, and the interview of the children and their teachers suggested a positive experience.

Lockwood et al. [76] evaluated “Lumi Nova” which is a smartphone app that combines evidence-based therapeutic content (exposure therapy) and psycho-educational content within an immersive game designed to provide timely support to children aged 7-12 years old. The game narrative is an intergalactic role-playing adventure in which players assume the role of a treasure hunter on a quest to save the galaxy and explore the universe, helping characters on various planets while training to overcome real-world fears. Results showed that Lumi Nova was effective in reducing anxiety symptom severity over the 8 weeks of gameplay.

Farve [77] of the MIT Media Lab developed a google glass game called “Smile Catcher” to make users interact with other users or people in positive ways which may result in a smile. This system only tracks users' smiles but does not elicit smiles nor give users a reason to smile. The “Smile Catcher” gives users a score of the number of smiles captured within a period. Although the “Smile Catcher” system has gamification elements like points, it does not have any form of interactivity to make users initiate any form of activity. Unlike the “Smile Catcher”, our system the SmileApp allows users to control images and icons with their smile. Being deployed on Google Glass, limited battery life is an obvious limitation of the” Smile Catcher” system. Also, users who use recommended eyeglasses may not be able to use this system coupled with the fact the people in developing nations may not be able to afford google glass. Our intervention has been evaluated for effectiveness using a scientific approach and it is ubiquitous since it can be deployed even on low-powered devices. Table 2.1 is a summary of the gamification elements employed in various reviewed studies.

Table 2.1 Summary of Gamified Interventions.

Paper	Gamified elements	Application
Christoforou et al. [74]	Goal setting, Progress/Feedback	The app presented a case example of a virtual character who had agoraphobia. The users were required to guide her, through the help of the virtual

		therapist, to complete the different therapeutic tasks. The 3 overarching goals were to decrease the virtual character's catastrophic cognitions, safety behaviours, and physiological arousal
Moltrecht et al. [75]	Challenges	Users Solve picture riddles and tap on happy faces as fast as they can.
Lockwood et al. [76]	Avatar Customization, Rewords and Narrative Storytelling	The game narrative is an intergalactic role-playing adventure in which players assume the role of a treasure hunter on a quest to save the galaxy and explore the universe, helping characters on various planets while training to overcome real-world fears
Farve [77]	Points	The "Smile Catcher" gives users a score of the number of smiles captured within a period.

The gamified interventions combined with psychoeducation were designed for a target population. Our solution aims to eliminate the cognitive load burden that comes with any form of learning and leverage smile to regulate users' emotion. Cognitive load refers to the number of information elements needed to be processed simultaneously [78]. We made the gamified feature (the SmileGram) of our intervention simple and captivating with the potential to reach everyone, unlike special population apps that target a few populations. Our app was designed not to impose any cognitive load on users. The goal is to encourage users to smile, unlike apps that require education and training and demand cognitive load.

2.3.4 Guided Meditation

Meditation is a self-regulation strategy that encompasses a deliberate practice of training one's attentional focus [79]. Several studies have shown the benefits of meditation and its contribution to emotional health. This has increased interest in the medical field [80]. Just like every other technique, there are proper ways to observe meditation for optimum results. To improve mental health, and reduce stress and depression, researchers have developed systems that help users practice proper meditation. For example, in one study, Mohr et al. [81] evaluated the use and efficacy of IntelliCare (a skill base app-suit for treating depression and anxiety). The IntelliCare

system consists of 13 clinical apps that deliver different functionality to the user, among others are:

- Helping users identify values that guide life.
- Daily tips to improve one's mood.
- Encouraging users to incorporate worthwhile productive activities.
- Teaches users to manage worry with lessons, distraction and worry management tools.
- Provides a personal map for finding and saving the user's mood-boosting location.
- Prompt users to identify supportive people in their lives.
- Prompt users to create mantras.
- Guides the user through an interactive cognitive restructuring tool to examine thoughts that might be exaggerated negatively.
- Allows the user to send oneself inspirational messages and reassuring statements, written in their own words
- Provides users with a library of audio recordings to relax and unwind.
- Helps the user select exercises to improve mood.
- Prompts the user to complete sleep diaries to track sleep.
- Encourages users to select and schedule positive activities ("boosts") when they notice a drop in mood.

The study suggests that the IntelliCare apps and coaching led to a large reduction in depression and anxiety.

In a different study, Huberty et al. [82] developed "Calm for Cancer" which is a cancer-specific meditation app, designed to guide cancer survivors and healthcare providers in meditation and breathing exercises. The study inquired into the feasibility of "Calm for Cancer" which was successful.

To measure the extent mobile app can be used to manage stress, Yang et al. [83] used the mindfulness app "Happier Healer". The app provides auto-guided mindfulness meditation to users. Participants used the app for 10-20mins daily for meditation and the result was successful and showed a decrease in perceived stress.

Furthermore, Huberty et al. [84] evaluated the efficacy and sustained effect of CALM over 8-weeks of mindfulness meditation. Calm is a consumer-based mindfulness meditation mobile app that offers a range of mindfulness meditation practice guide modules that vary in length, instruction, and content including Vipassana (a technique of mindfulness that explores how the mind influences the body and how the body influences the mind) and Cognitive behavioural therapy (CBT) which showed success in improving users' mental health.

Throuvala et al. [85] employed an online intervention based on cognitive behavioural principles (i.e., self-monitoring, mood tracking, and mindfulness) to reduce distraction and stress among university students. This study evaluated the preliminary efficacy of this platform. The intervention involved active engagement for a period with three smartphone apps serving three different functions: to access the smartphone and social media use. A mindfulness session with an emphasis on eliminating distraction was also conducted, mood tracking, and stress and self-regulation measures were also measured. The result of the intervention showed a reduction in stress levels and fear of Missing Out (FoMo), a positive effect on emotion regulation loss of control measure.

Goyal et al. [86] conducted a study to determine the efficacy of meditation programs to improve stress-related outcomes and have shown no evidence that meditation programs were better than any active treatment. This study reviewed 18,753 citations which included 47 trials with 3,515 participants. In addition to this finding, meditation often takes place in a serene environment, which is not the typical daily environment of the majority world population stressed out and with challenged emotional wellbeing. The design of our intervention (The SmileApp) considered the day-to-day activities of users; hence we incorporated smiling into messages sent by MyTribe members which are in tandem with the user's daily flow of activities. The SmileGram feature helps the user return to a positive mood irrespective of the user's current mood and environment.

2.3.5 Journaling/Mood Tracking

Journaling is a method of data which has been accepted as a valid method of accessing rich qualitative data [87]. There is no clear consensus yet about the best technique for journaling. studies have shown that journaling used as a reflective meditative activity has the potential to promote creativity, self-awareness and personal development [88]. Journaling can be employed in mood tracking, to help users keep track of their mood which has been shown to facilitate reflection

and improve emotional awareness [89]. Mood tracking also helps users learn about their mood patterns and self-manage their mental illness [90]. Researchers have employed Journaling and mood tracking using technology as a strategy to regulate mood and reduce stress, and depression.

Harrer et al. [91] approach to addressing the elevated stress among college students was the use of an app which gave them a journaling feature to track their mood. The study showed that this internet-based mobile intervention was effective, acceptable, and possibly cost-effective in reducing negative consequences associated with college-related stress. This app however has a specialized audience and narrow use case (college students), this will limit the generalization of its use and may probably not be useful to other strata of the stressed population [91].

Moberg et al. [92] validated the effectiveness of a popular commercially available app for the self-management of mild-to-moderate stress, anxiety, and depression called, Pacifica. Pacifica allows users to track their mood by giving them the functionality to rate their mood once per day. The app recommends personalized activities to users based on their mood and users can set a goal towards achieving a better mood. Results showed that Pacifica is effective in reducing self-reported symptoms of depression, anxiety, and stress. This app focuses on tracking mood and recommending activities but it was not very clear how compliance will be measured.

Hetrick et al. [93] aimed to close the gap between guidelines about monitoring and real-world practice by codesigning an app with young people to integrate self-monitoring and support young people in the interval between face-to-face appointments. The app also provides personalized support generated by a back-end algorithm that pops-up in the app which was designed to make monitoring attractive. This app has the potential as a tool to assist both clinicians and young people in managing depression and suicide-related behaviours [93].

Leonard et al. [94] employed a combination of a mobile app and a wearable sensor for emotion regulation in a mHealth technology called “Calm Mom”. The system consists of a wrist-worn sensor band for ambulatory measurement, the wristband alerts the user of increased electro dermal activity (EDA) and gives the user an option to log their feeling. The researchers examined the acceptability, feasibility, use patterns and mechanisms by which a mobile technology used as an adjunct to in-person, provider-delivered sessions fostered adolescent mothers’ adaptive emotion

regulation strategies under real-life conditions. The study showed that Calm Mom technology was effective in regulating the emotions of adolescent mothers in a theoretically meaningful way.

Barker and Rickard [95] investigated the possibility of self-monitoring by investigating the effectiveness of an app called MoodPrism in reducing depression and anxiety symptomatology. The app offers users the functionality to track their moods. The study showed that participants who engaged with the app throughout the study (30 days) experienced a greater decrease in anxiety and depression and an increase in mental wellbeing.

Hides et al. [96] examined the effects of using Music eScape on emotion regulation, distress, and well-being at 1, 2, 3, and 6 months. The Music eScape app analyzes each song in the users' music library according to its level of valence (pleasant to unpleasant) and arousal (very low to very high). The songs are then located in a two-dimensional space consistent with Russell's circumplex model of emotion. Labelled around the borders with 8 emotions (see): aggressive, excited, happy, chilled, peaceful, bored, depressed, and stressed. Once the music scanning is complete, the user is presented with a mood map of their music (the eScape) to help them identify the prevalent moods of their library. The study showed that Music eScape can improve young people's emotion regulation skills however further study is required to determine its efficacy.

To summarize, journaling helps to improve mood and mental wellbeing, however, this does not happen instantaneously. Poor participation, feeling exposed and staying on track are three major setbacks of journaling as a data collection method [87], hence may also impact its effectiveness in improving the mood of users in the wild. In our work, we are interested in a solution that will not expose the user to any form of vulnerability. Hence, we did not consider journaling as a feature. Rather, we created an anonymous supportive community, where users can indicate any kind of emotion that reflects how they feel without leaving too many details about themselves that will leave them vulnerable.

2.3.6 Social Support

The term social support does not have a consensus definition. Authors have held the opinion that a contextualized definition of social support is necessary to give clarity to the study [97]. In the context of this work, we see social support as emotional comfort given to an individual by others to improve their mood and emotional wellbeing. Social support serves as a buffer to poor health caused by stressful living conditions and has been associated with a low rate of several mental and

physical disorders [98]. Several social media platforms have been launched to facilitate social connectedness, a good example is Facebook [99]. Social connectedness can be defined as "an aspect of the self that reflects a subjective awareness of interpersonal closeness with the social world" which has the potential to improve perceived social support [68]. To address loneliness and mental health-related illnesses, researchers have adopted several approaches.

Chung et al. [100] developed and evaluated a user-friendly question-and-answer (Q&A) knowledge database–based chatbot (Dr Joy) for perinatal women's and their partners' obstetric and mental health care. This app was designed to lead users to perceive enjoyment when seeking health information and medical help for their prenatal and postnatal care. With the text-mining technique and implementing contextual usability testing (UT), respectively, the researchers were able to determine whether these medical chatbots can provide male and female users with a good user experience. The outcome of the study showed a potential for the app.

BruechIman-Senecal et al. [101] employed the smartphone app **Nod** to address loneliness among college students. The app was designed to deliver cognitive and behavioural skill-building exercises to reduce loneliness during the transition to college. The **Nod** app incorporates positive psychology and mindfulness-based self-compassion. The app delivers skills via social challenges, and suggested ideas for reaching out to others thereby promoting social connectedness. The App also utilizes reflection, and short in-app exercises that help students process social experiences and reduce self-criticism. It also encouraged students to write testimonials that encourage a growth mindset towards social connection building. The evaluation of NOD showed no significant difference in loneliness after 4 weeks. Our app (SmileApp) explored a different approach to increase feelings of social connectedness. We considered an anonymous supportive community with censored content to positive messages only.

Schlosser et al. [102] tested the efficacy of a new mobile intervention called PRIME (personalized real-time intervention for motivational enhancement), which was designed to improve motivational impairments early in the course of schizophrenia. Prime gives participants access to a supportive environment where they select and document progress on small, self-determined goals in the domains of health/wellness, social relationships, creativity, and productivity. The study demonstrated that PRIME is a feasible, acceptable, and efficacious

intervention for improving mood and motivation in young people with schizophrenia spectrum disorders (SSD) [102].

Shih et al. [103] developed Quokka to evaluate local community-based interventions. Quokka is a web platform for promoting well-being activities on university campuses. The web platform promotes activities relating to socialization, exercise, good deeds, Healthy eating, Journaling, sleep, productivity and mindfulness through a network of friends. The outcome showed that participants reported more local activities than remote activities, users reported more social activities than individual activities, and new rather than familiar activities. This shows that Quokka was successful, however, because it was built on university culture, generalization will be more difficult.

In our study, we took a different approach to promote mood regulation and improve well-being. Unlike other apps presented in this section that require high cognitive load activities (for example learning and reading psycho-education contents), the inconvenient and discomfort of journaling, we considered a process that does not require any form of training. Our approach has the potential to impact the mood of the user instantly. Our app employs smiling and lets users play games with smiles and read messages with their smiles. To the best of our knowledge, this is one of the first attempts to explore the idea of interacting with technology by smiling. We also created an anonymous supportive community with censored content, unlike other community-based solutions where content is not censored.

Chapter 3 : SMILEAPP DESIGN METHODOLOGY

Drawing from the insights gained through an extensive review of existing literature and the identified research gaps, the primary objective of our study was to design, implement and evaluate an effective intervention for mood regulation and the cultivation of positive emotions. In developing this intervention, we relied on the theoretical underpinnings of four well-established psychological constructs: Csikszentmihalyi's flow theory[104], the PSD Model [105], the PERMA model of well-being [106] and the concept of Happiness [107]. These theoretical frameworks provided the conceptual basis for our persuasive system [21]. This chapter offers a comprehensive account of our intervention, including a detailed description of its conceptualization, the processes involved in its implementation, the chosen platform and technology for development, as well as the nature of user interaction within the system.

3.1 Underlying Theories and Models

The analysis of existing apps revealed a predominant emphasis on cognitive behavioural therapy, exercise, and journaling as approaches for addressing stress. In alignment with our objective to explore the role of positive emotion in stress management, the SmileApp was developed by integrating four key psychological theories and models: Csikszentmihalyi's flow theory [104], the concept of Happiness [107], the PERMA model [106], and PSD Model [105]. These theories and models played a crucial role in informing the design of the intervention's features, ensuring a comprehensive approach to promoting positive emotion and addressing stress within SmileApp.

3.1.1 Flow Theory

Csikszentmihalyi [104] proposed the flow theory, which postulates that people find genuine satisfaction during a state of consciousness called “Flow” [104]. This is a state where the individual is completely absorbed in an activity, especially an activity that involves their creative ability. This theory provoked our brainstorming to find a way to immerse users in an activity that engages their minds and creative tendencies. This was the basis for designing the SmileGram feature in our intervention (see Fig. 3.1). The flow theory reinforced the position held by great thinkers of the past that happiness comes from within oneself. This increased our confidence in the quest to provoke happiness that is inherent in people using the SmileApp, allowing them to experience states of flow. We will expand on the details of this SmileApp feature (SmileGram) in the design section.

The concept of happiness can be subjective, but according to the Flow theory, the concept of happiness can be narrowed to seven habits (Relationship, Act of Kindness, Physical Exercise and Well-being, Flow, Spiritual engagement and meaning, Strength and value, and positive mindset) [107]. We incorporated these concepts to foster happiness in users of SmileApp by implementing features that promote these underlying habits. The MyTribe feature (Fig. 3.3) gives users a sense of relationship, encourages acts of kindness, and invokes immersion and a positive mindset. The PocketBuddy feature (Fig. 3.2) also gives a sense of companionship to users.

3.1.2 PERMA Model

The PERMA model describes self-actualization and outlines the characteristics of a flourishing individual and well-being theory (WBT) [106]. The concept of well-being according to this theory involves Positive emotion, Engagement, Relationships, Meaning and accomplishment.

To promote positive emotions within our system, we devised several key features in SmileApp. The SmileGram feature (Fig. 3.4) was designed to actively engage users in maintaining a smile for a brief period. It incorporates two images, one animated (floating/moving) and the other static. Users are encouraged to navigate the moving object until it precisely overlaps with the static object, using their smile as the controlling mechanism. This interactive element fosters user engagement and keeps them actively involved with the system as they try to align the two SmileGram objects by controlling the intensity of their smile (which controls the speed of the moving object).

The MyTribe feature was implemented to foster a sense of community and support among users. It establishes a community comprising anonymous individuals who provide support to one another. This sense of belongingness enhances the users' emotional well-being, as they receive supportive messages from community members during times when they experience negative emotions.

Furthermore, the SmileGram feature incorporates goal setting to instil a sense of accomplishment in users. Drawing upon the principles outlined in the PERMA model, which emphasizes achievement, mastery, and competence, users are challenged to paint the entire world green by aligning the on-screen objects with their smiles for as long as they desire. Additionally, intermittent "fun facts" about smiles and a dialogue box prompting users to continue their progress further contribute to the sense of accomplishment and engagement within the feature.

3.1.3 PSD model

To enhance the persuasive nature of our intervention in assisting users with emotion regulation, we incorporated commonly used persuasive strategies Reminders, Tunnelling, Praise, Self-Monitoring, Goal Setting and rewards [32], [108], [109]. These strategies were adopted from the PSD model developed by Oinas-Kukkonen in 2009[32].

To motivate users, we emphasized the impact of SmileApp and its potential benefits in regulating emotions. Additionally, during the gameplay of SmileGram, we employed a pop-up feature that presented users with interesting facts about the advantages of smiling (Fig. 3.10). This reinforcement further enhanced users' motivation to participate in the activity. We also ensured that the gameplay was designed to be simple and easy to use. By requiring only a smile to participate, we eliminated the need for extensive effort or specific skills. This simplicity increased the users' ability to act, allowing a broader range of individuals to engage with the app effectively.

Furthermore, we strategically utilized smiles as a means to unlock messages received by the user. This served as a trigger to encourage users to smile, as it aligned with the desired behaviour and provided additional motivation to engage with the app and its features.

3.2 Intervention Design and Implementation

In this section, we provide a comprehensive overview of the development process of SmileApp, starting from the initial conceptualization to the final implementation. We delve into the design choices, technologies utilized, the iterative refinement approach, and the key features of the completed application. Additionally, we will provide a detailed account of the app's usage and functionality.

3.2.1 SmileApp Design Considerations

When designing SmileApp, several considerations were taken into account to ensure optimal performance and a user-friendly experience. The choice of platform for intervention distribution was carefully deliberated, with options including web, mobile, or utilizing existing social media apps such as Facebook, Twitter, Telegram, or WhatsApp. Drawing from the insights gained through the literature review, it was observed that the majority of reviewed papers (85%) deployed their interventions on mobile devices. This aligns with the widespread adoption of mobile technology for mental health interventions, supported by studies that have shown the effectiveness of smartphone apps in this domain [40][110][111][112]. Furthermore, mobile platforms provide

the advantage of ubiquitous accessibility, enabling personalized notifications and reminders to users.

In terms of colour considerations, the selection of the dominant colour in SmileApp was driven by the objective of evoking positive emotions. Green was chosen based on research indicating that it predominantly elicits positive emotions such as relaxation and comfort, as it symbolizes nature [107]. Ensuring ease of use was another key design goal, as it has been identified as a crucial factor influencing users' decision to engage and continue engaging with mobile apps according to the study conducted by Chang et al. [113].

To guide the design process, to enhance the usability and usefulness of the app, HCI researchers were engaged in the evaluation process. Their expertise and insights were sought to assess the app's design and functionality, leading to valuable recommendations and improvements. This approach facilitated the creation of a system that aligns with their needs, preferences, and contextual factors. As a reflection of our commitment to developing a useful and functional app, I conducted a pilot study among HCI researchers. This pilot study aimed to assess the usability of the initial design of SmileApp and gather valuable feedback for further improvements.

For the pilot study, seven HCI researchers were recruited to use the beta version of SmileApp for three days. After three days, they completed the system usability questionnaire (SUS) to assess the system's usability and participated in an interview session to provide additional insights through open-ended questions. The qualitative data from the pilot study was thematically analyzed while a one-sample t-test was conducted on the SUS data. feedback and recommendations gathered from the pilot study were instrumental in refining the three main features of the app. In the subsequent sections, we provide detailed descriptions of the implementation and design aspects of SmileApp.

3.2.2 SmileApp Development Tools

This section provides an overview of the development process that transformed the initial concept of SmileApp, based on the aforementioned models, into a fully functional and user-enjoyable mobile application. To implement the front-end of SmileApp, we utilized the Dart programming language [35] and the Flutter framework [114]. The choice of Flutter was driven by the desire to have a single code base that could cater to both Android and iOS platforms, which are the most widely used smartphone operating systems at the time of this study [115]. By leveraging Flutter,

we could streamline the development process and ensure a consistent user experience across different devices.

For the backend development of SmileApp, we employed the Java programming language [116] and the Spring Boot framework [117]. Java is a well-established and robust object-oriented programming language that offers a rich set of APIs, making it ideal for developing efficient software systems [116]. The Spring Boot framework provided a comprehensive set of tools and libraries to support the backend development process. To code the backend and front-end, we utilized the IntelliJ integrated development environment (IDE) and Android Studio, respectively. IntelliJ is a widely used smart Java development IDE by JetBrains, well-regarded in the software industry [118], and offers excellent support for Spring Boot. Android Studio, on the other hand, is the official IDE for Android application development [119] and offers robust support for cross-platform frameworks like Flutter.

By leveraging these technologies and development tools, we were able to create a fully functional mobile app that delivers the SmileApp experience to users. The integration of Dart, Flutter, Java, and Spring Boot facilitated efficient and effective development, allowing us to bring our vision to life and provide a seamless and enjoyable user experience.

3.3 SmileApp Architecture

In the development of our intervention, we placed a strong emphasis on optimizing the performance of the SmileApp to ensure its use on a wide range of devices, including low-performance devices. This consideration was essential as our target audience spans various regions, from developed nations to developing countries. To address the challenge that users may face in running the app on low-performance devices, we adopted a client-server architecture [120] for the entire system.

In this architecture, we separated most of the computationally intensive processes from the mobile application. The backend application, hosted on AWS Canada [121], was responsible for handling these resource-intensive tasks, while the frontend (mobile app) interacted with the backend through an application programming interface (API) [122]. This separation of responsibilities allowed us to offload the computational burden from the mobile app and leverage the processing power of the backend infrastructure.

To minimize the impact on the user's device and reduce network bandwidth usage, we implemented a local temporary memory within the mobile app. This temporary memory stored data locally on the device and was only sent to the backend after a user stopped using a feature instead of sending data as the user used the feature, thereby reducing frequent API calls. By employing this approach, we not only improved the overall efficiency of the system but also mitigated potential bandwidth constraints. The high-level system architecture of the SmileApp is depicted in Figure 3.1, illustrating the different components of the entire system and their interactions:

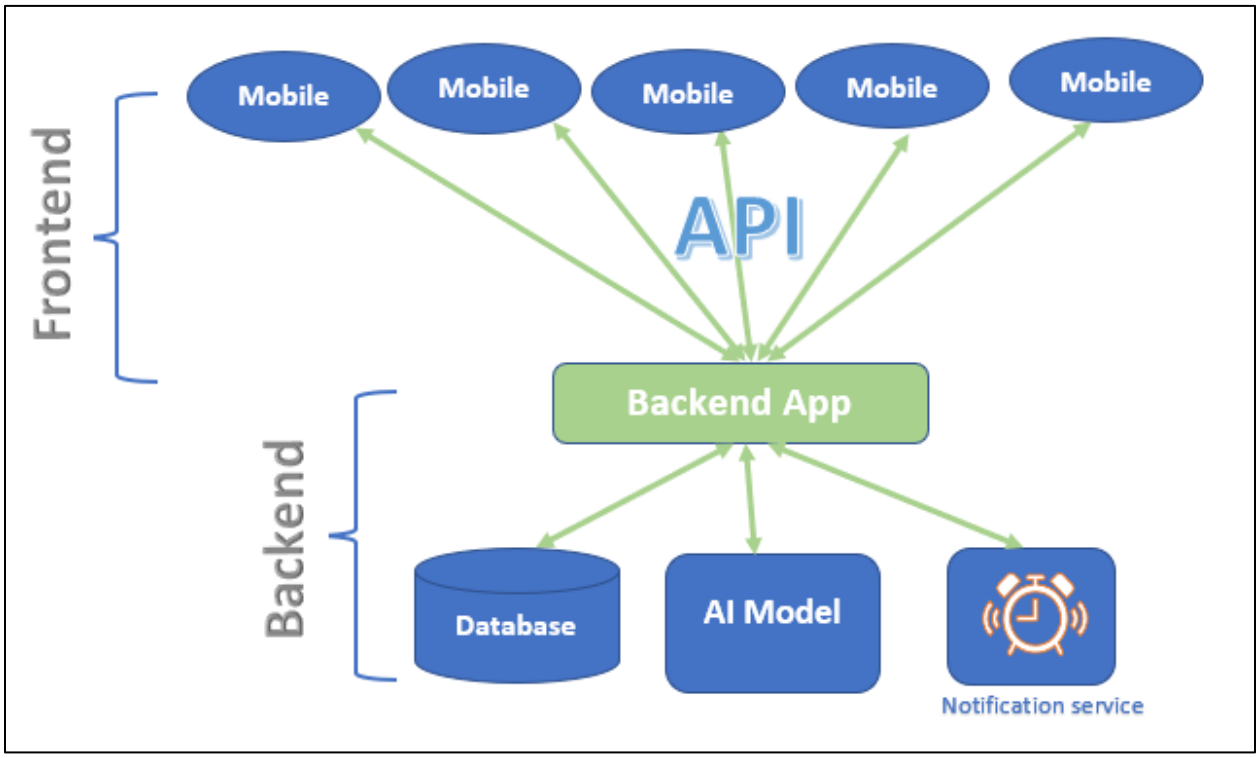


Figure 3.1 High-level System Architecture of SmileApp Showing the Mobile App and Backend Interaction.

3.3.1 Backend Architecture

The backend of the SmileApp is a Java application built on the Springboot framework [117]. The backend architecture is broken into smaller services where each service is responsible for a single task. In the backend, three core components make up the backend of this system.

1. The Database
2. The Notification Service

3. AI Model

The Database: We used a relational database MySQL to store user data. The choice of a relational database was necessary due to its efficiency in storing structured data [123]. The data we were expecting are structured hence the MySQL was a good fit, we managed interaction and database query using the Object Relational Mapping tool hibernate [124].

The Notification Service: This component implemented a push notification on the system using Firebase. The push notification functionality helps deliver asynchronous messages to users.

The AI model: Our intervention has a conversational AI feature that interacts with a user as a friend. This is to create a form of companionship in pursuance of our goal to improve the user's mood and reduce feelings of loneliness and boredom. To achieve this, we trained a machine learning model to generate conversational-like text. We employed an open-source OpenAI GPT and GPT 2 Transformer learning model [125] which allows us to retrain the model using a different dataset that best suits our intervention target. The data we used in training the model is secondary data from 25k empathic conversations based on emotional situations [126]. After training the model with this dataset and testing it, it generated comprehensive responses, however, it could not hold broad discussions as users may want to discuss everyday activities other than emotional content as a way to companionship and distract themselves from their stress. To resolve this and provide a chatbot that users could have a broader conversation with, we explored the option of using ChatGPT API which is more robust in conversation and trained with very large datasets and parameters.

ChatGPT is an AI chatbot published by Open Artificial Intelligence (OpenAI) in November 2022. This bot was built on generative Pre-trained Transformer (GPT) architecture [127]. To ensure the sentiment of the generated text by the AI, the tone transformation prompt technique was employed to influence the AI's output towards positive sentiments that align with users' comments. Additionally, the feedback from the AI model was tested using Dart-sentiment [34] to validate that it consistently generates positive feedback. This approach aimed to maintain a sentimentally positive tone in all text generated by the AI and enhance the user experience. To the best of our

knowledge, we are the first to use ChatGPT as a companionship tool for developing a tool that helps users regulate their emotions.

3.3.2 Frontend Architecture

The front-end architecture of the SmileApp consists of four key components that collectively drive the application's features and functionality: (1) the API call module, (2) the Statement management module, (3) the popup messages, and (4) the user interface (UI) display components.

1. The API call module facilitates the interaction between the front-end and the back-end of the system. It enables the app to save data to the remote database and retrieve the most up-to-date information by making asynchronous API calls. By employing asynchronous calls, the app's efficiency is improved, and users' activities are not obstructed while waiting for server responses because they run in the background. This approach enhances usability and compensates for potential delays in data transfer over the Internet.
2. The statement management module handles the application's data during usage. It caches data locally, minimizing the frequency of database calls, and facilitates the seamless transition of data between different screens. This module interacts with both the API module (for fetching data from the backend) and the UI module (for displaying data to users). To implement this module, we utilized the built-in state management system in Flutter, specifically the Value-Notifier because it has a performance advantage over third-party state-management solutions since it is native to Flutter [128].
3. The UI component comprises various Flutter Widgets responsible for displaying content to users and enabling their interaction with SmileApp. This includes tables, lists, buttons, text boxes, and containers. The UI widgets refresh dynamically whenever there are changes in the data content, and this process is managed by the Value-Notifiers.
4. The popup module consists of alerts that guide users on appropriate actions or provide warnings regarding incorrect actions. We also utilize pop-up mechanisms to encourage users as they progress in using the app and achieve points or milestones.

By incorporating these four components (as shown in Figure 3.2) into the front-end architecture, we ensure a cohesive and user-friendly experience for SmileApp users, facilitating seamless data

interaction, efficient API communication, and effective display of information through the user interface.

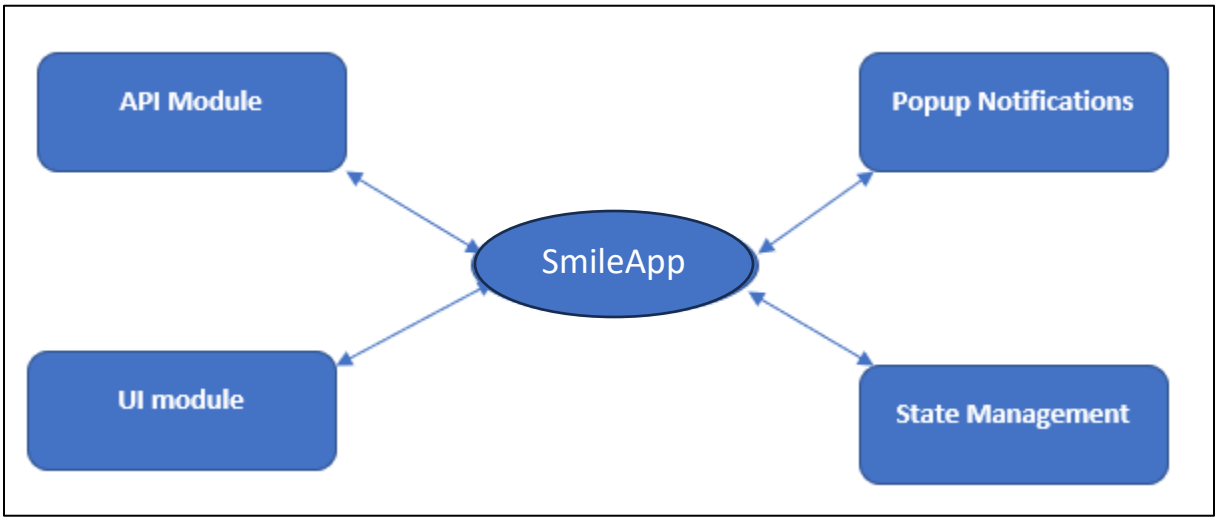


Figure 3.2 SmileApp Frontend Modules.

3.4 Deconstructing the SmileApp Functionalities

The SmileApp encompasses a comprehensive set of emotion regulation functionalities, primarily consisting of three main features that align with the theoretical frameworks discussed in section 3.1, which formed the basis of our design. Additionally, we incorporated specific functionalities to enhance the usability and efficiency of the system. Every component of the SmileApp was meticulously designed to foster mental well-being and alleviate stress.

In this section, we delve into the different components and features of the SmileApp, shedding light on the purpose behind each feature and its intended impact. By exploring these aspects, we aim to provide a comprehensive understanding of how SmileApp effectively promotes emotional well-being.

This section is subdivided into three to describe each specific aspect of the SmileApp we are highlighting. These subsections include:

1. The SmileApp Features: In this section, we will provide a detailed overview of each feature incorporated into SmileApp. We will delve into the functionality and purpose of each feature, highlighting how they contribute to the overall user experience and emotional well-being enhancement.

2. The Persuasive Strategy: This section will focus on discussing the various persuasive strategies employed in SmileApp. We will explore the underlying principles and techniques utilized to motivate users and facilitate behaviour change. By examining the persuasive strategies implemented, we aim to shed light on the mechanisms through which SmileApp effectively encourages users to regulate their emotions and cultivate positive well-being.

Figure 3.3 will provide a visual representation of the home screen, presenting the three main features of the SmileApp. When each of the features is clicked, a brief description of its function pops up to guide the user.

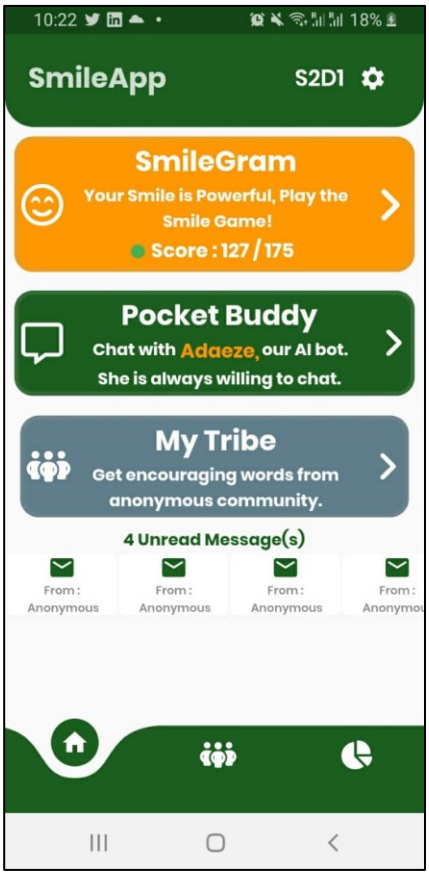


Figure 3.3 SmileApp Home Screen

3.4.1 SmileApp Persuasive Strategies

In the SmileApp design, we employed persuasive strategies that are commonly used in various persuasive health apps. These persuasive strategies were adopted from Oinas-Kukkonen's persuasive system design (PSD)model [105]. In this section, we highlight the persuasive strategies implemented in SmileApp. We implemented 8 persuasive strategies in the SmileAPP as shown in Table 3.1.

Table 3.1: Persuasive strategies employed in SmileApp.

Strategy	Description	Implementation
Reminder	The system reminds users to partake in actions that will further achieve a target behaviour.	Notifications and voice Prompt to remind players to keep smiling.
Tunnelling	Guides users' attitude or behaviour to achieve a set target by providing means to action.	The SmileGram Game
Praise	Provides user feedback based on behaviour	Smile Fun-fact Popup with a congratulatory message
Self-Monitoring	Provides user means to track performance and status, thereby giving a user a clear view of achievement per time.	Your Smile Map
Social Comparison	Provide means to compare the performance of users to other users.	Top Smilers
Rewards	Provides virtual rewards to users to give credit to achievement in performing a target behaviour.	Points Gained from Painting Countries
Goal Setting	This gives users things to work towards, a target to meet and surpass which keeps them motivated	Target countries to Paint
Social Role	Give users a sense of responsibility and value knowing they are contributing to others	Responding to Community members' emotional request

3.4.2 SmileApp Features

3.4.2.1 The SmileGram feature.

In this feature, we implemented a gaming activity that was aimed to completely immerse the user and absorb in a mental activity which according to the flow theory creates genuine satisfaction [104]. Studies have shown that a smile helps the body to release neuropeptides which fight off stress [27]. As the overall purpose of our intervention is to elicit positive moods, we used this feature to persuade users to smile to fight off stress and improve users' moods which will lead to positive emotions. According to the PREMA model [106], positive emotion is more than just "happiness" alone, it includes interest and pride. According to Conner et al., one can build positive emotions by doing creative activities they enjoy [129]. Behind this background, we designed the SmileGram with gaming elements to captivate users' interest and give them pride in accomplishing goals with their smiles compared to other users in the system. The core of this feature is to motivate a user to smile, irrespective of the situation around them at the moment (see Figure 3.4).

Figure 3.4 The SmileGram Feature: Letters A-G represent components of this feature.

A – Sound Control, B – Countdown timer, C – Country Name, D – Country Count, E – Moving icons, F – the map (completed and incomplete portion), G – Camera preview.

The SmileGram feature (Figure 3.4) of the SmileApp presents users with a mission to transform the world from grey to green through the power of the user's smile as an innovative way to give the user target goal in line with the persuasive system design model. The feature encompasses a map that initially appears in grey, representing 175 countries (F). The user's objective is to paint the entire map green by aligning two icons (E) with their smile. Each time the icons overlap perfectly with a specific country, indicated by the country name appearing (C), that country will be painted green.

To accomplish this task, users must maintain a smile until the two icons overlap. Precision is crucial, as the user needs to promptly pause their smile once the icons align, preventing them

from moving past each other. To track the user's smile, the SmileGram feature utilizes the Google ML kit (Flutter package) [130] The ML Kit has high accuracy which has been likened to that of humans [131] this technology detects the user's smile and ensures that they actively participate in the feature. If the smile is not detected for 3 seconds, a voice note is played, reminding the user to "Keep smiling." Users have the option to mute this sound by using the A button. Additionally, a countdown timer (B) is implemented to provide users with an indication of the time required to align the moving icons, adding a sense of challenge and urgency to the experience to give users a sense of accomplishment in line with the PERMA model.

3.4.2.2 PocketBuddy feature.

Pocket Buddy is a conversational chatbot with the persona of a friend called Adaeze, who interacts with users as a friend would have, to keep them company. Chatbot as defined by Shevat is a kind of interface [132] which stands between the abstract computing process of the computer and the user. The use of chatbots is gradually appearing in the area of mental health as an intervention tool to administer mental health solutions [132].

Studies have shown the efficacy and feasibility of using an AI chatbot to address mental health-related issues. For example, Fulmer et al. [133] evaluated the efficacy of integrative psychological AI (Tess) for therapy and mindfulness thereby reducing self-identified symptoms of depression and anxiety in college students [133]. The results of the study showed that AI can serve as a cost-effective and accessible therapeutic agent. Similarly, Fitzpatrick et al. [134] employed an automated conversational agent (Woebot) to deliver a self-help program for college students who self-identify as having symptoms of anxiety and depression [134], the result from the study validates the feasibility and effectiveness of conversational agents to deliver CBT. Although chatbots have been used for several purposes like customer service inquiry, here we implemented the conversational agent as a companion. Hence, the name “PocketBuddy”, is like giving users a “friend” to converse with. Unlike other chatbot implementations that focused on delivering information, we used a chatbot to deliver a sense of companionship to users. The chatbot can engage in any type of discussion on any topic making it a worthy companion. Companionship has been shown to improve mood [135], hence we incorporated a conversational AI agent that will serve as a companion to users.

Figure 3.5 Pocket Buddy

There are no keywords required to initiate a conversation between the user and the chatbot. To interact with the chatbot, the user clicks on the feature and can start any form of conversation with a key phrase or anything as shown in Figure 3.5.

3.4.2.3 myTribe Feature.

This is a community of users who share supportive messages anonymously. This feature was designed to build a sense of support, connectedness, and relationship amongst users as it is a reflection of flourishing well-being according to the PERMA model. In the study conducted by Alqahtani et al. [136], a comprehensive investigation was undertaken to discern the essential functionalities required for the development of a next-generation mHealth system. The researchers gathered insights by surveying self-diagnosed patients grappling with mental health concerns, aiming to capture their opinions, perceptions, preferences, and experiences. The results of this survey indicated that anonymous communication within a social community emerged as one of the favoured choices among the participants. Anonymity removes bias and fear of judgment, allowing users to freely express how they feel. The myTribe feature is aimed at building a community where everyone feels loved, supported and valued; this is what the PERMA model

refers to as a relationship[106]. We keep every interaction in the community safe, supportive, and empathic by censoring every message shared by users. We achieved this by using Dart sentiment 0.0.9, an AFINN-based sentiment analysis for the Dart programming language[34] as the first point of the check. When the Dart sentiment flags the content of the message as positive, the system will allow the user to send it. Upon the user's message submission, an additional layer of verification is implemented, wherein the research team carefully reviews the content to ensure its positivity and supportiveness. This serves as an extra step in the approval process before the message is deemed appropriate for delivery. Once approved by the research team, the message is then transmitted to the intended user. The myTribe feature is aimed at increasing connectedness which is associated with low stress[137].

This feature is initiated by a user selecting an emotion that closely relates to how they feel from the emotion palate (see Figure 3.7) adapted from Ekman et al.'s six basic emotions ("Not Happy", Surprised, Fearful, Sad, Angry, and Disgusted) [138]. When the user clicks on the "submit" button, the app notifies all users about the emotion of the user. The notification generated by the system to inform other users of the user's emotion is subjected to a persuasive rephrasing process aimed at increasing its impact on users. For instance, when a user indicates their emotional state as "Not Happy" within the SmileApp, the system encapsulates this information in an alert message that reads, "An individual is currently experiencing unhappiness. Would you be willing to offer words of kindness and encouragement by replying?" The intention behind such formulation is to motivate users to actively engage in supporting and uplifting others through their responses in the MyTribe feature. When other users receive the alert, they will compose a supportive and empathetic message for this user. If the message is not positive the app will alert the user to edit it or else, it will not be sent. As recommended by the ethics committee, a second layer of verification by the research team was implemented by checking the message to ensure that it is positive and approving the message before it is delivered to the proposed recipient. When the user receives an empathic message from other community members, they can only unlock the message with a smile by clicking on the envelope icon that appears and wait for the 5-second countdown then smile to the camera.

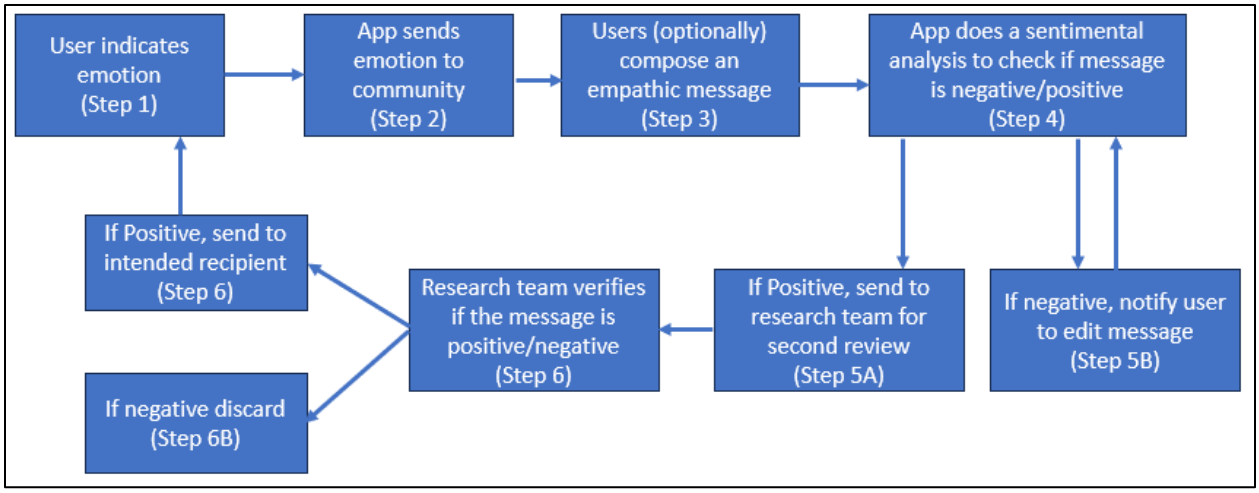


Figure 3.6 MyTribe Feature logic flow diagram.

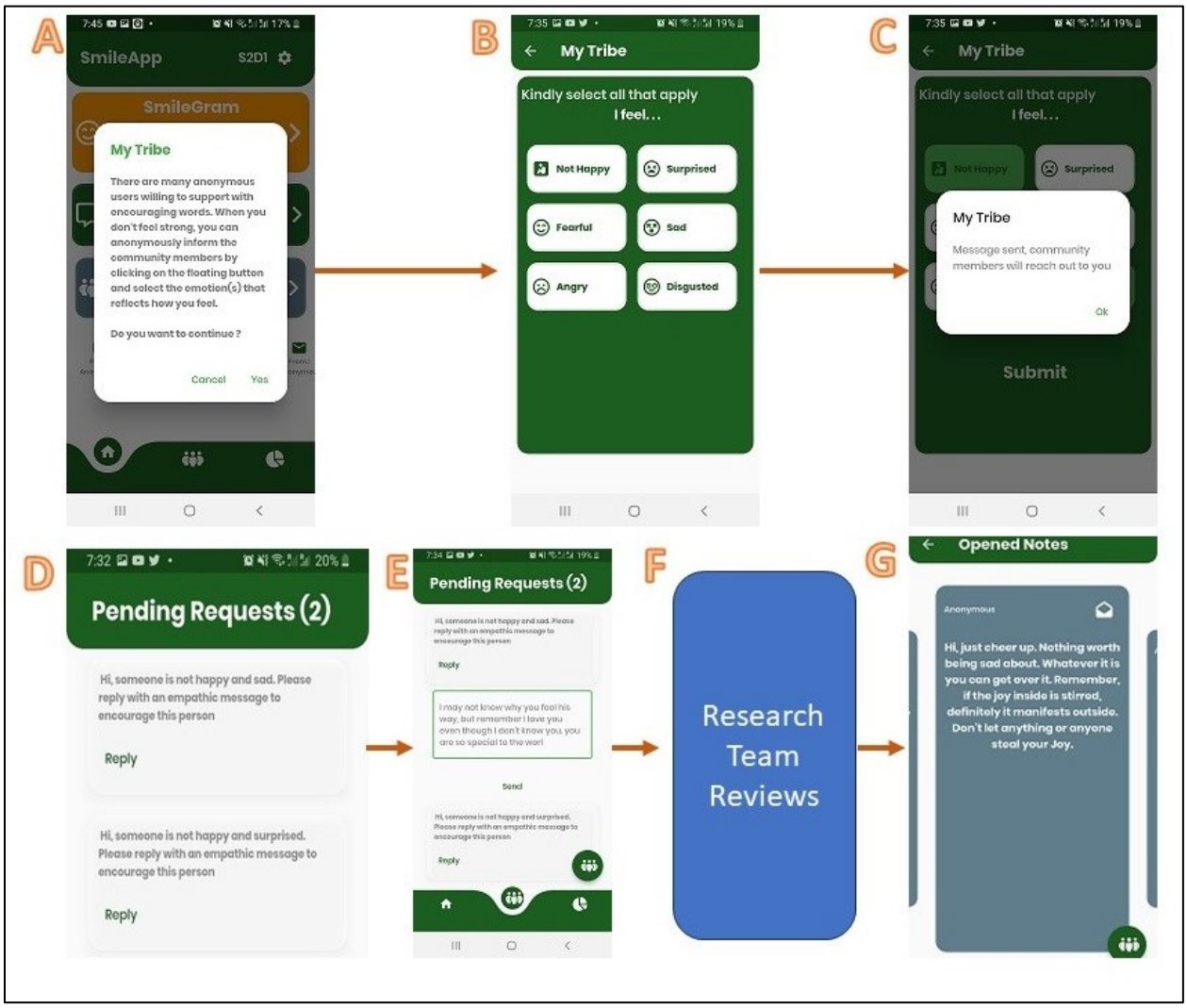


Figure 3.7 MyTribe Feature Screenshots: Letters A-G represent each step in this feature.

A – The user clicks to share emotions, and SmileApp pops up a summary of how the feature works.

B – List of emotions from where the user selects one or more emotion(s) closest to how they feel.

C – SmileApp informs the user to expect messages shortly from other users.

D – Logs of yet to be responded emotion broadcast from users who share their emotions.

E – Recipient replies to the message (Dart-sentiment, analyzes the message at this point before allowing this user to send this reply).

F – The research team reverifies the message as a second layer of check to ensure the user's emotion safety.

G – When it is delivered and read by users, it is logged.

3.4.2.4 Top Smilers

The SmileApp includes a leaderboard feature (Figure 3.8) that provides users with insights into their performance relative to other users as a social comparison in line with the persuasive system design model. The leaderboard displays users' rankings based on the number of countries they have successfully painted green using the SmileGram feature. This ranking is dynamically updated each time a user achieves a new score, this is in line with a social comparison of persuasive system design model.

The ranking process occurs at the backend of the system, where an array of users is sorted in descending order based on the number of countries they have painted green with their smiles. This sorted array is then sent to the front-end, where it is presented to the user as a leaderboard. By providing this ranking system, users can compare their performance with others and derive a sense of achievement and progress within the SmileApp community.

Figure 3.8 Leaderboard

3.4.2.5 Your Smile Map

This feature shows the user their performance in the app (Figure 3.9). Every country the user paints is displayed on this page with the pending countries painted grey. This will help users to keep track of the number of countries they have painted green and how many are left.

Figure 3.9 SmileMap

3.4.2.6 Reminder

This feature reminds users of pending tasks and encourages users to play the SmileGram game intermittently. The reminder notifies users when someone in the community needs supportive words and when the users receive supportive words from other users they are also reminded.

3.4.1.7 Smile Fun-Facts

The SmileApp incorporates a pop-up feature that complements the SmileGram functionality. This pop-up feature triggers when a user successfully aligns the icons and paints three countries at once, which occurs every three instances of alignment. The pop-up provides additional engagement and motivational elements to enhance the user experience.

Once activated, the pop-up feature not only acknowledges the user's achievement but also presents interesting and enjoyable smile-related facts. These fun facts serve as a form of encouragement and reinforcement, motivating the user to continue using the app and engaging with the SmileGram

feature. By integrating this feature, SmileApp aims to create a positive and rewarding user experience that promotes sustained usage and interaction with the app.

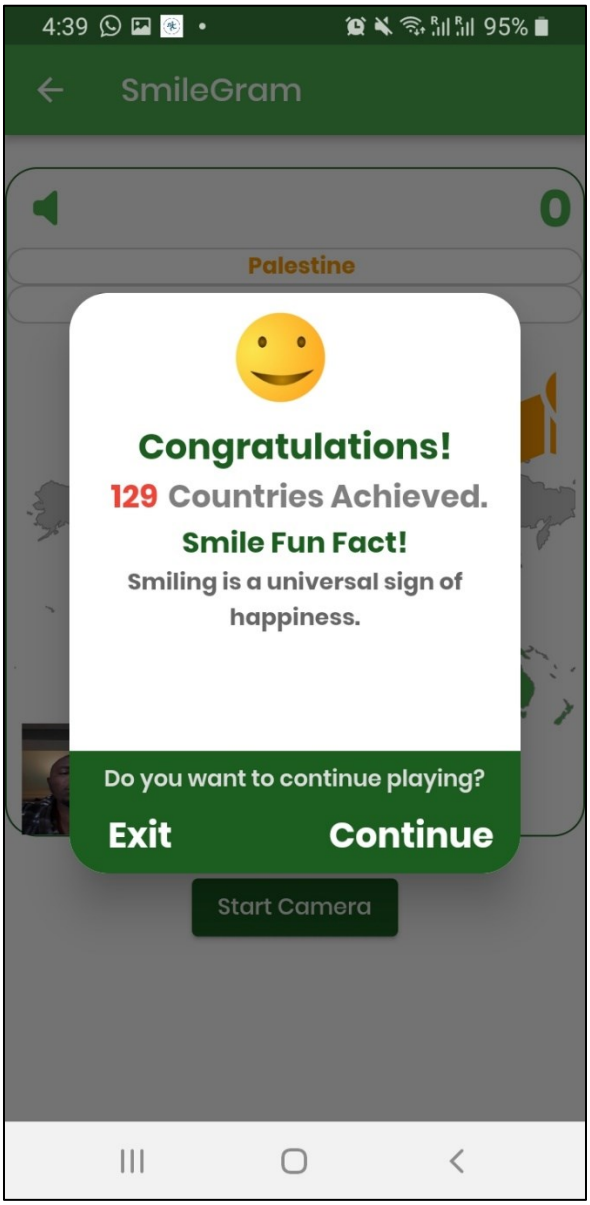


Figure 3.10 Smile Fun-Facts

Chapter 4 : SMILEAPP EVALUATION

To assess the effectiveness and usability of SmileApp in achieving its intended objectives, a comprehensive evaluation was carried out through a combination of quantitative and qualitative research methods. This evaluation aimed to gather valuable insights and data to address the research questions outlined in Section 4.3, which guided the trajectory of our study.

The evaluation process involved administering pre- and post-questionnaires to participants, allowing for the collection of qualitative feedback and perceptions regarding the app's impact on their emotional well-being. Additionally, quantitative data gathered from the app itself supplemented the quantitative responses from the questionnaires, providing a more comprehensive understanding of the participants' engagement and progress.

By employing this mixed-methods approach, we sought to capture both the participants' experiences and their measurable outcomes, enabling us to gain a holistic perspective on the effectiveness of SmileApp in achieving its intended goals. The findings from this evaluation will contribute valuable insights to inform future improvements and enhancements to the app's functionality and user experience.

4.1 Materials and Procedures

The core of our intervention is a smartphone app (the SmileApp) described in section 3.4. There were two phases to the SmileApp evaluation, the first was the pilot study followed by the main study.

4.1.1 The Pilot Study

To assess the usability of the SmileApp and gather initial feedback for further refinement, a pilot study was conducted involving a group of seven experts in the field of human-computer interaction (HCI). These experts, who are researchers from the Persuasive Computing Lab at Dalhousie University, possess a strong background in smartphone app development and extensive knowledge in the area of HCI.

During the pilot study, the selected experts were given access to the SmileApp and instructed to use it for 3 days. This allowed them sufficient time to explore the app's features and functionalities. Following the usage period, the experts provided valuable feedback using the system usability

scale (SUS) on the app's usability and made recommendations for improvement based on their experience.

To evaluate the usability of the app, the experts were asked to complete a post-study questionnaire that included statements adapted from the System Usability Scale (SUS) [139]. The SUS is a widely recognized and validated instrument for assessing the usability of software systems. By utilizing this questionnaire, we aimed to gather quantitative data on the experts' perception of the app's usability (see Figure 4.1) and identify areas that required further attention and enhancement.

The feedback received from the pilot study played a crucial role in refining and finalizing the development of SmileApp for the subsequent main study. The insights and recommendations provided by the experts helped to address any identified usability issues and ensure that the app was optimized for a wider audience in the main study.

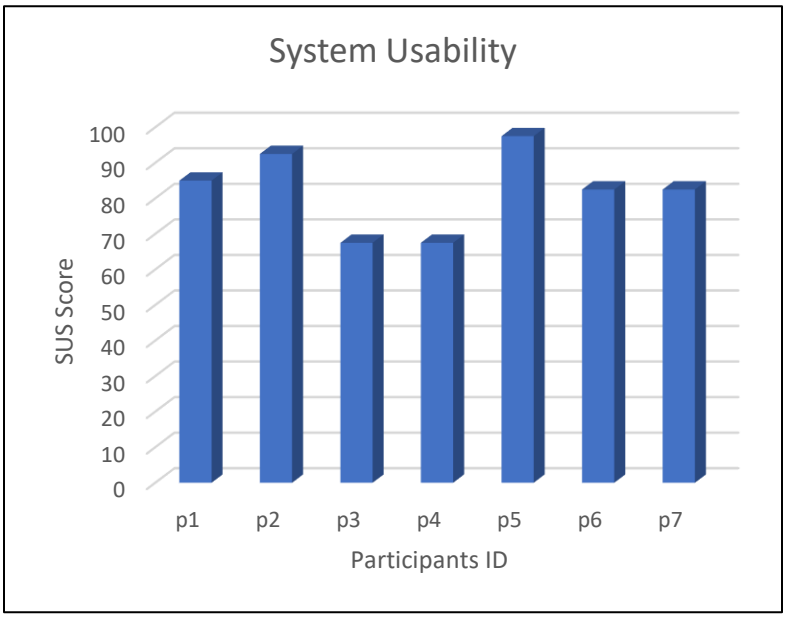


Figure 4.1 Pilot study SUS score. (M = 82.1, SD = 10.6)

The SUS revealed an average score of 82.5 (SD = 10.6) which indicates the overall usability of SmileApp is "excellent"[140]. Participants saw the concept of SmileApp to be unique. For example, one expert commented "*The concept of the app is nice and unique*" [P5]. We also received some recommendations for improving the app which we implemented before the main

study. Below is a list of the recommendations selected through thematic analysis from the pilot study interview which we found helpful and implemented to improve the app.

- To make the SmileGram less boring, a pop-up message can be presented after a few countries are painted.
- Reduce the number of reminder notifications.
- The keep smiling voice prompt in SmileGram is too repetitive. Reduce it.
- Display the total points on the homepage.

To implement the pilot study recommendations, we added the praise pop-up on the SmileGram and reduced the "keep smiling" voice prompt on the SmileApp to every 3 seconds. We also reduced notification to users from hourly to twice a day and added the total points achieved by a user on the home screen in line with the recommendation.

4.1.2 The Main Study

After improving the SmileApp based on the feedback received from the pilot study, we proceeded to the main study which involved a random recruitment of 101 participants who met the eligibility criteria (Age > 18, Proficiency in English Language, Having access to Smart Phone, and Have internet access) to use the app for 14 days [141]–[144]. This part of the study aims to investigate the effectiveness of SmileApp, this process involved:

- Participant recruitment
- Participants screening
- Pre-study questionnaire: Online
- App use: User's natural environment (e.g., at home)
- Post-study questionnaire (online)
- An optional interview session: Online (Conducted and recorded via Microsoft Teams)

4.2 Participant Recruitment

To recruit participants for our study, we employed various methods including social media campaigns on platforms like Twitter and LinkedIn, as well as email notices. We also encouraged individuals within our network, including friends and social media followers, to share the recruitment notice about our study and the invitation for participants. Through these recruitment efforts, we received significant interest from approximately 175 individuals.

To ensure that the recruited participants met the necessary criteria, we implemented a screening process. Initially, 74 individuals were deemed ineligible during the screening due to not meeting the specific requirements. However, 101 participants successfully passed the screening and met all the necessary qualifications, subsequently joining the study.

To participate in the study, prospective participants were directed to a screening questionnaire (Appendix P) to verify their eligibility. The screening questionnaire assessed criteria such as age (18 years or above), proficiency in the English language, possession of a smartphone, and internet access. If the prospective participant met all the required criteria and clicked the "NEXT" button, they were presented with the consent form (Appendix B).

For those who did not meet the criteria, upon clicking the "Next" button, a message was displayed informing them that they were not eligible to participate in the study. The message expressed appreciation for their interest while explaining that their exclusion was due to not meeting all the requirements.

The eligible participants were presented with the consent form (Appendix B), which provided detailed information regarding their participation in the research. To proceed with the study, participants were required to provide their consent by selecting the "yes" option in response to the "I consent" question. Additionally, participants were requested to provide their email address, which would be used to send them a download link for the SmileApp and their login details, facilitating their involvement in the study.

4.2.1 Participants onboarding

Upon providing their consent to participate in the study, participants proceeded to complete the demographic survey (Appendix: D). This survey collects information about participants' demographic characteristics, allowing for a comprehensive understanding of the study population. However, participants who did not provide consent to the study conditions will not be able to proceed any further, receiving a message indicating that their participation is contingent upon consent to participate.

After completing the demographic questionnaire, participants were directed to fill out a pre-study questionnaire. This questionnaire includes assessments of participants' happiness levels and social connectedness, which are important factors to consider in the context of the study. The pre-study

questionnaire consists of multiple sections, including Appendices E, F, and G, which capture relevant data related to happiness and social connectedness.

Once participants have submitted the pre-study questionnaire, they receive an email containing a download link for the SmileApp and a unique participant ID, such as P012. The participant ID serves as a means for participants to log in to SmileApp and access the app. This process ensures that participants have the necessary tools and information to engage with SmileApp and contribute to the study.

4.2.2 Participants Activities

Once participant receives the link to download the app in their email provided at the beginning of the study, participants will download the *SmileApp* and install it on their smartphone so they can use it for the duration of the study. Once the participant downloads the app, the 14-day period starts counting down and we tracked the usage log. When they log in for the first time, they will see instructions for each of the three features (SmileGram, PocketBuddy, MyTribe) to understand how to use the app (Appendix U). Participants in the study were able to engage with various features of the SmileApp, each serving a specific purpose aligned with the research objectives. These features include:

SmileGram Game: Participants were able to actively participate in the SmileGram game, where their objective was to paint each country green by aligning the smile icons. By successfully aligning the icons, participants contributed to the overall goal of smiling, improving their mood and enhancing emotional well-being.

Empathic and Supportive Messaging: Users had the opportunity to share empathic and supportive messages with other participants through the app. This feature aimed to foster a sense of community and provide emotional support within the SmileApp user base.

Unlocking Supportive Messages: Participants could unlock additional supportive messages from the app by utilizing their smile. This feature encouraged users to engage with the app and further reinforce positive emotions and well-being.

Interaction with the AI Bot: The SmileApp offered participants the ability to interact with an AI bot. This interactive component provided users with a conversational experience, allowing for engagement and potential guidance in their emotional well-being journey.

Performance Tracking and Leaderboard: Participants had access to a scoreboard within the app, which allowed them to track their performance and progress over time. Additionally, the leaderboard provided insight into the performance of other users, fostering a sense of competition and motivation.

On the final day of the study, participants were requested to complete the post-study questionnaire (Appendices: E, F, G, H, I, J, K, L, N). This comprehensive questionnaire aimed to gather valuable feedback and insights regarding participants' experiences with SmileApp, its effectiveness in promoting emotional well-being, and any suggestions for improvement. By collecting this data, we could further evaluate the impact and usability of SmileApp in achieving its intended goals.

Following the completion of the post-study questionnaire, participants were allowed to voluntarily participate in an optional interview. The purpose of this interview was to gather additional insights about SmileApp and obtain potential recommendations for improvement. It is important to note that the interview was entirely voluntary, and participants were free to opt out at any point during the interview if they felt any discomfort or preferred not to continue.

If participants expressed their willingness to be interviewed by selecting "Yes" and clicking "Next," they were presented with the Interview Consent Form (Appendix C). By selecting "Yes" and providing their email address, participants indicated their consent for the interview and expressed their interest in participating. Subsequently, the lead researcher reached out to these participants via email to coordinate a convenient time and date for the interview.

However, if participants chose "No" for the optional interview or did not provide consent, they were thanked for their time and participation in the study without being invited for an interview. It is important to respect participants' preferences and decisions regarding their involvement in the research process.

Only those participants who expressed interest and consented to the optional interview were contacted via email. Their provided email addresses were used as a means of communication for arranging the interview session. It is worth mentioning that participant email addresses were collected solely to coordinate the optional interview and ensure effective communication.

Figure 4.2 provides a visual representation of the flow of activities throughout the study, highlighting the various stages and decision points participants encountered during their engagement with the SmileApp research study.

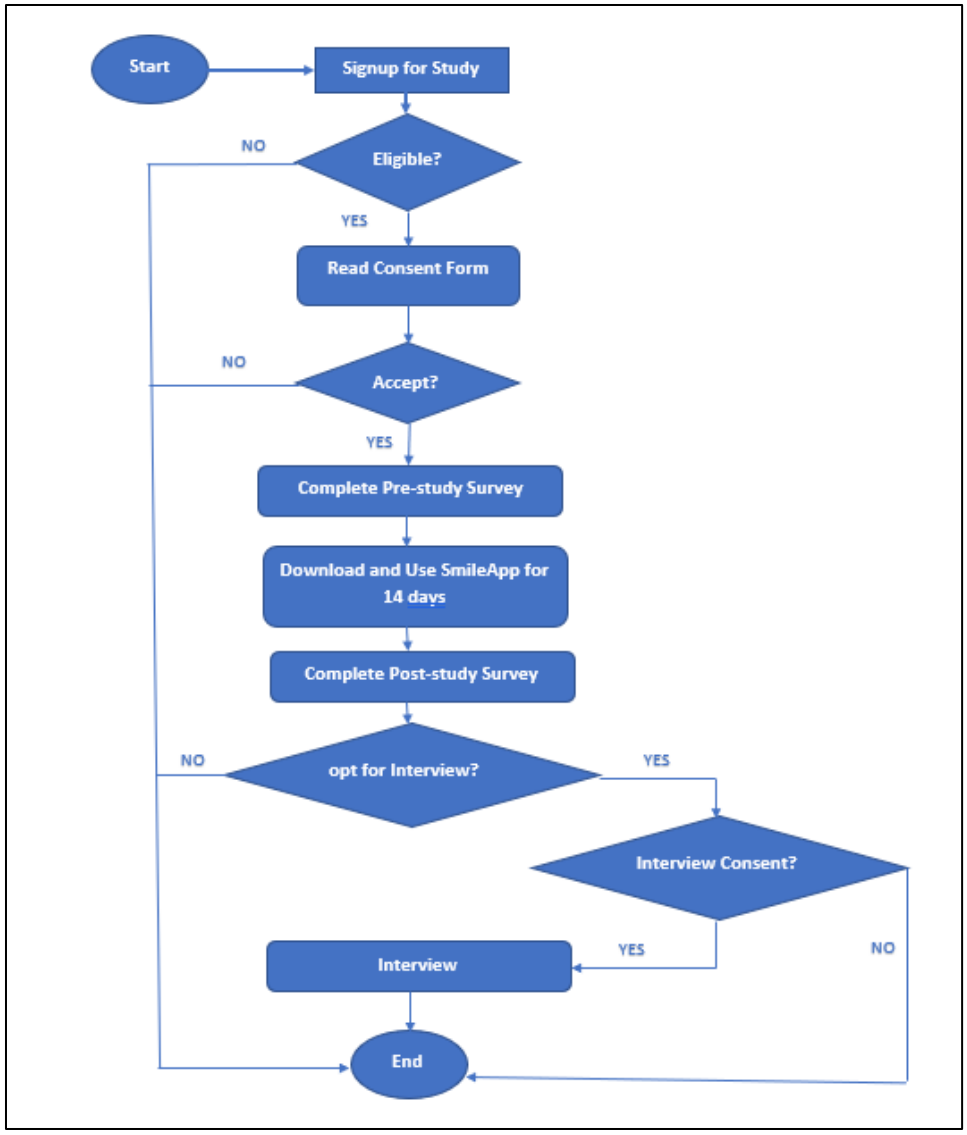


Figure 4.2 Participants' onboarding process.

4.3 Research Questions and Measures

The main purpose of the study is to evaluate to what extent SmileApp can elicit positive moods and regulate user emotions. We developed 5 research questions which guided our study which we aim to answer at the end of this study:

1. How effective is SmileApp for eliciting a positive mood?
2. How engaging and Usable is the SmileApp for users to accomplish their goals of activating positive mood?
3. How effective is SmileApp in helping users find social support?
4. How effective is the Smile App for motivating continued use?
5. How persuasive and useful is SmileApp in improving user's mood?

To address the research questions outlined above, our study employed a range of validated questionnaires commonly used in the field of Human-Computer Interaction (HCI). These questionnaires have been extensively utilized by previous research studies, ensuring their reliability and relevance. The following questionnaires shown in Table 4.1 were employed to gather data and insights.

Table 4.1 Instruments used.

Questionnaires	**Description of Use**	**Appendix**
Demographic Questionnaire	This questionnaire collected participant characteristics such as age, gender and educational background.	Appendix D
Oxford Happiness Scale (OHQ) [145]	This scale was used to assess participants' psychological well-being and measure their level of happiness.	Appendix E
Social Connectedness Scale [146]	The Social Connectedness Scale was employed to evaluate the extent to which participants felt connected to others in their social environment.	Appendix F
Positive and Negative Affect Schedule (PANAS-SF) [147]	This scale measured participants' emotions by assessing their positive and negative affect levels.	Appendix G
User Engagement Scale (UES-SF) [148]	The User Engagement Scale was utilized to gauge participants' level of engagement with SmileApp.	Appendix I

Intrinsic Motivation Inventory (Value/Usefulness subscale) [149]	This inventory assessed participants' intrinsic motivation by examining their perceived value and usefulness of the SmileApp.	Appendix J
Perceived Persuasive Scale	The Perceived Persuasive Scale was used to evaluate participants' perception of the persuasiveness of various features within SmileApp.	Appendix L
Interview Questions Guide	This guide provided a framework for conducting optional interviews with participants to gather further insights and recommendations for improving the app.	Appendix M
Brief Mood Introspection Scale (BMIS) [150]	The BMIS was utilized to capture participants' current mood and introspection during the study.	Appendix N
System Usability Scale (SUS) [139]	The SUS was employed to assess the usability of the SmileApp and gather participants' feedback on its user-friendliness.	Appendix H
Future Intention Questionnaire	This questionnaire captured participants' intentions and interest in continuing to use SmileApp in the future.	Appendix K

By employing these validated scales and questionnaires, we were able to measure various aspects of SmileApp's usability, effectiveness, persuasiveness, and user experience. These measurements provided valuable insights and facilitated the answering of our research questions.

4.3.1 Dependent Variables

Participant Mood: To assess the impact of our intervention on participants' moods, we utilized validated scales to measure their psychological well-being and emotions. The Oxford Happiness Scale (OHQ) and the Brief Mood Introspection Scale (BMIS) (Appendix N) were employed for this purpose.

The Oxford Happiness Scale (OHQ) is designed to evaluate both the cognitive and affective dimensions of happiness. It captures participants' cognitive assessment of their overall well-being and their affective experience, including the presence of positive emotions and the absence of negative emotions. The OHQ has been widely used in previous studies as a reliable measure of happiness [151][152][153][154].

To further understand participants' moods and emotions, we utilized the Positive and Negative Affect Schedule (PANAS-SF). This standardized instrument employs a 5-point Likert scale and has been extensively employed in research to measure both positive and negative affect [155][156].

By employing these measurement tools, we aimed to answer RQ1 (*How effective is the SmileApp for eliciting positive mood?*). These assessments provided us with a baseline measurement of participants' mental well-being before engaging with SmileApp, enabling us to track and evaluate any changes in mood throughout the study.

System Usability, Engagement, and Intention for Future Use: To assess the usability and engagement of SmileApp, we employed validated questionnaires and measurement tools. Usability refers to the quality of the user experience when interacting with a system, and it is crucial to understand how participants perceive the usability of our app.

To measure the perceived usability of the SmileApp, we utilized the System Usability Scale (SUS). The SUS is a widely used questionnaire-based instrument that assesses users' subjective perception of a system's ease of use, efficiency, learnability, and overall user satisfaction. It has been applied in various domains, including software development, website design, and product evaluation [157][158][159].

In addition to usability, we wanted to evaluate the level of user engagement and the likelihood of future app usage. For this purpose, we employed the User Engagement Scale (UES-SF). The UES-SF not only measures usability but also captures aspects such as aesthetic appeal and the feeling of reward during app usage. It has been widely utilized in previous studies to assess user engagement [160][161][162].

Furthermore, we collected data on participants' intentions for future use of the app using the Future Intention questionnaire. This allowed us to investigate **RQ**2 (*How engaging and usable is the SmileApp for users to accomplish their goals of activating positive mood?*). Research suggests that users are more likely to continue using software if they find it useful [163].

To complement the quantitative data, we also conducted interviews with participants using a set of interview questions (Appendix M). These interviews provided an opportunity for participants to elaborate on their thoughts and experiences, offering deeper insights that complemented the quantitative data gathered through the questionnaires.

By employing these measures, we aimed to gain a comprehensive understanding of the usability, engagement, and future intention for app usage, providing valuable insights into the effectiveness of SmileApp in helping users achieve their goals of a positive mood.

Social Connectedness: Loneliness has been associated with negative emotions [164], and in our study, we aimed to explore the social components of the SmileApp that promote connectedness and assess its impact on users' social connectedness. To measure the perceived social connectedness of users, we utilized the Social Connectedness Scale (SCS) (Appendix F). The SCS has been widely employed in previous research to assess users' perceived social connectedness [165][166][167].

By using the SCS, we sought to examine the effectiveness of the SmileApp in helping users find social support, which aligns with **RQ**3 (*How effective was the SmileApp in helping users find social support?*). We hypothesized that participants who initially scored lower on the social connectedness scale would experience an improvement in their SCS scores after engaging with SmileApp.

This measurement was crucial as our intervention aimed to promote positive mood, and understanding the impact of SmileApp on users' social connectedness would provide insights into its effectiveness in fostering social support. By analyzing the data obtained from the SCS, we anticipated observing positive changes in participants' social connectedness scores, indicating the potential of the SmileApp to enhance users' sense of social support.

User experience of the SmileApp: To understand participants' subjective experiences and their motivation to use the SmileApp, we utilized the Intrinsic Motivation Inventory (IMI) (specifically, the usefulness subscale) [145] (see Appendix J) and the Future Intention Scale (FIS) (Appendix K). The FIS is a 5-point Likert scale that measures participants' willingness to use the SmileApp in the future, while the IMI is a 7-point Likert scale that helps us determine the user experience and whether their motivations are intrinsic or not.

By employing these subjective questionnaires, in conjunction with the objective data logged from the SmileApp (such as "frequency of use" and "smile duration"), we aimed to answer **RQ4** *(How effective is the SmileApp for motivating continued use?*). We sought to understand the factors that drive participants' motivation to continue using the app and assess whether SmileApp effectively fosters sustained engagement.

The IMI and FIS questionnaires, along with the objective usage data, provided valuable insights into participants' experience, their perceptions of the app's usefulness, and their intentions to continue using the SmileApp in the future. These measures allowed us to examine the effectiveness of SmileApp in promoting sustained motivation and usage among users.

System Persuasiveness: The term "persuasiveness" is employed to describe the inherent capacity of a system to effectively influence and motivate changes in behaviour [168]. In the context of our research, we were interested in assessing the persuasiveness of the SmileApp and its effectiveness in improving users' moods. This inquiry guided us in answering **RQ5 (***How persuasive and useful is the SmileApp in improving users' mood?*)

To evaluate the persuasiveness of the SmileApp, we collected subjective data using the Perceived Persuasive Scale [169] (see Appendix L). This scale utilizes a 7-point Likert scale to examine users' perceptions of SmileApp's overall persuasiveness, as well as the persuasiveness of its features. By employing this scale, we aimed to gather insights into how users perceive the app's ability to influence their attitudes and behaviours positively. By assessing the perceived persuasiveness of the SmileApp, we gained valuable information on users' perceptions of its persuasive qualities and its effectiveness in improving their mood. This data complemented the objective measurements we collected and contributed to a comprehensive understanding of the app's overall persuasiveness and usefulness in achieving its intended goal of enhancing users' moods.

4.3.2 Data Analysis

In this study, we collected both quantitative and qualitative data to enable us to gain more insight into the impact of the SmileApp and our analysis was thus:

Quantitative Data. For the quantitative data, we conducted a reliability test on all the scales used to confirm we have a good internal consistency with Cronbach's alpha (α) [170]. With a good internal consistency of all our scales, we separated our data into two sets.

The first set was data collected before and after the intervention, Brief Mood Introspection Scale (BMIS), Oxford Happiness Scale (OHQ), Social Connectedness Scale (SCS) and Positive and Negative Affect Schedule (PANAS-SF). We conducted a Shapiro-Wilk normality test on the Pre and Post data which showed that our data was not normally distributed then we used the

Wilcoxon signed-rank test (M= Mean, SD= Standard 83 Deviation, W= Statistics, df = degrees of freedom, p = probability) to match the pairs of pre_study and post_study to see if there was a significant difference.

The second set of data was the data we collected just once after the intervention. We conducted a one-sample t-test on the System Usability Scale (SUS), User Engagement Scale (UES-SF), Intrinsic Motivational Inventory (IMI), Future intention scale (FIS), and Persuasiveness Scale (PS) fall into this category. The one-sample t-test was used to compare whether the ratings were significantly above the midpoint. Lastly, we compared the means of the persuasiveness of each feature of the SmileApp (SmileGram, PocketBuddy, MyTribe) and compared each of the features across demographic variables Age, Gender and Education status using Repeated Measures ANOVA. Table 4.2 summarizes the statistical tests conducted and when they were conducted in the study.

Table 4.2 Instrument used and analyses conducted.

Instrument	Test Conducted	Collection Period
OHQ	Internal consistency, Shapiro-Wilk normality test, Wilcoxon signed-rank test	Before the intervention and After the Intervention
SCS	Internal consistency, Shapiro-Wilk normality test, Wilcoxon signed-rank test	Before the intervention and After the Intervention
PANAS-SF	Internal consistency, Shapiro-Wilk normality test, Wilcoxon signed-rank test	Before the intervention and After the Intervention
BMIS	Internal consistency, Shapiro-Wilk normality test, Wilcoxon signed-rank test	Before the intervention and After the Intervention
SUS	Internal consistency, one-sample t-test	After Intervention
UES-SF	Internal consistency, one-sample t-test	After Intervention
IMI	Internal consistency, one-sample t-test	After Intervention
FIS	Internal consistency, one-sample t-test	After Intervention
PS	Internal consistency, one-sample t-test, RM Anova	After Intervention

All analyses were done using SPSS[171]. SPSS is a widely used and powerful tool for analyzing data and performing statistical analysis. We used it to perform inferential statistics such as t-tests and RM ANOVA.

Qualitative Data. We conducted a thematic analysis [172], following Braun and Clarke's [173] 6-step process to analyze the qualitative data:

Step 1: Become familiar with the data,

Step 2: Generate initial codes,

Step 3: Search for themes,

Step 4: Review themes,

Step 5: Define themes,

Step 6: Write-up.

The qualitative data provided deeper insights into the users' view of *SmileApp* and their possible recommendation(s). The results of the thematic analysis helped us gain additional insight into patterns and commonalities in users' behaviour**,** which reinforced the quantitative data collected from users.

Chapter 5 : STUDY RESULTS

In this chapter, we present the results from the quantitative and qualitative analysis of the SmileApp evaluation. We first discuss results from the scales and instruments used (quantitative data) followed by the themes that were extracted from the qualitative data. This chapter is divided into three subsections, namely the Demographic subsection, the Qualitative analysis subsection and the Qualitative analysis subsection. The qualitative analysis section will comprise the analysis of the data from the semi-structured interviews and open-ended questions in the survey, we will be highlighting the themes derived from this data after a thematic analysis [172], following Braun and Clarke's [173] 6 step process to analyze the qualitative data. The quantitative analysis section will elaborate on the result of all scales and surveys used in this study, which was used in answering the research questions. We will be presenting the result of the Oxford Happiness Scale (OHQ) [145], Social Connectedness Scale [146], Positive and Negative Affect Schedule (PANAS-SF) [147], Intrinsic Motivation Inventory (Value/Usefulness) [149], Future Intention questionnaire, System Usability Scale (SUS) [139], Brief Mood Introspection Scale (BMIS) [150] and perceived persuasiveness of the SmileApp. We will present the overall usability of the SmileApp in terms of the User Engagement Scale (UES-SF) [148] in its subscales "*Perceived Usability*", "*Aesthetic Appeal*", "*Focused Attention*" and "*Reward Factor*".

We conducted a reliability test which demonstrated that all the scales used in the study had good internal consistency with the Cronbach's alpha (α) [170] values above the recommended threshold of 0.70 as shown in Table 5.1.

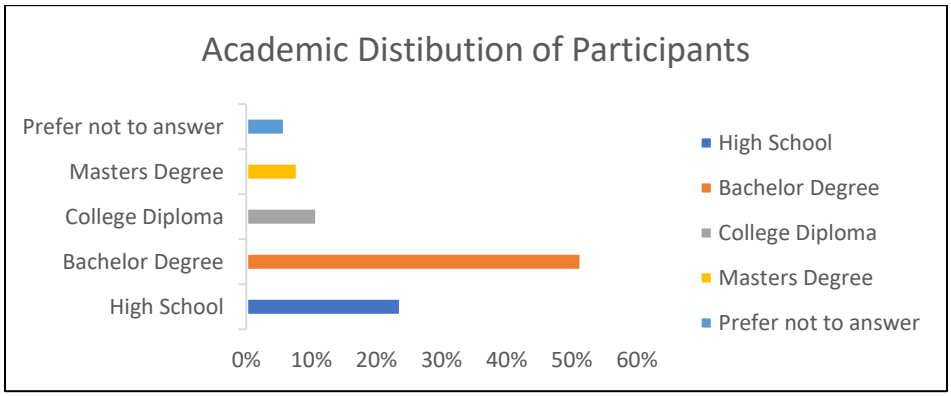
Table 5.1 Cronbach's alpha for all scales used in the study.

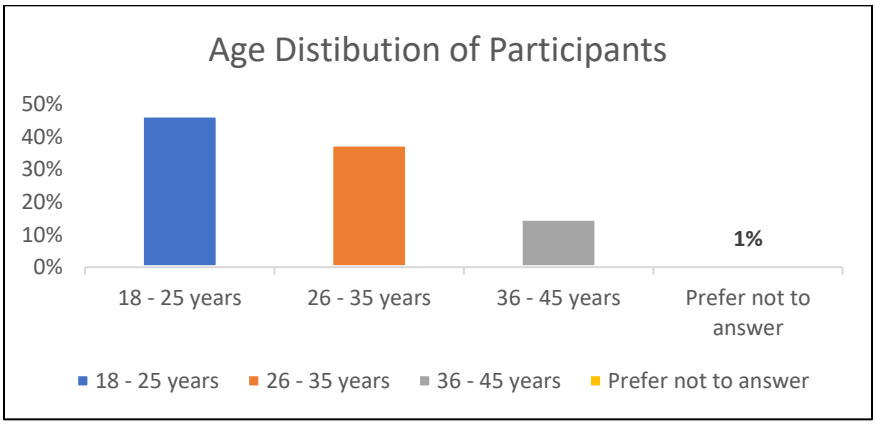
Scale	**Cronbach's Alpha (α)**
Oxford Happiness Questionnaire	0.795
Social Connectedness Scale	0.918
Positive Negative Affect Schedule (PANAS) (Positive)	0.918
Positive Negative Affect Schedule (PANAS) (Negative)	0.890
System Usability Scale (SUS)	0.700
User Engagement Scale (UES-SF) Short form	0.771
Intrinsic Motivation Inventory (IMI)	0.945
Future Intention Scale	0.891
Brief Mood Introspection Scale (BMIS)	0.841

Persuasive Scale (SmileGram)	0.940
Persuasive Scale (PocketBuddy)	0.969
Persuasive Scale (MyTribe)	0.978

5.1 Demographics

The demographics of our study population are shown in Table 5.2, also an overview of the participants' demographic data is shown in Figure 5.1. Results showed that the majority of participants fall in the age bracket of 18-25 years old (47%), most of the participants were women (63%) while for academic qualification, the majority held a bachelor's degree (51%) followed by high school graduates (24%).





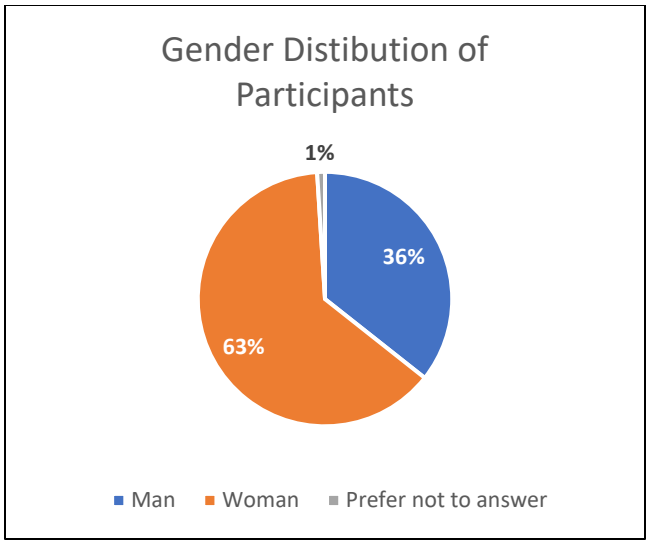


Figure 5.1 Overview of the demographics of the study population

Table 5.2 Frequency and percentage of the demographics of the study population

Demographic Factors		n (%)
Academic Qualification	High School	24%
	Bachelor's degree	51%
	College Diploma	11%
	Master's degree	8%
	Prefer not to answer	6%
Age	18 - 25 years	47%
	26 - 35 years	38%
	36 - 45 years	15%
	Prefer not to answer	1%
Gender	Man	36%
	Woman	63%
	Prefer not to answer	1%

5.2 Quantitative Analysis

To enable us to provide answers to all our research questions, we conducted different statistical analysis on the quantitative data we collected from the study using standardized scales and usage logs tracked from the SmileApp. An alpha level of 0.05 was set for all statistical tests.

First, we conducted a normality test on the Pre and Post data of the Oxford Happiness Scale (OHQ) [145], Social Connectedness Scale (SCS) [146], Brief Mood Introspection Scale (BMIS) [150], and Positive and Negative Affect Schedule (PANAS-SF) [147] using the Shapiro-Wilk normality test [174]. The result of the Shapiro-Wilk normality test revealed that our data was not normally distributed. Due to this non-normal distribution, we conducted a Wilcoxon signed-rank test [175] on the four scales (OHQ, BMIS, PANAS-SF, and SCS) which had Pre- and – Post data as shown in Table 5.3.

Next, we conducted a one-sample t-test on the other scales: Intrinsic Motivation Inventory (Value/Usefulness) [149], Future Intention questionnaire, System Usability Scale (SUS) [139], Perceived scale and User Engagement Scale (UES-SF) [148] to measure if the data is significantly different from the mid score of each scale.

Table 5.3 Summary results of the descriptive statistics and the Shapiro-Wilk test (M= Mean, SD= Standard 83 Deviation, W= Statistics, df = degrees of freedom, p = Significant value), N= 101, 87(for BMIS) for OHQ, SCS, PANAS-SF and BMIS

	PRE						Post					
	Descriptive Statistics			Shapiro-wilk test			Descriptive Statistics			Shapiro-wilk test		
Measures	Mean	Median	SD	W	df	p	Mean	Median	SD	W	df	p
OHQ	4.6	4.71	0.69	0.87	101	0.001	4.7	4.8	0.61	0.95	101	0.001
SCS	5.05	5.5	1.17	0.8	101	0.001	5.26	5.75	1.06	0.7	101	0.001
PANAS-SF	3.84	4	0.61	0.96	101	0.003	4.06	4.1	0.58	0.97	101	0.009
BMIS (Pleasantness)	53.26	54	6.75	0.92	87	0.001	56.67	58	6.39	0.91	87	0.01
BMIS (Calm)	37.53	38	4.09	0.95	87	0.003	40.16	40	4	0.98	87	0.13
BMIS (Positivity)	44.07	44	4.66	0.89	87	0.001	46.33	47	3.49	0.96	87	0.01

Table 5.3 presents the observed rise in Pre-Test and Post-Test means, indicating the positive outcomes achieved through our intervention aimed at enhancing the emotional well-being of the participants. Nevertheless, to thoroughly assess the extent of this improvement, we conducted additional analyses to determine the significance of these changes. We also employed various indicators and scales to evaluate the overall effectiveness of the SmileApp intervention.

Table 5.4 Summary results of the descriptive statistics of the One-sample t-test (N= Sample Size, SD= Standard Deviation) for SUS, UES-SF, IMI, FIS, PS

	Descriptive Statistics (N = 101)		
Measures	Scale Midpoint	Mean	SD
SUS	3	79.51	15
UES-SF	3	3.75	0.59
IMI	4	5.95	1.21
FIS	3	4.45	0.73
Persuasive (SmileGram)	4	5.87	1.45
Persuasive (PocketBuddy)	4	6.07	1.37
Persuasive (PocketBuddy)	4	5.66	1.77

Table 5.4 shows that each instrument's Mean was above the mid-points (SUS = 68, UES-SF = 3, IMI = 4, FIS = 3, PS = 3) indicating the effectiveness of our intervention. However, we further examined whether there is a significant difference in this improvement. In the following sections, we provide the details of each scale and how it answers the research questions.

5.2.1 Perceived Happiness Level

Our intervention aims to elicit smiles and improve users' emotions hence we intend to measure the participant's happiness level which will contribute to answering RQ1 "*How effective is SmileApp for eliciting positive mood?*". To achieve this, we employed the Oxford Happiness Questionnaire (OHQ). The OHQ is 6 points (1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Slightly Agree, 5 = Agree and 6 = Strongly Agree) Likert scale with 3.5 as the neutral point assesses both the cognitive and affective components of happiness. While affective happiness captures the presence of positive emotion and absence of negative emotion, the cognitive happiness refers to individual satisfaction with their overall well-being. The OHQ has been applied in several studies to measure happiness [151][152][153][154].

To begin with, we conducted a comprehensive analysis that involved computing a frequency distribution and calculating the average score (OHQ) for the participants in both the Pre-Test and Post-Test phases. The findings exhibited improvements across participants' self-assessed ratings of happiness, as depicted in Figure 5.2. Furthermore, there was a discernible enhancement in the average OHQ score, with the Pre-Test score of 4.6 increasing to 4.84 in the post-test, as demonstrated in Figure 5.3. These results indicate positive progress in the participants' well-being and suggest the efficacy of the intervention.

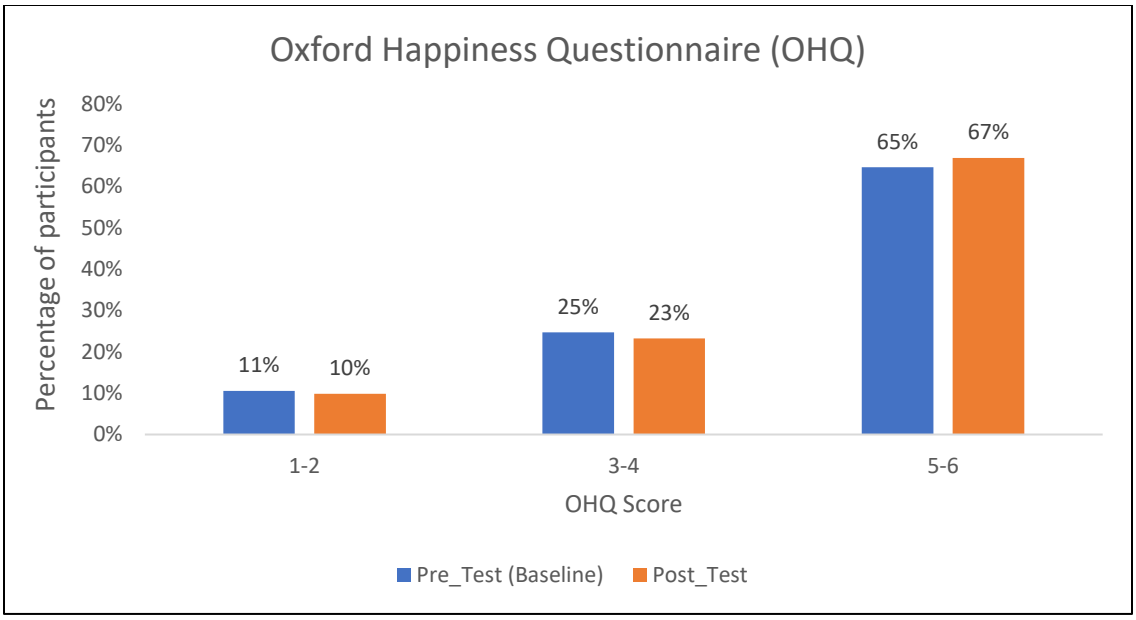


Figure 5.2 A bar chart showing the frequency of distribution of participants' responses to the Happiness level before and after the intervention on a scale ranging from 1 to 6 (ranging from 1 = Strongly Disagree to 6 = Strongly Agree).

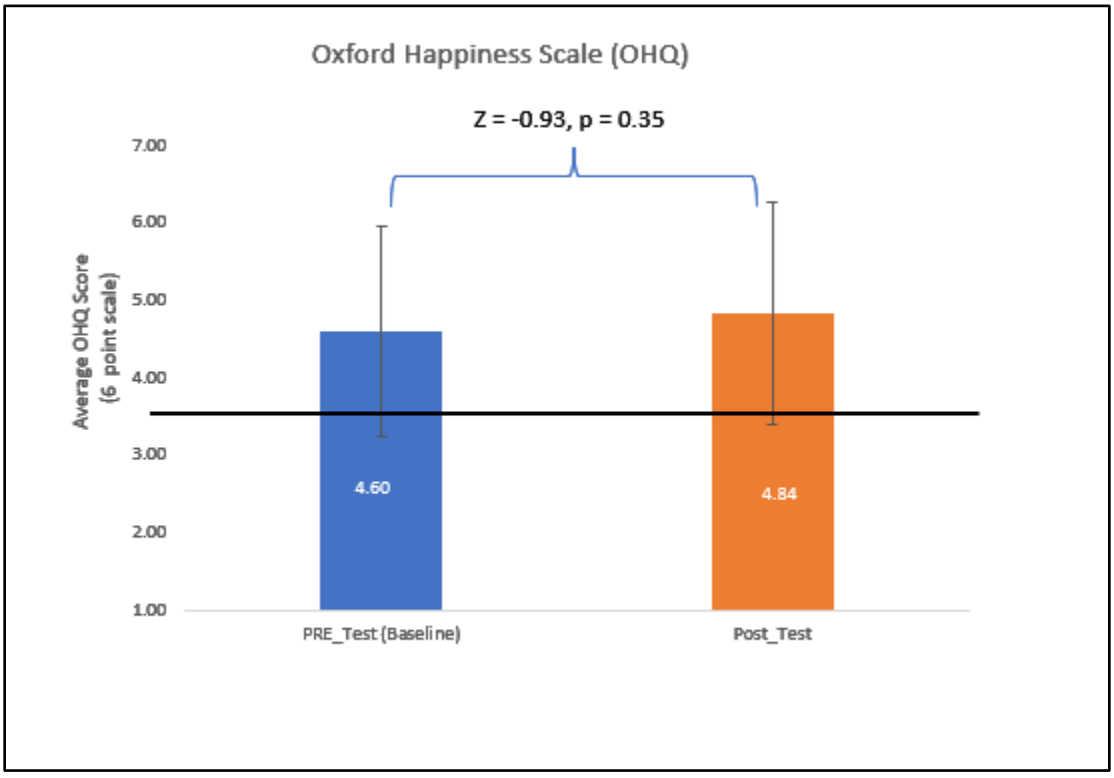


Figure 5.3 A bar chart showing participants' average level of Happiness before and after the intervention on a scale ranging from 1 to 6. The horizontal line indicates a neutral score of 3.5. Wilcoxon signed-rank test of p = 0.35.

In general, the data showed some improvements in happiness before and after the intervention, albeit not significant, however, a deeper look into the data shows some interesting results. We split our participants into two categories based on the average accumulated time (5918 seconds) spent on the app and the accumulated duration participants smiled on the app (2434 seconds). To achieve this, we calculated the average time spent on the app by all participants and also the average duration each participant smiled using the app during the study, then divided the participants into two depending on if they used the app above the general average or below it. This dichotomy was necessary as participants used the app in their natural environment without strict rules on when and how long to use the app each day, we expected variance in utilization across participants. Figures 5.4 and 5.5 below showed a significant improvement in OHQ scores for participants who spent more time on the app and also those who smiled more using the app.

Table 5.5 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for OHQ Pre - and -Post-intervention for participants who spent more than the average time on the SmileApp.

	Above Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	*p*
OHQ Pre_Test	34	4.56	4.71	0.76	-2.57	0.01
OHQ Post_Test	34	4.84	4.93	0.63		

Table 5.6 Summary results of the descriptive statistics and the Wilcoxon signed-ranked test (SD = Standard Deviation) for OHQ Pre - and Post-intervention for participants who spent less than the average time on the SmileApp.

	Below Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	*p*
OHQ Pre_Test	67	4.61	4.71	0.66	-0.67	0.51
OHQ Post_Test	67	4.62	4.71	0.59		

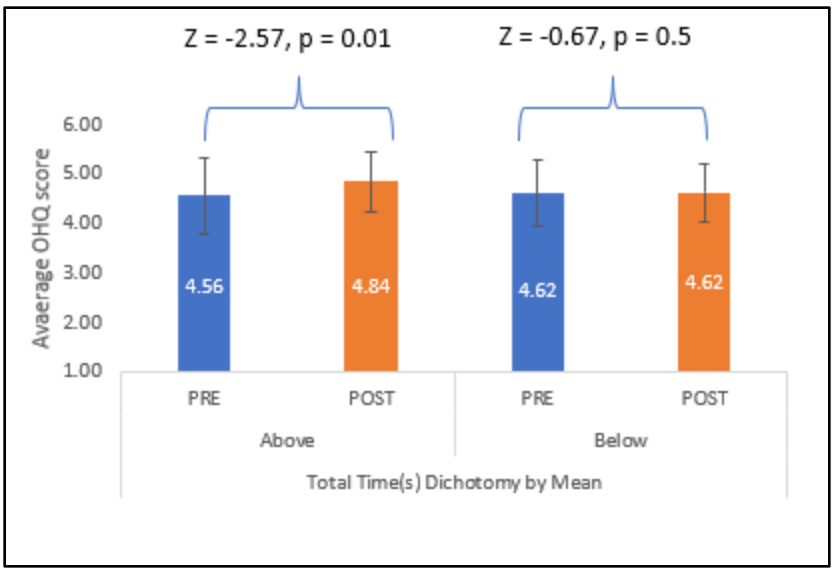


Figure 5.4 A bar chart showing the participants' level of Happiness before and after the intervention categorized by the Mean of the total time spent with Wilcoxon signed-rank test result.

Table 5.7 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for OHQ Pre - and -Post-intervention for participants who smiled more than the average Smile duration of all participants.

	Above Average Smile Duration (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	*p*
OHQ Pre_Test	42	4.58	4.75	0.73	-1.96	0.05
OHQ Post_Test	42	4.79	4.93	0.61		

Table 5.8 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for OHQ Pre - and -Post-intervention for participants who smiled less than the average Smile duration of all participants.

	Below Average Smile Duration(sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	*p*
OHQ Pre_Test	59	4.61	4.71	0.67	-0.554	0.58
OHQ Post_Test	59	4.63	4.64	0.6		

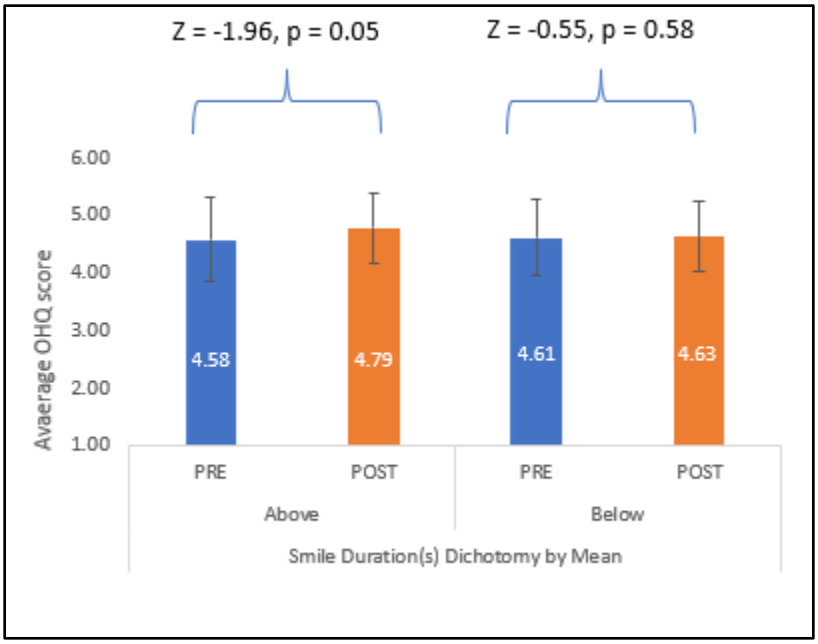


Figure 5.5 A bar chart showing the participant's level of Happiness before and after the intervention categorized by the Mean of the total smile duration with Wilcoxon signed-rank test result.

The analysis of data, illustrated in Figure 5.4 and Figure 5.5, revealed a noteworthy correlation between participants who spent above-average time engaged with the SmileApp and those who exhibited an extended duration of smiling. Notably, these participants experienced more pronounced improvements in their levels of happiness. This finding strongly suggests that the SmileApp holds the potential to enhance happiness when utilized for a substantial duration. Comprehensive details of the descriptive statistics, along with the corresponding significant values, are presented in Tables 5.5, 5.6, 5.7, and 5.8. These tables provide a comprehensive overview of the analytical outcomes and their statistical significance, further bolstering the evidence supporting the effectiveness of the SmileApp intervention.

5.2.2 Perceived Social Connectedness

The SmileApp was designed to foster social interaction and support via the MyTribe feature as a means to improve the mood of participants. To address RQ3, "*How effective is SmileApp in helping users find social support?*", we conducted measurements to assess the participants' perceived social connectedness or feelings of connectedness to others while utilizing the SmileApp. To achieve this, we employed the Social Connectedness scale (SCS) of 6 points (1 = Strongly Agree,

6 = Strongly Disagree) which captures the subjective experience of social relationships and the sense of belongingness. The social connectedness scale has been used in previous studies to measure the perceived social connectedness of users [165][166][167].

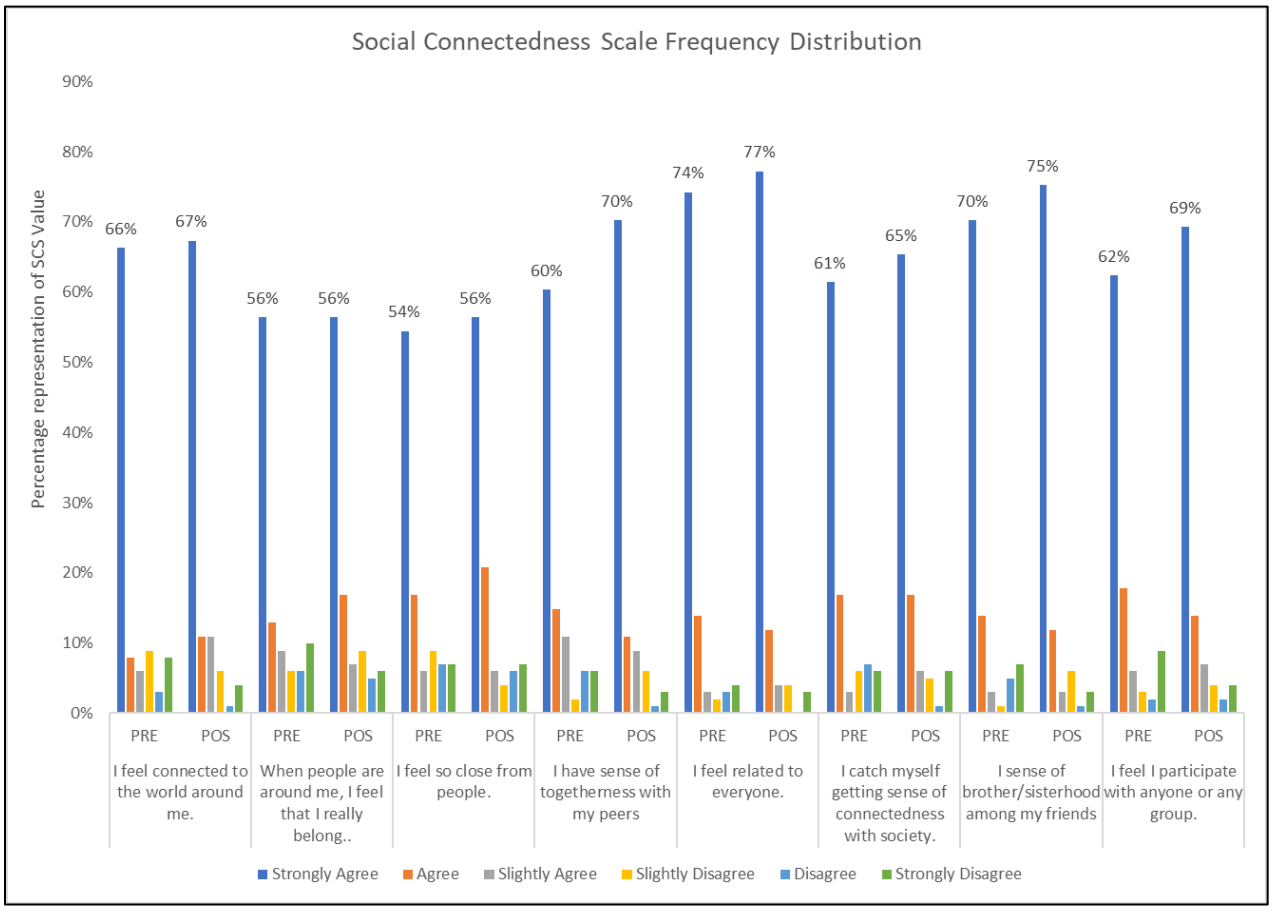


Figure 5.6 A Bar chart showing the level of agreement to social connectedness before and after the intervention on a scale ranging from 1 to 6 (1 = Strongly Agree, 6 = Strongly Disagree).

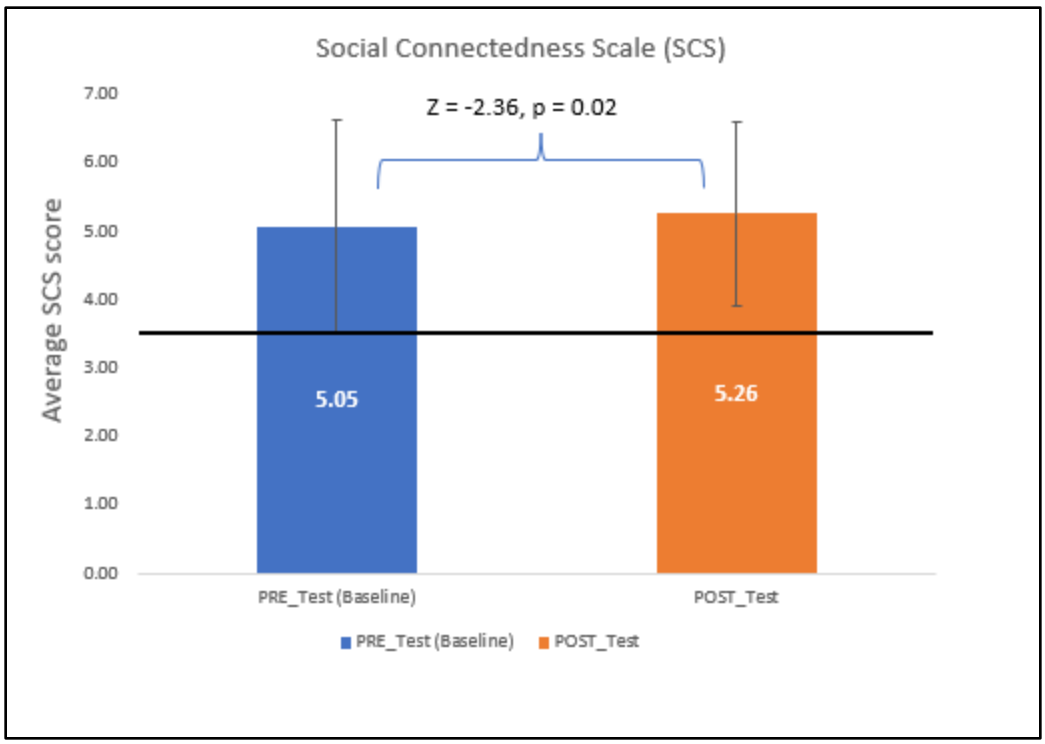


Figure 5.7 A bar chart showing the participants' average social connectedness score before and after the intervention on a scale ranging from 1 to 6 (1 = Strongly Agree, 6 = Strongly Disagree) with Wilcoxon signed-rank test result.

As shown in Figure 5.7 (horizontal line indicates a neutral score of 3.5), the SCS data showed that participants' feeling of social connectedness increased significantly Z = -2.36, $p = 0.02$) after using the SmileApp intervention. Next, we split the participants into two categories based on the average accumulated time (5918 seconds) spent on the app and the average accumulated duration participants smiled on the app (2434 seconds). Table 5.9 and Table 5.10 show the SCS scored within these two dichotomies of participants based on time spent on the app which showed an increased level of social connectedness while Figure 5.8 highlights the significant differences.

Table 5.9 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for SCS Pre - and -Post-intervention for participants who spent more than the average time on the SmileApp

	Above Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
SCS Pre_Test	34	5.18	5.56	1.06	-1.92	0.05
SCS Post_Test	34	5.4	6	1.01		

Table 5.10 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for SCS Pre - and -Post-intervention for participants who spent less than the average time on the SmileApp

	Below Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
SCS Pre_Test	67	4.99	5.38	1.22	-1.64	0.01
SCS Post_Test	67	5.18	5.63	1.08		

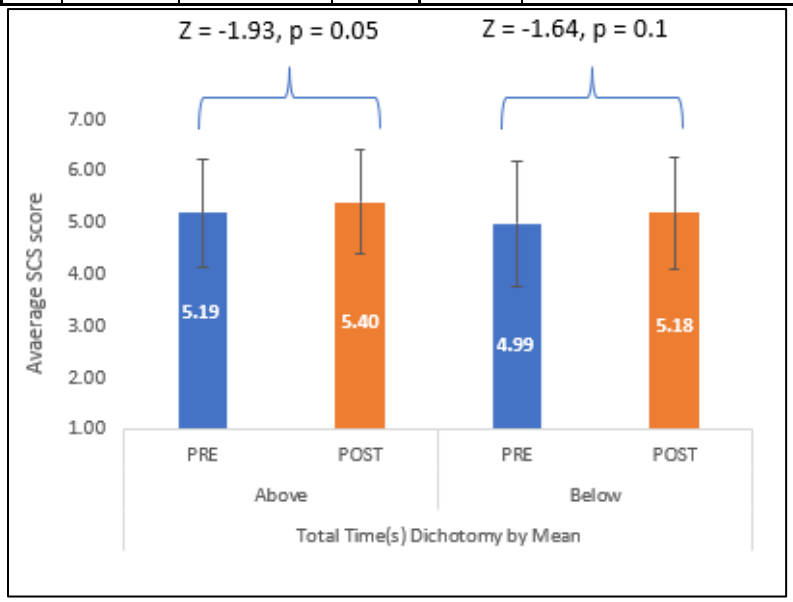


Figure 5.8 A bar chart showing the participant's level of social connectedness Pre and Post-intervention categorized by the average of the total time spent with Wilcoxon signed-rank test result.

As shown in Table 5.11 and Table 5.12, there was an increased level of social connectedness among participants who had a longer duration of smile (above average) compared to participants whose accumulative duration of smile was below average of all participants.

Table 5.11 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for SCS Pre - and -Post-intervention for participants who smiled more than the average Smile duration.

	Above Average Smile Duration (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
SCS Pre_Test	42	5.16	5.5	1.05	-1.96	0.05
SCS Post_Test	42	5.32	5.94	108		

Table 5.12 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for SCS Pre - and -Post-intervention for participants who smiled less than the average Smile duration.

	Below Average Smile Duration (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
SCS Pre_Test	59	4.98	5.38	1.25	-1.52	0.13
SCS Post_Test	59	5.21	5.75	1.05		

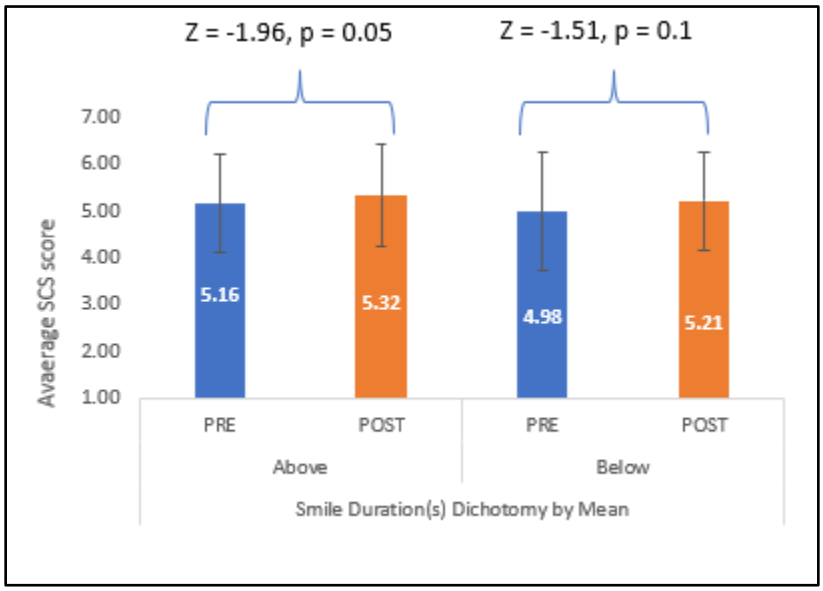


Figure 5.9 A bar chart showing the participant's level of social connectedness Pre and Post-intervention categorized by the mean of the total smile duration with Wilcoxon signed-rank test result.

5.2.3 SmileApp Effect on Participant's Negative and Positive Affect

To answer RQ1 "*How effective is SmileApp for eliciting positive mood?*", we evaluated participants' positive and negative affect, which refers to the experience of positive and negative emotions or moods. We employed the Positive and Negative Affect Schedule – Short Form (PANAS-SF). PANAS-SF which is a standard 5 Likert (1 = Very slightly, 2 = A little, 3 = Moderately, 4 = Quite a bit, 5 = Extremely) scale instrument that has been used to measure negative and positive affect [155][156]. First, we plotted the frequency of participants' responses to the PANAS questionnaire before and after the intervention (see Figure 5.10), then we compared the

PANAS score before and after the intervention and the statistical significant difference (see Figure 5.11).

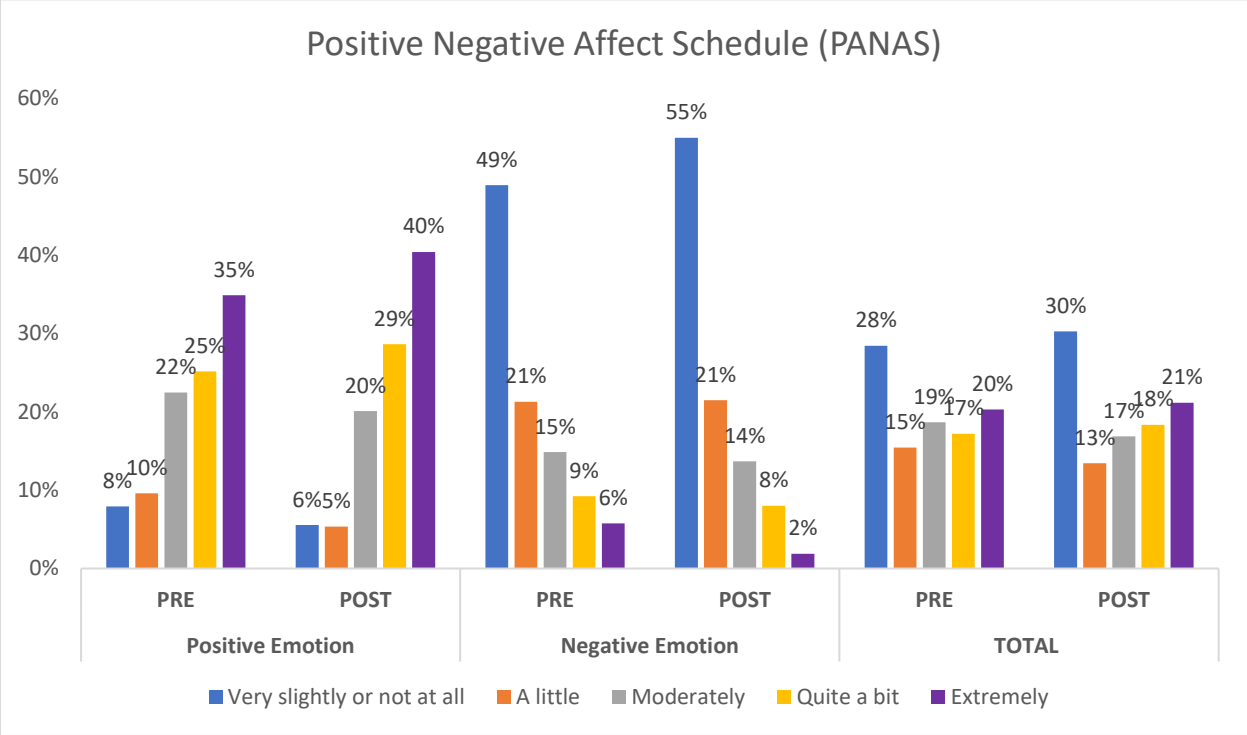


Figure 5.10 A Bar chart for the frequency of positive and negative affect schedule before and after the intervention on a scale ranging from 1 to 5 (1 = Very slightly and 5 = Extremely).

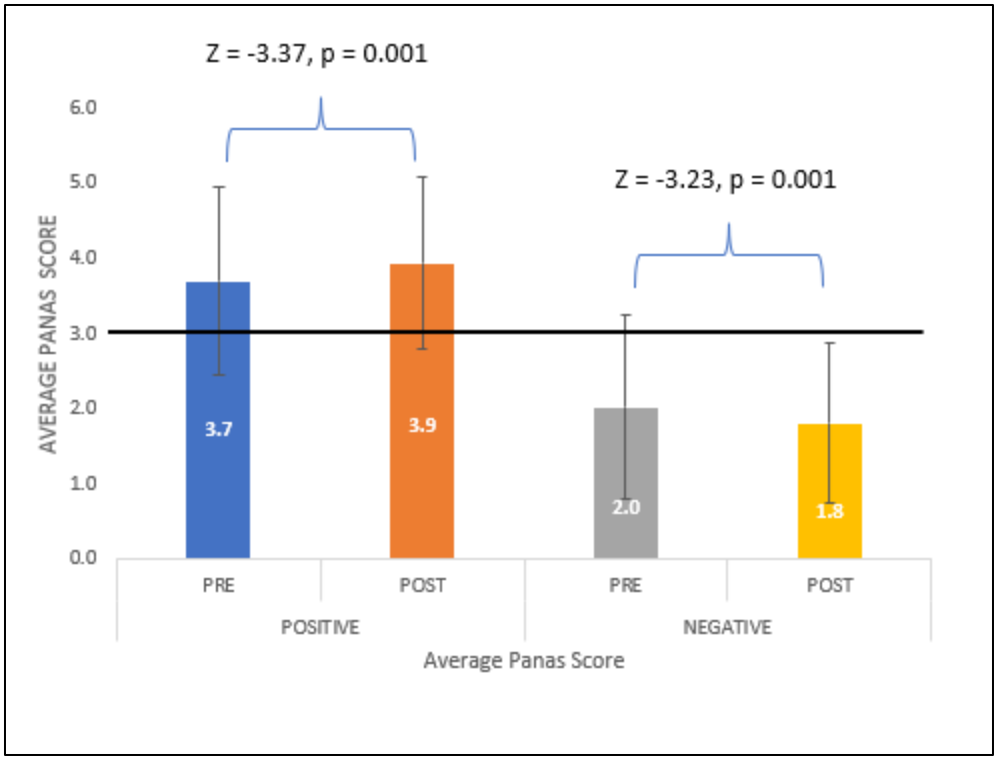


Figure 5.11 A bar chart showing PANAS-SF score and sub-scales before and after the intervention with Wilcoxon signed-rank test result.

From Figure 5.11, it is obvious that participants reported improvement in all PANAS subscales and the combined scale. There was a significant increase in positive emotion and a significant decrease in negative emotion. In addition to the pre-and post-test measurements, we separated the participants into two groups based on time spent on the SmileApp and average smile duration. We compared the PANAS score of participants who spent more time (above the average of all participants) in the SmileApp and participants who spent less time in the SmileApp (below the average of all participants) see Table 5.13, Table 5.14 and Figure 5.12. Also, compared the PANAS score of participants who smiled for a longer duration (above the average of all participants) and participants who smiled lesser duration (below the average of all participants) see Table 5.15, Table 5.16 and Figure 5.13.

Table 5.13 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for PANAS-SF Pre - and -Post-intervention for participants who spent more than the average time on the SmileApp

	Above Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
PANAS Pre_Test	34	3.88	4.08	0.64	-2.69	0.01
PANAS Post_Test	34	4.15	4.18	0.55		

Table 5.14 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for PANAS-SF Pre - and -Post-intervention for participants who spent less than the average time on the SmileApp

	Below Average Total Time Spent (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
PANAS Pre_Test	67	3.82	3.95	0.6	-2.58	0.01
PANAS Post_Test	67	4.02	4.05	0.59		

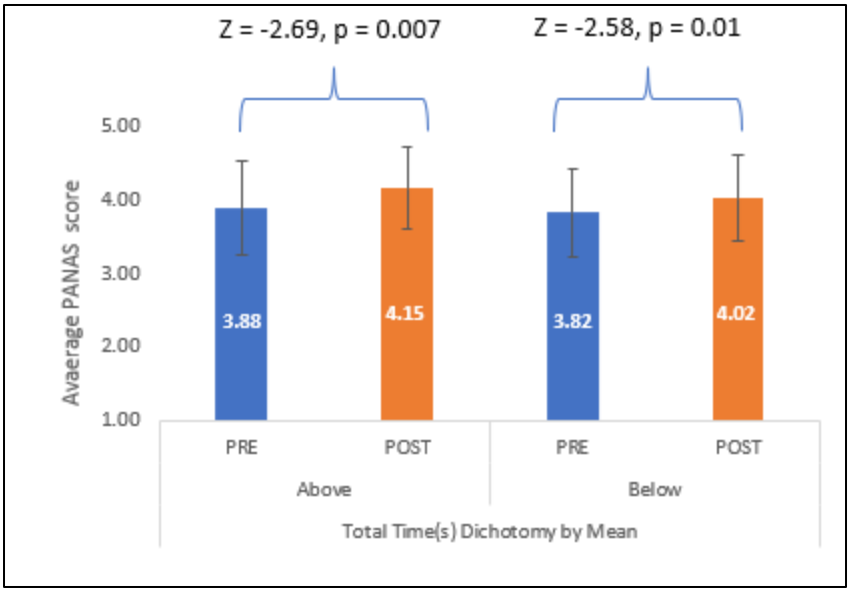


Figure 5.12 A bar chart showing participants' PANAS-SF scores before and after the intervention categorized by the mean of the total time spent on SmileApp with Wilcoxon signed-rank test result.

Table 5.15 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for PANAS-SF Pre - and -Post-intervention for participants who smiled more than the average Smile duration.

	Above Average Smile Duration (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
PANAS Pre_Test	42	3.84	3.9	0.6	-2.91	0.004
PANAS Post_Test	42	4.11	4.15	0.56		

Table 5.16 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for PANAS-SF Pre - and -Post-intervention for participants who smiled less than the average Smile duration.

	Below Average Smile Duration (sec)					
	Descriptive Statistics				Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Z	p
PANAS Pre_Test	59	3.84	4	0.62	-2.38	0.02
PANAS Post_Test	59	4	4.05	0.59		

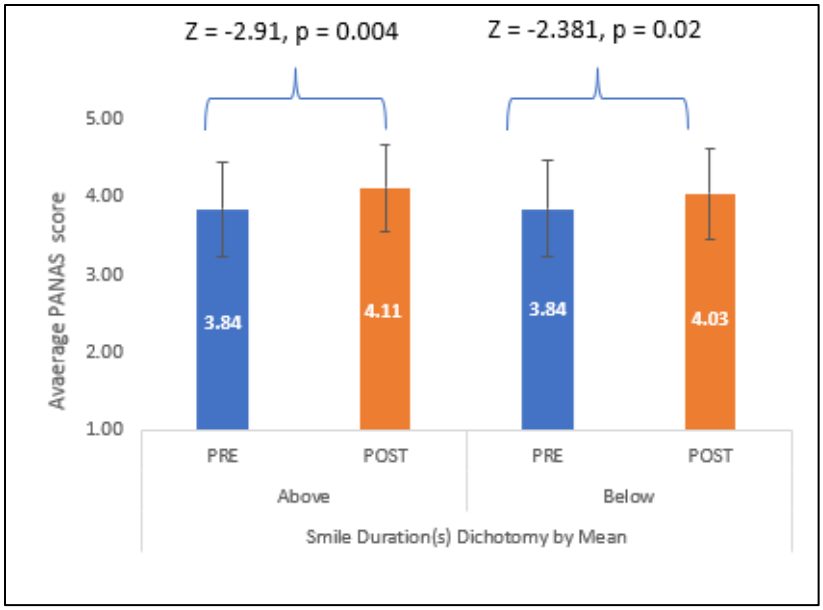


Figure 5.13 A bar chart showing the participants' PANAS-SF score Pre and Post-intervention categorized by the mean of the total Smile duration on SmileApp with Wilcoxon signed-rank test result.

5.2.3.1 SmileApp Effect on Mood

In addition to the PANAS-SF, we also employed the Brief Mood Introspection scale (BMIS) to measure the mood of participants before and after using SmileApp the intervention to further answer RQ1 "*How effective is SmileApp for eliciting positive mood?*". The BMIS is a 4 scale (1 = definitely do not feel, 2 = do not feel, 3 = slightly feel, 4 = definitely feel) employed to assess mood fluctuations and emotional reactivity which have been employed in several studies [176][177][178][179]. As shown in Table 5.17 and Figure 5.14, there was a significant improvement in the BMIS score of participants after the intervention.

Table 5.17 Summary results of the descriptive statistics and the Wilcoxon signed-rank test (SD= Standard Deviation) for BMIS Pre - and -Post-intervention.

	Descriptive Statistics								
	Pre_test (Baseline)				Post			Wilcoxon signed-rank test	
Measures	N	Mean	Median	SD	Mean	Median	SD	Z	p
BMIS (Pleasantness)	87	53.26	54	6.75	56.67	58	6.39	-4.3	0 .001
BMIS (Calmness)	87	37.53	38	4.09	40.16	40	4.01	-5.03	0 .001

BMIS (Positivity)	87	44.07	44	4.66	46.33	47	3.49	-4.62	0.001
BMIS(Overall)	87	45	46	3.23	47.72	48	3.23	-5.95	0.001

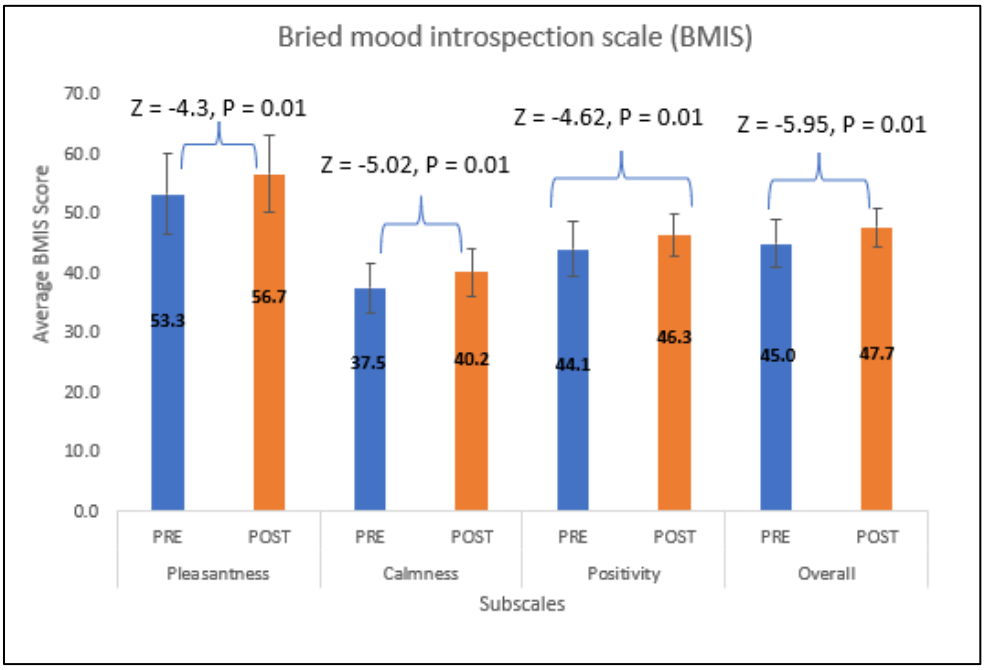


Figure 5.14 A bar chart showing BMIS score and sub-scales before and after the intervention with Wilcoxon signed-rank test.

5.2.4 Perceived Usability, Engagement and Aesthetic Appeal of the SmileApp

To answer RQ2 "*How engaging and Usable is the SmileApp for users to accomplish their goals of activating positive mood?*", we measured the user experience of participants by conducting a one-sample t-test on the system usability scale (SUS) and User Experience Questionnaire (UEQ) ratings compared to the midpoint.

The SUS revealed an average score of 79.51 (*SD* = 15.0), indicating that the overall usability of our system is "Good". The average SUS score is 68 from the literature based on the study [180] Hence we conducted a one-sample t-test to confirm that the SUS score of our data was significantly higher than the Average SUS score of 68 as shown in Table 5.18 and Figure 5.15

Table 5.18 Summary results of the descriptive statistics and one-sample t-test (SD= Standard Deviation) for SUS.

Measures	N	Mean	SD	Test Value	p
SUS	101	79.5	15	68	<0.001

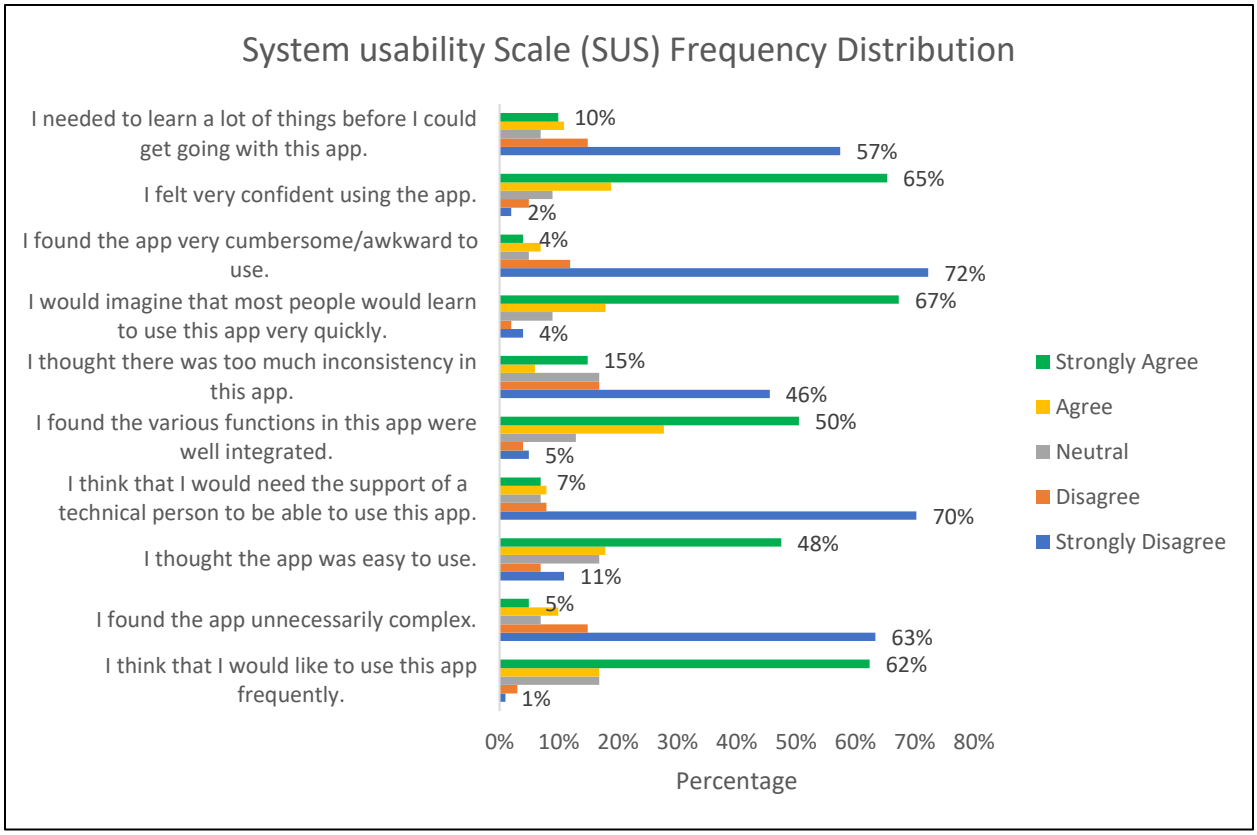


Figure 5.15 A bar chart showing the frequency distribution of the level of Agreement to the SUS questions.

In our analysis, we examined the participants' responses on the User Engagement Scale (UES), which utilizes a 5-point Likert scale. To assess the level of engagement, we compared the participants' ratings against a neutral rating of 3. Overall, the results indicate that participants found the SmileApp to be engaging (see Figure 5.16 and Figure 5.17). Upon further examination of the UES subscales, we observed that participants perceived SmileApp to have high aesthetic appeal, reward factor, and perceived usability. However, the focused attention subscale showed relatively lower scores (see Table 5.18). It is worth noting that all three subscales were significantly higher than the neutral value ($p < .001$) (see Table 5.18). This suggests that SmileApp is considered usable, aesthetically appealing, and rewarding by the participants. However, there may be room for improvement in terms of maintaining focused attention while using the app.

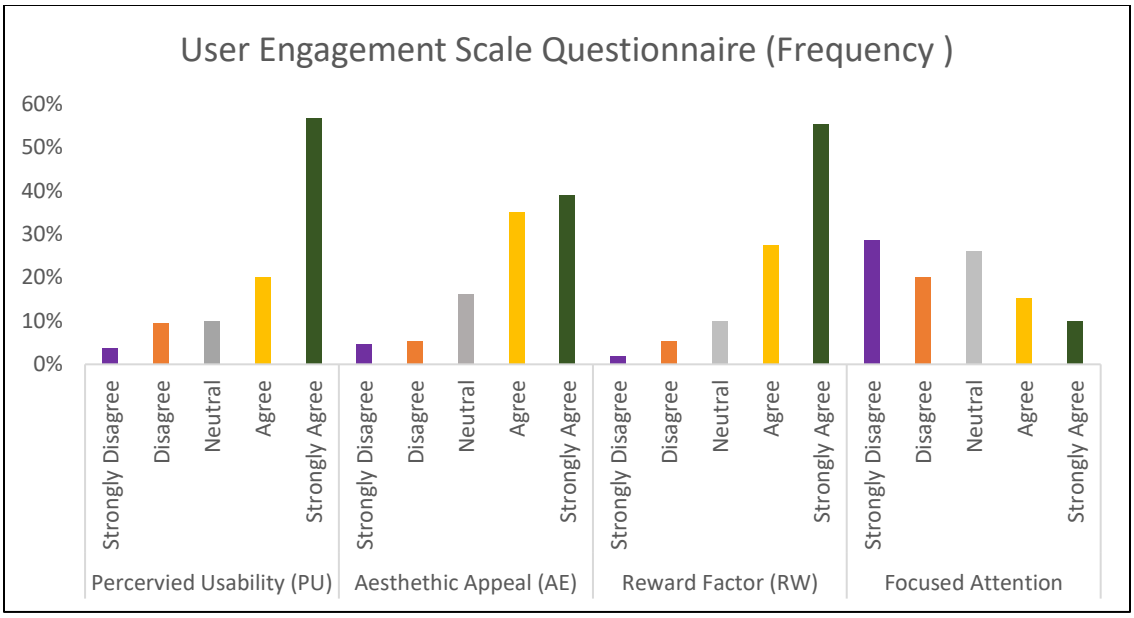


Figure 5.16 A bar chart showing the frequency distribution of level of Agreement to the UEQ questions.

Table 5.19 Summary results of the descriptive statistics and one-sample t-test (SD= Standard Deviation) for UEQ.

Measures	Mean	Standard Deviation	Test Value	p
Perceived Usability	4.17	0.91	3	<0.001
Aesthetic Appeal	3.98	0.94	3	<0.001
Reward Factor	4.29	0.92	3	<0.001
Focused Attention	2.57	0.898	3	<0.001
UES Total	3.74	0.59	3	<0.001

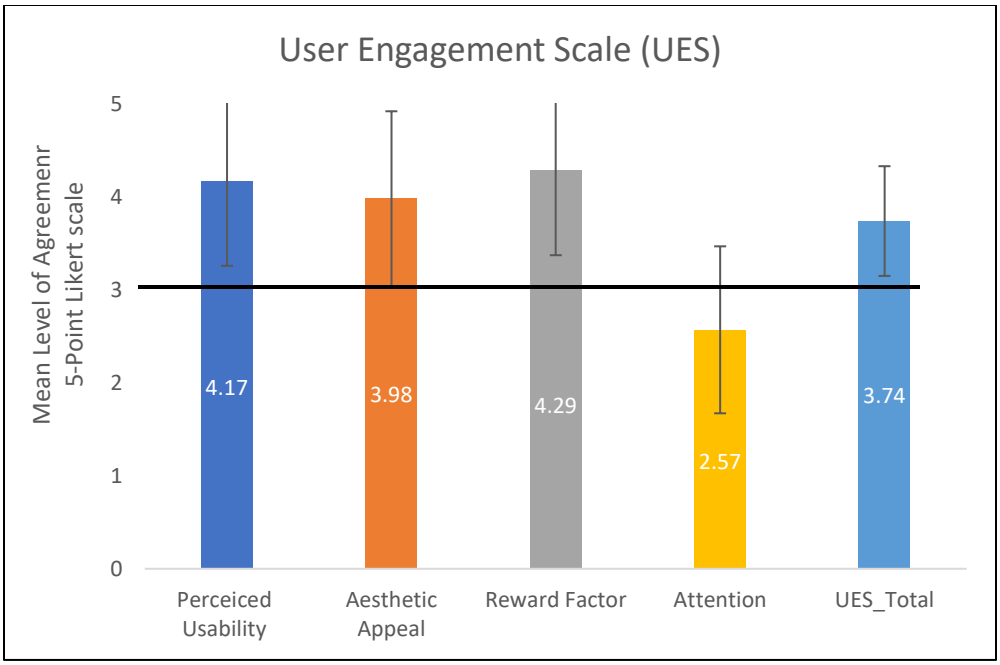


Figure 5.17 A bar chart showing Average UEQ scores and subscale scores.

5.2.5 Motivation for prolonged use of the SmileApp

To answer RQ4 "*How effective is the Smile App for motivating continued use?"* we measured the chances of participants using the SmileApp after the study and also to ascertain whether the motivation driving the use of SmileApp is intrinsic and not influenced by external factors, hence we employed the Future intention Scale (FIS) and the Intrinsic motivation inventory (IMI) (Figure 18 and 19). The FIS is a 5 points Likert scale (1= Won't, 2 = Unlikely, 3 = Neutral, 4 = Likely, 5 = will) that measures the willingness to use the SmileApp in the future while the IMI is a 7-point Likert (1= Not true at all, 2, 3, 4 = Somewhat true, 5 6, 7 = Very True) which helps us assess the user experience and the source of motivation of use, whether intrinsic or not. We performed a one-sample t-test against a neutral rating of 3 and 4 for the FIS and IMI respectively.

From Table 5.20, we can see the scores of FIS and IMI were significantly higher than the neutral value, indicating a strong intention to continue using the SmileApp and also confirming they were intrinsically motivated and had positive a user experience from using the SmileApp.

Table 5.20 Summary results of the descriptive statistics and one-sample t-test (SD= Standard Deviation) for FIS and IMI.

Measures	N	Mean	Standard Deviation	Test Value	p
FIS	101	4.45	0.73	3	<0.001
IMI	101	5.95	1.2	4	<0.001

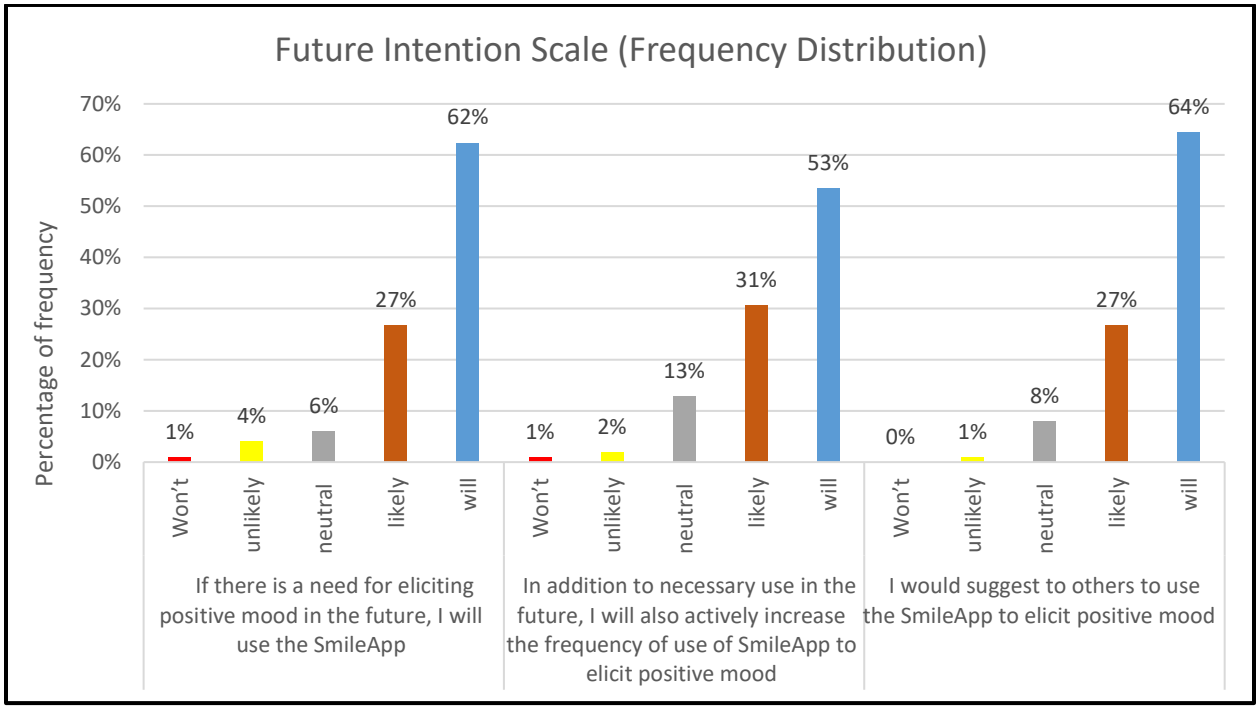


Figure 5.18 A bar chart showing the frequency distribution of level of Agreement to the FIS questions.

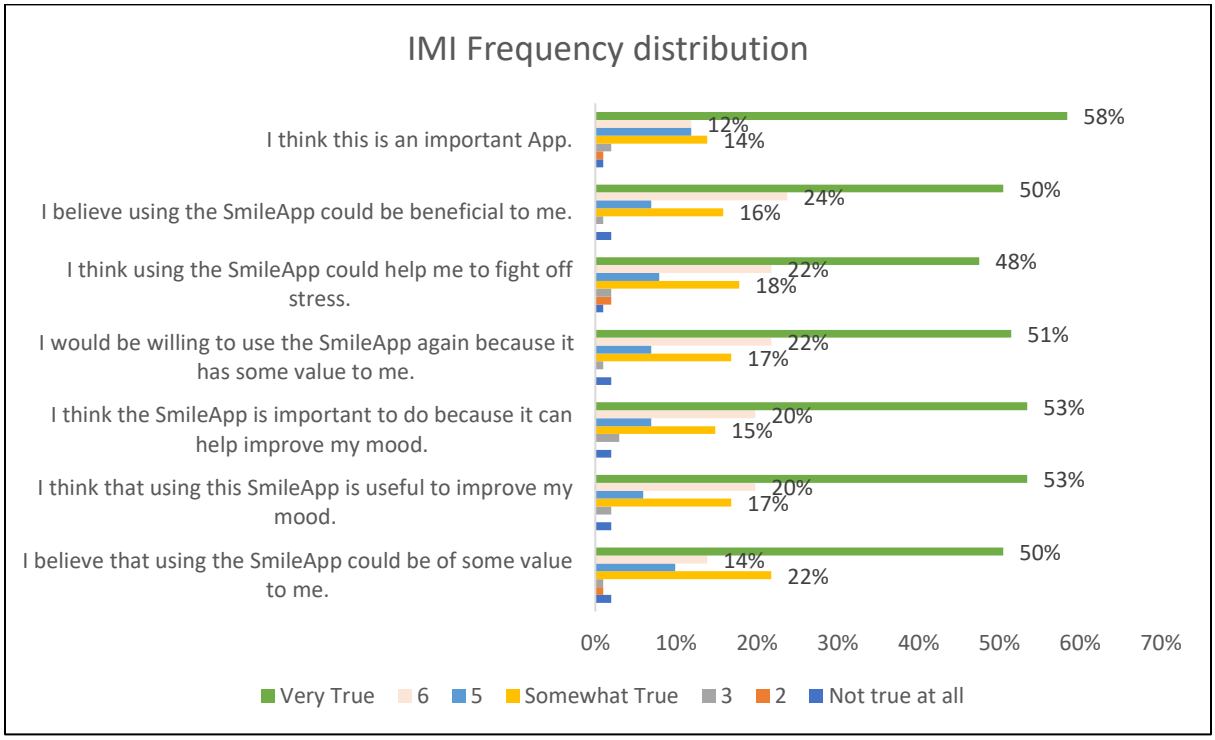


Figure 5.19 A bar chart showing the frequency distribution of the level of agreement evaluated by the IMI questions using the value/usefulness subscale.

5.2.6 Perceived Persuasiveness of the SmileApp

To answer RQ5 "*How persuasive and useful is SmileApp in improving user's mood?*" We investigated the perceived persuasiveness of SmileApp by performing a one-sample t-test on the persuasive scale (PS) data against a neutral rating of 4. The persuasive scale is 7 points (1= Strongly Disagree, 7 = Strongly Agree). I employed the Likert scale to investigate the perceived persuasiveness of SmileApp and its features (Figure 5.20). We collected persuasive scale data for each of the three features on the SmileApp (SmileGram, PocketBuddy and MyTribe). Table 5.21 shows that participants perceived the three features to be significantly persuasive.

Table 5.21 Summary results of the descriptive statistics and one-sample t-test (SD= Standard Deviation) for persuasive scale.

Measures	N = 101			
	Mean	SD	Mid Value	p
Persuasive Scale (SmileGram)	5.87	1.44	4	<0.001
Persuasive Scale (PocketBuddy)	6.07	1.37	4	<0.001
Persuasive Scale (MyTribe)	5.66	1.77	4	<0.001
Overall Persuasiveness	5.87	1.35	4	<0.001

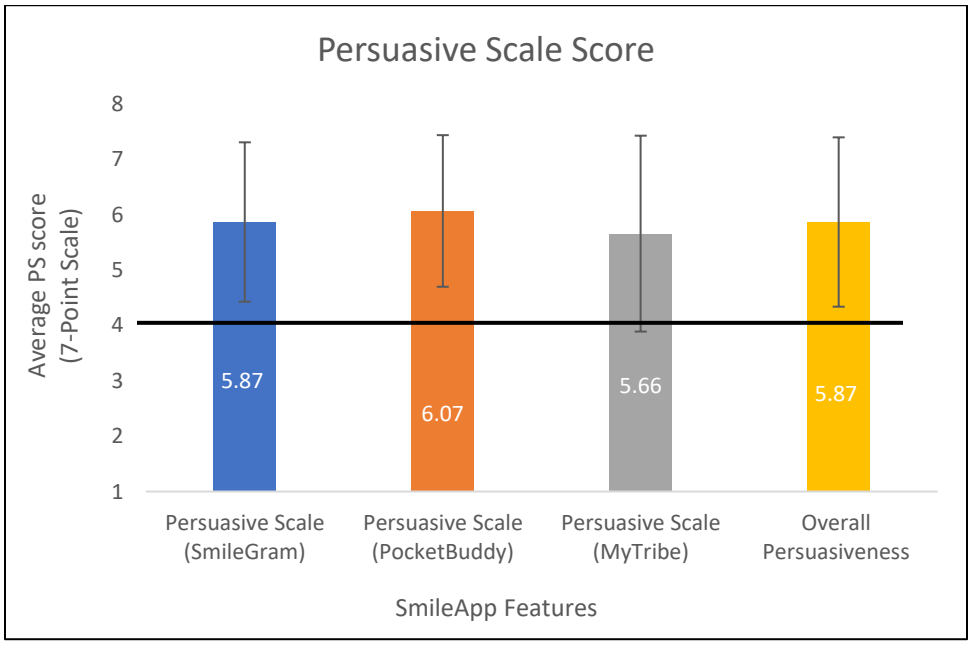


Figure 5.20 A bar chart showing the persuasive score of each feature and the overall persuasiveness of the app in general.

5.2.6.1 Measure of Persuasiveness with Respect to Demographic Factors

We examined the persuasiveness of each of the features of the SmileApp depending on the demographic factors of participants' age, gender, and education. The results of an RM-ANOVA as shown in Table 5.22 show that there is a significant difference in the persuasiveness of the features (SmileGram, PocketBuddy, and MyTribe).

Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 3.606$, $p = .165$ and therefore, Sphericity was assumed. Overall, the results show a significant effect which means that there is a significant difference in persuasiveness among the 3 features (SmileGram, PocketBuddy and MyTribe) $F(2,200) = 5.294$, $p = .006$, $\eta_p 2 = .05$. A pairwise comparison with Bonferroni correction shows that PocketBuddy was the most persuasive feature, followed by SmileGram and MyTribe.

Table 5.22 RM-ANOVA table (a within – and between-subject design) for persuasiveness and demographic factors

	Test of Within-Subject Effects s				
Demographic Factors	F	df	df (error)	p	η_p^2
Overall	4.805	2	186	0.009	0.05
Age	0.553	4	182	0.697	0.012
Gender	0.655	2	184	0.520	0.012
Level of Education	0.536	6	180	0.781	0.018

Concerning age, Mauchly's Test of Sphericity indicated that the assumption of sphericity, χ^2 (2) = 4.51, $p = .105$. There was no significant main effect of age on persuasiveness, F (4,182) = 0.553, p = .697, $\eta_p^2 = .012$.

Mauchly's Test of Sphericity indicated that the assumption of sphericity, χ^2 (2) = 4.794, $p = .091$ for gender. There was no significant main effect of gender on persuasiveness, F (2,184) = 0.655, $p = .52$, $\eta p^2 = .007$.

Mauchly's Test of Sphericity indicated the assumption of sphericity, χ^2 (2) = 4.817, p =.090 for education level. There was no significant main effect of education on persuasiveness, F (6,180) = 0.536, p = .781, η_p^2 = .018.

5.2.7 Impact and Usage of SmileApp across demographic factors

To gain insights into the utilization patterns exhibited by our study participants, we analyzed the usage log data extracted from the SmileApp database. This analysis aimed to provide a comprehensive overview of the participants' engagement with each feature of the application. The findings, depicted in Figure 5.21, indicate that SmileGram emerged as the most frequently utilized feature, followed by PocketBuddy and MyTribe.

Furthermore, we delved into the examination of usage patterns daily. Our analysis revealed an interesting trend: Participants exhibited higher app usage on weekdays (Monday to Friday) compared to weekends, as depicted in Figure 5.22. Additionally, we sought to explore the distribution of app usage throughout the day. Notably, our findings, illustrated in Figure 5.23, suggest that users displayed higher usage of the SmileApp during the peak period from the 7th (7 a.m.) to the 16th (4 p.m.) hour of the day.

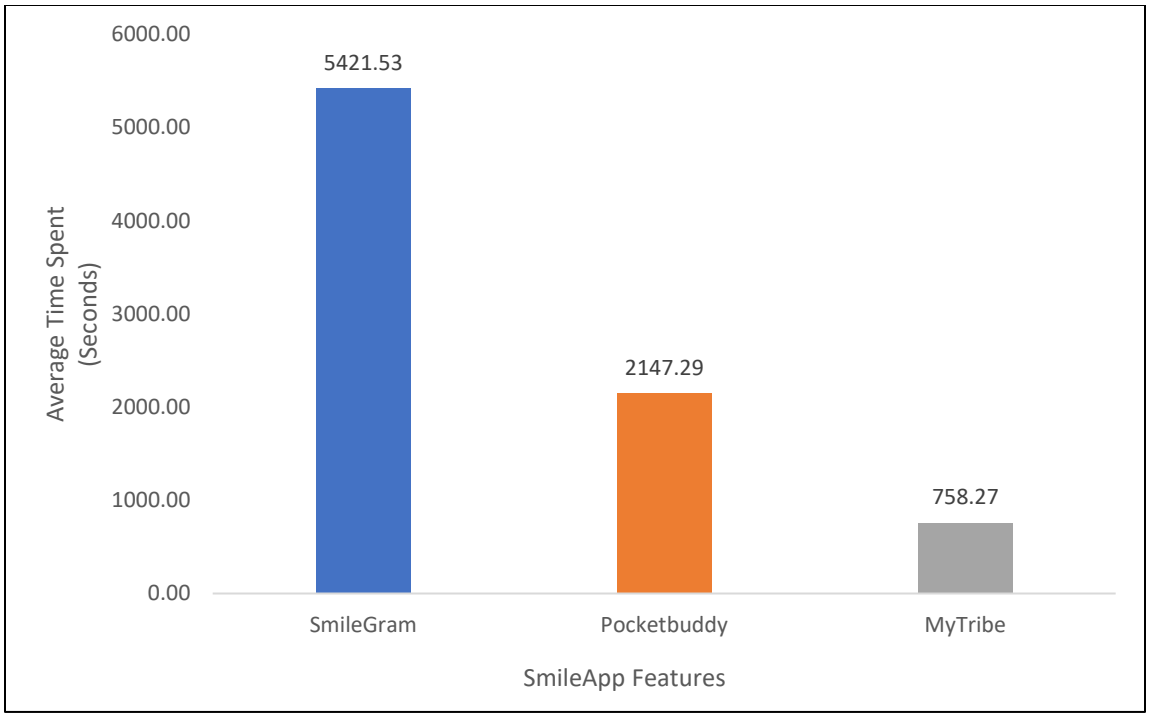


Figure 5.21 Bar chart of average time spent on each feature by participants in the 2-week study duration.

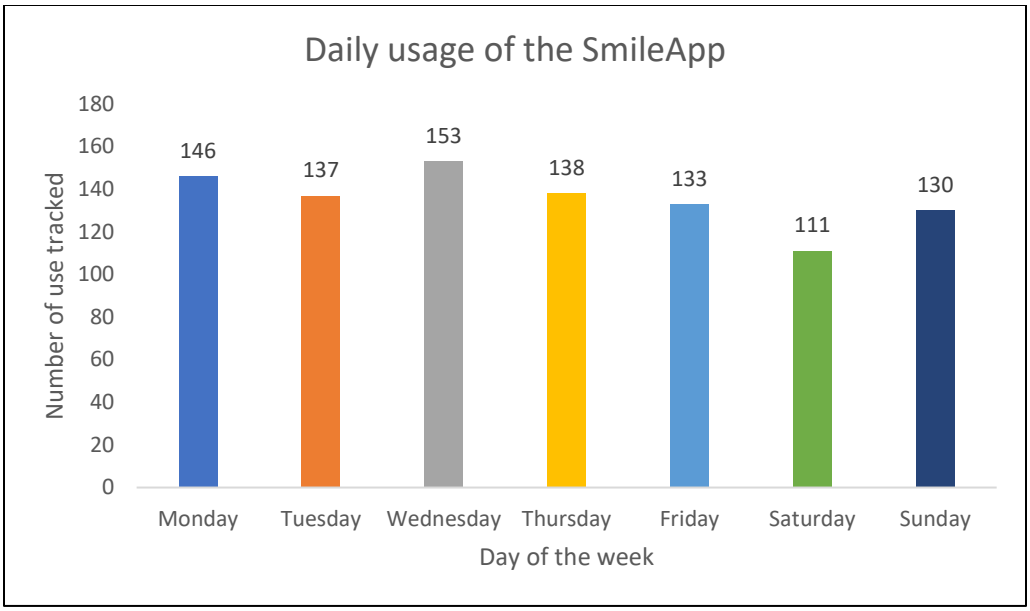


Figure 5.22 Bar chart of SmileApp use count for every day of the week.

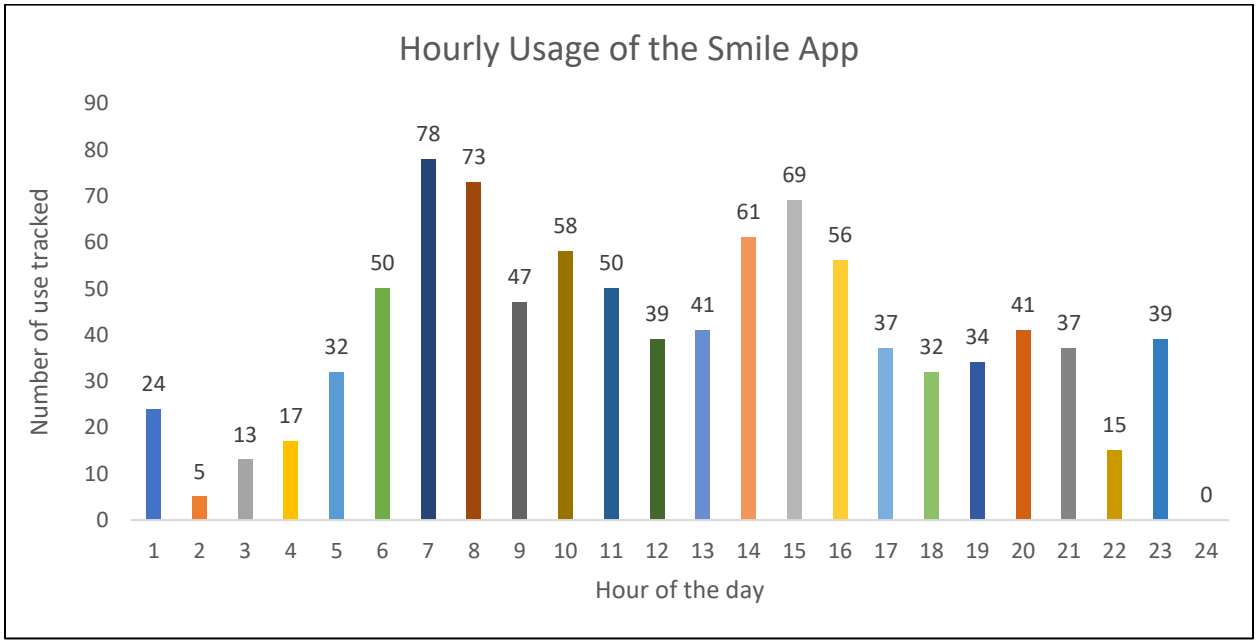


Figure 5.23 Bar chart of SmileApp use count for the hour of the day.

Moreover, our investigation extended to examine the usage patterns exhibited by male and female participants. Through meticulous analysis, as illustrated in Figure 5.24, we discovered noteworthy distinctions in the utilization behaviour between the two genders. Specifically, male participants demonstrated higher engagement with SmileApp during weekends, whereas female participants

exhibited relatively similar levels of usage throughout the weekdays. However, when considering the distribution of app usage across gender, the data revealed a minimal disparity in terms of the time of day at which participants accessed the application (see Figure 5.25).

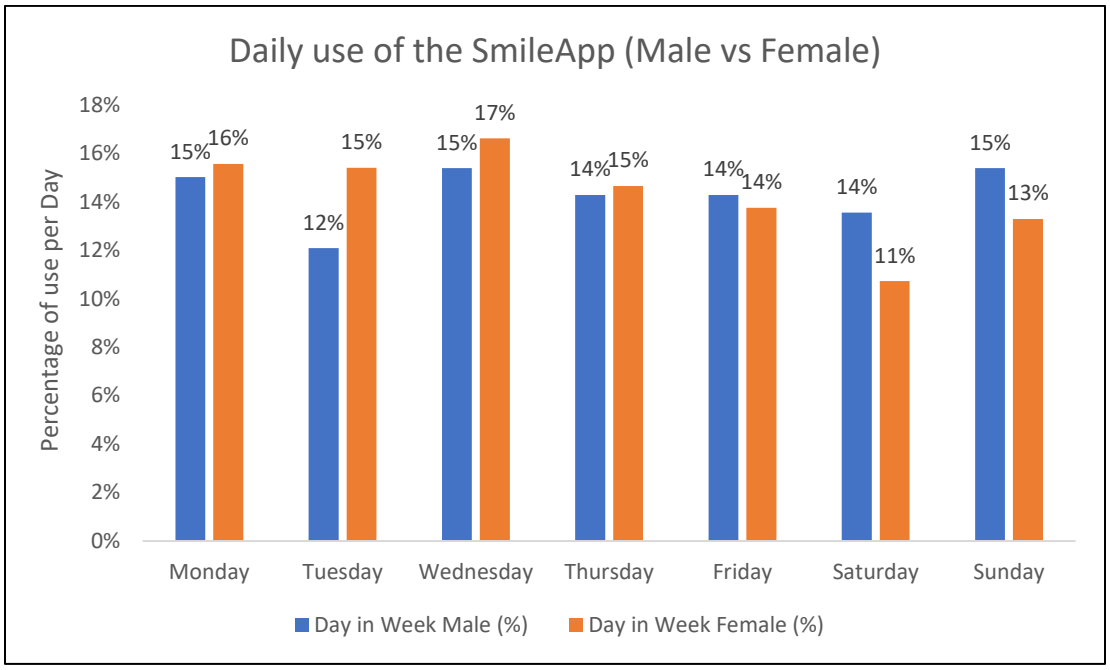


Figure 5.24 Bar chart showing daily percentage use of SmileApp by Male and Female participants.

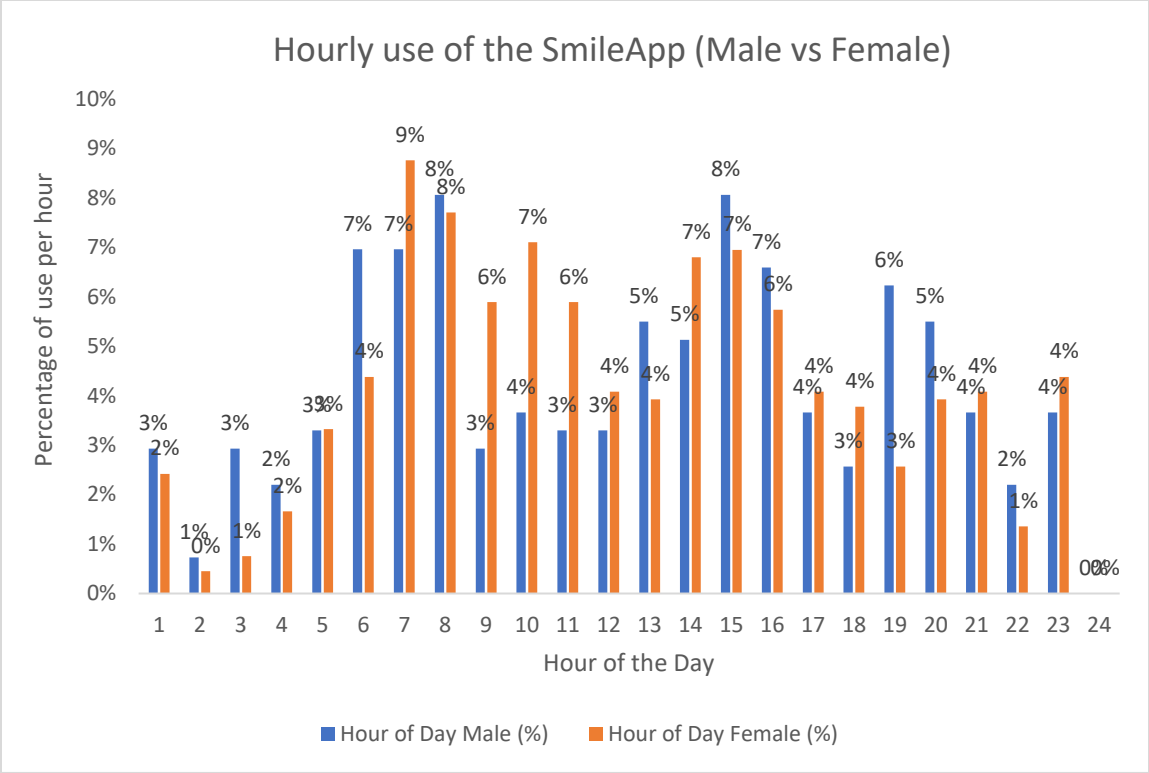


Figure 5.25 Bar chart showing hourly percentage use of SmileApp by Male and Female participants.

Furthermore, we conducted a series of repeated measures ANOVA (Table 5.23) to examine the interaction effects between subjective measures (happiness, social connectedness, and mood) and demographic characteristics (age, gender, and level of education). First, a measure of happiness was tested and a significant interaction effect was observed for gender, $F(1, 98) = 5.625$, $p = .020$, $\eta_p^2 = .054$. A pairwise comparison with Bonferroni correction shows that males experienced lower levels of happiness before ($M = 4.373$, $SD = .921$) than after ($M = 4.708$, $SD = .573$) the intervention. Conversely, for females, there was no statistically significant difference in levels of happiness before ($M = 4.709$, $SD = .477$) compared to after ($M = 4.676$, $SD = .627$) the intervention. This suggests that the use of the SmileApp had more effect on males. As shown in Table 5.22, none of the main effects was significant and none of the other interaction effects (happiness by age, and happiness by level of education) was significant.

Table 5.23 Repeated measure ANOVA results for subjective measures and demographic characteristics.

		RM ANOVA				
Measure	Demographics	*df*	*df* (error)	*F*	*p*	η_p^2
Oxford Happiness Scale	Age	1	97	0.964	.329	.010
	OHQ × Age	2	97	0.027	.974	.001
	Gender	1	98	3.819	.050	.038

	OHQ × Gender	1	98	5.625	.020	.054
	Education	1	96	1.410	.238	.014
	OHQ × Education	4	96	1.685	.160	.066
Social Connectedness Scale	Age	1	97	1.034	.312	.011
	SCS × Age	2	97	0.929	.399	.019
	Gender	1	98	5.035	.027	.049
	SCS × Gender	1	98	1.568	.213	.016
	Education	1	96	4.577	.035	.046
	SCS × Education	4	96	0.644	.633	.026
PANAS	Age	1	97	17.652	<.001	.154
	PANAS × Age	2	97	2.772	.067	.054
	Gender	1	98	16.356	<.001	.143
	PANAS × Gender	1	98	2.648	.107	.026
	Education	1	96	8.123	.005	.078
	PANAS × Education	4	96	1.582	.185	.062
BMIS	Age	1	84	18.354	<.001	.179
	BMIS × Age	2	84	0.346	.709	.008
	Gender	1	85	15.065	<.001	.151
	BMIS × Gender	1	85	5.570	.021	.062
	Education	1	82	15.280	<.001	.157
	BMIS × Education	4	82	.460	.765	.022

Next, a measure of social connectedness was tested and there was a significant main effect of gender, $F(1, 98) = 5.035$, $p = .027$, $\eta_p^2 = .049$, and also a significant main effect of education, $F(1, 96) = 4.577$, $p = .035$, $\eta_p^2 = .046$, but no significant main effect of age, $F(1, 97) = 1.034$, $p = .312$, $\eta_p^2 = .011$. Males seemed to have experienced lower feelings of connectedness before ($M = 4.837$, $SD = 1.215$) than after ($M = 5.243$, $SD = .879$) the intervention, and likewise females also seemed to have experienced lower feelings of connectedness before ($M = 5.160$, $SD = 1.139$) than after ($M = 5.275$, $SD = 1.161$) the intervention. This suggests that the use of the SmileApp can increase feelings of social connectedness for both males and females. As for level of education, Table 5.24, shows that all education levels experienced lower levels of connectedness before than after the intervention. This suggests that the use of the Smile app can increase the level of social connectedness for users who have different levels of education.

Table 5.24 Descriptive statistics of the level of education before and after the intervention

N = 101		Descriptive Statistics			
		PRE		POST	
Education Level	*n*	*M*	*SD*	*M*	*SD*
High school graduate	24	4.953	1.273	5.203	0.995
College diploma	11	5.227	0.766	5.284	1.131
Bachelor's degree	52	5.195	1.047	5.296	1.078
Master's degree	8	4.609	1.513	5.297	0.563
Prefer not to answer	6	4.500	1.820	5.021	1.731

Finally, a measure of mood (evaluated by the PANAS and BMIS) was tested. Results showed that there was a significant main effect of age, $F(1, 97) = 17.652$, $p < .001$, $\eta_p^2 = .154$, gender, $F(1, 98) = 16.356$, $p < .001$, $\eta_p^2 = .043$, and education $F(1, 96) = 8.123$, $p = .005$, $\eta_p^2 = .078$. Likewise, results also showed that there was a significant main effect of age, $F(1, 84) = 18.354$, $p < .001$, $\eta_p^2 = .179$, gender, $F(1, 85) = 15.065$, $p < .001$, $\eta_p^2 = .151$, and education $F(1, 82) = 15.280$, $p < .001$, $\eta_p^2 = .157$, as well as a significant interaction effect between mood and gender, $F(1, 85) = 5.570$, $p < .021$, $\eta_p^2 = .062$, as evaluated by the BMIS. From both the PANAS and the BMIS, all age groups seemed to have experienced less positive moods before compared to after the intervention (Table 5.25), all gender types seemed to have experienced less positive moods before compared to after the intervention (Table 5.25), and all education level seemed to have experienced less positive moods before compared to after the intervention, except for individuals who are high school graduates (Table 5.25). Collectively, this suggests that the use of the SmileApp can elicit more positive moods helping users to experience an increase in positive emotions, except for individuals who are high school graduates.

Table 5.25 Descriptive statistics for demographic characteristics with respect to mood as evaluated by the PANAS and BMIS.

		PANAS (N = 100)					BMIS (N = 87)				
		n	PRE		POST		*n*	PRE		POST	
Demographic characteristics			*M*	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*
Age	18-25 years	47	3.893	.616	3.988	.627	41	43.634	2.790	44.963	2.717
	26-35 years	38	3.795	.578	4.063	.502	33	44.288	4.703	46.212	3.072
	36-45 years	15	3.750	.685	4.267	.597	13	43.115	4.334	45.039	3.178
Gender	Male	36	3.690	.661	4.057	.576	31	44.790	2.647	45.339	2.996
	Female	64	3.928	.567	4.084	.570	56	43.259	4.270	45.509	2.953
Education	High school graduate	24	4.015	.500	3.965	.634	21	43.512	2.487	44.381	2.765
	College diploma	11	3.727	.767	4.050	.590	10	43.825	2.848	45.800	2.679
	Bachelor's degree	52	3.807	.629	4.113	.583	43	44.814	3.486	46.547	2.492
	Master's degree	8	3.813	.631	4.188	.471	8	40.063	7.044	42.500	3.655
	Prefer not to answer	6	3.658	.497	3.883	.481	5	42.300	3.007	44.500	2.574

5.3 Qualitative Analysis

To obtain general feedback and a broader perspective of participants' experiences, we collected qualitative data to better understand the users' views about SmileApp and any possible recommendation(s). We conducted semi-structured interviews in addition to the open-ended questions in the post-study survey, where participants were allowed to share more detailed information about the SmileApp app and their general experiences. 23 participants opted for this optional interview which was conducted by the lead researcher. There were no criteria for participation in the interview as all participants in the study were qualified for the interview. Hence we performed a thematic analysis [172] on the data using NVivo software to organize and uncover patterns in the collected data[181].

To conduct this thematic analysis [172], we transcribed the interview recording and then we employed Braun and Clarke's [173] six-step process to analyze the qualitative data [182] from both the interview and the qualitative data collected from the post-study questionnaire.

1. *Become familiar with the data* – we read the transcribed interview data repeatedly to have a full and grounded understanding of what details are in the data.
2. *Generate initial codes* – While reading through the data, we noted concepts and participants' ideas as code. This code represents the most basic unit of analysis that breaks what the participant was saying into small chunks with each chunk representing an idea. We uncovered about 21 codes from the entire qualitative data which formed the building blocks of thematic analysis.
3. *Search for themes* – After coding the data, we now try to make more sense of the codes by aggregating related codes into higher-level topics or themes. These relationships among codes were based on semantics. Codes with close ideas, concepts and meanings were grouped as a theme, and we ensured the code supported the theme the participants were communicating. We aggregated these codes and arrived at 10 initial themes also known as the "candidate theme"[182].
4. *Review themes* – We revisited the data coded in the component codes to determine if the data sufficiently supports the theme. At this point, we renamed the themes and collapsed some of the themes into sub-themes which left us with 6 more refined themes.
5. *Define themes* – At this stage, we refined the names of the themes to ensure that they are on the same semantic plane as the underlying idea. We ensured the name of the themes represents the underlying coded data.
6. The Last step of these six steps is telling the story of the qualitative data which we will be doing below for each of the themes.

This analysis aimed to identify and explore key themes related to participants' interest in using the SmileApp, the impact and general perception of the SmileApp. The analysis revealed a consistent and overwhelmingly positive response, with a majority of participants expressing their admiration for the app's innovative features, aesthetic design and the impact it had on them which resulted in 6 themes we will discuss in the subsections below.

5.3.1 SmileApp: An Innovative and Interesting Way to Make People Smile.

5.3.1.1 Unique and Innovative

Most participants found the SmileApp to be unique and innovative especially the SmileGram that allows them to play games with their smile; this is the first of its kind to the best of our knowledge

and participants re-echoed this through their comments during the semi-structured interview. Below is a list of such comments with minor grammatical and spelling errors corrected:

"*Interesting**. I've never had to do something like that before** and having a piece of technology to encourage me to do something. I thought was a very interesting and new experience for me. I was using it so that that was kind of interesting.*" P1

"*... **my first time using that kind of app that will require one to actually smile**. When I am not in a good mood, I just open the app and Smile.*" P13

5.3.1.2 Interesting

The analysis also revealed a widespread interest in the app among participants, it shows a spike in interest in using the app to improve their mental wellbeing and regulate their emotions. Participants also identified the source and features of the app that drove this overall appeal of which SmileGram, which is our innovative game played with a smile was a leading feature to spark participants' interest. We captured some comments from participants:

"***Each time I'm smiling looking into the app. It's fun. Like when I'm smiling**, even my daughter will join me and say, keep smiling, keep smiling*." P23

P43: "*At first, it's a bit funny and confusing, **but getting to the next stage, I found it was very interesting, I couldn't frown. I had to smile all through to get to the next stages and I kind of got used to it**, I started smiling a lot of the time unconsciously.*"

"*I recommended it to some of my friends since now, yeah. **I find it very interesting, I know my friends would like it too**, so I recommended it to them and I will still recommend it to other people, yes.*" P7.

"***There is this urge to continue to or just want to continue smiling. I forgot that the object has already overlapped** and it just runs off and starts again, you know*". P21

"*It gave me nice tips too about smiling. After maybe three or four or maybe five things it will give me a little message. Do I want to continue or stop? **It will give me some fun facts. That was kind of interesting too**.*" P1

"***The interaction is captivating and interesting***" P66

". . . ***hearing the sound of "keep smiling" I am thrilled***!" P85

"***The moving image alone is captivating. Because it's not just your smile, but the fact that it is tied to moving objects***. *That's just the key features and I also suggest maybe some of those colours*." P16

5.3.2 Stress-Relieving Source

The insights gained from this analysis provide valuable information and show a pattern of participants using the app as an effective way to manage stress. From the interview, we observed a common consensus among participants on how the app was useful for them to relieve stress. This theme shows one of the positive impacts of SmileApp and reinforces that it achieved the design objective of improving users' emotions. Below are comments from participants:

"***It was really stress-relieving because at some point when you get stressed up, you just go look at the app***. *Since it connects with your smile, your smile is all you need to do and in the process all the facial muscles get relaxed*." P16

"*I never knew that smiling can have something correlating to feeling good.* ***I remember there was a day I was feeling anxious. Like I had a lot of pain and I tried using the app. I just used the app not as a remedy to my anxiety; I just wanted to use it suddenly I realized when I started using the app I started feeling much better***. *So, after that day, I realized that, OK, this smiling of a thing can, you know help me even when you're faking it. So, it's a good idea and to be honest I play with the smiling app more than the chat. I use the chat slightly but overall; I love the smile and I love the app in general.*" P2

"***It's a brilliant way to ease stress as you forget about some things happening to you while using the app***." P20.

"*My experience with this app has been so amazing.* ***It helps me to achieve my aim in terms of trying to live up to reduce stress.***" P8

"*So even if, like you are worn out, you're stressed out, just follow. I Keep smiling, keep smiling. It kind of relieves you. So, I think I like this.*" P16

"***Ohh I'd find it useful because it makes me relax, you know, we have a lot of things on our head, here in this country there are a lot of things on my head***. *So, when I feel worn out, I*

remember the Smile App. So it helps me relieve pressure and stress. I just like it! It makes me have fun, like a fun time." P23.

" ***There are times you know I'm choked up with work and all of that, so it helps to relieve stress for me***. *Yes. So because you have to force yourself to smile even if you don't want to do so*." P7

"*It's very useful, especially for me, that juggle between my career and entrepreneurship. I work, and I do business. You know, most times I don't even get time to go out with friends and relax.* ***So during the period, we were reviewing this app, I think one of the things that helped me is that I could be in the office. And when I see that I'm stressed, I can just open it and smile***. *One day my colleague was like Why are You smiling*." P9

"*I want to say I really thank you for coming up with such an app at this moment when the world is actually feeling down* ***when there are many challenges in this part of the world. And I really thank you so much because this app has really impacted my life. Yes, I will say it impacted my life positively***." P13

Participants' comments also revealed that work and office was the major source of stress they experienced as shown in sample comments below:

"*Well, maybe* ***if I am working and then I'm not getting the result I need***. *I will feel stressed. So I am mostly stressed with work*" P15

"*Sometimes emotional stress can pop up anytime,* ***but work stress is the most***. *So, I use this app to rest*." P19

"I get stressed *when I feel I'm not being heard* ***especially at work***." P20.

5.3.3 Mood Enhancement and Motivation to Smile

We also discovered a trend in participants' responses which provides valuable insight into the fact that participants perceive the SmileApp as an effective tool for mood enhancement and promoting Smiling and laughter. This indicated that the app was valuable to the participants in regulating their mood and enhancing general well-being which is in line with the app design objectives. Below are some comments from participants:

"*Using the app, mostly the SmileGram, it* ***relieves me of headaches and enhances my mood*** *and distracts me from whatever was bothering me at the moment.*" P74

"*Yeah, really, the thing has ever* ***improved on my level of everyone laughing*** *at times because. I'm always on it.*" P11

"***I find the SmileGram very, very funny****, especially when I must open my teeth. Even when I don't feel like smiling. I just must open because I want to really colour the world and, you know, so it makes a whole lot of sense*." P12

"*I get entertained while I'm smiling and, I like the chatbot feature very well. I think that's my favourite. It's entertaining and helps in keeping one company, making* ***you feel like it's your companion****. It's always there*" P4.

"*You know to wind down and try* ***distracting myself from everything that is frustrating me*** *in the day. So, I found it highly useful.*" P2

" *Oh I'd be very useful for people to at least* ***help reduce depression*** *Also it gives me something to do to smile more.*" P5

"*If I don't have reason to smile again, the app now comes to mind and* ***I'll just take up SmileApp and then I will start smiling***." P16

"*Most times I found myself* ***laughing stuff, just smiling****. Because one keeps* ***smiling on the app sometimes you just end up laughing***." P20

"*It was a little funny, honestly. One day I was down and then, you know, because you will see your camera there that will pop up and you will see the way your shiny smiley face.* ***It was easy for me to smile***." P12

"*I saw some people dropping some messages encouraging support. Keep pushing. You do well. Don't give up and all that. So****, I felt good and supported***." P9

"*It was kind of funny, It was easy. But I noticed that sometimes when I try to smile, I try to hold my smile so that I can be able to catch up with the matching game. You know****, I found myself, over smiling****. **So, I can say it's even easier to smile**, you know you have to manage yourself with the whole game so you will not be attached to it."* P2

"*Yeah, really, the SmileApp (the SmileGram feature) has* ***improved my level of laughing*** *at times because I'm always on it*" P11.

"*I enjoy it while making me laugh, I saw it was an awesome experience* ***because sometimes when I'm feeling a headache and I feel maybe I'm stressed when I use that app as in, I'm just looking at it and smiling****. I don't know there's some miracles the smile does to me*." P19.

5.3.4 SmileApp was Intuitive and Aesthetically Appealing

From the thematic analysis of feedback, we saw mentions about the aesthetic of the SmileApp with a mention of the icons and labels, logical flow and colours used. Generally, the view of participants was predominantly positive. Users showed appreciation for the colours and addressed the icons as clear and accurately representing the app's purpose. They found it helpful when the labels matched the icon, making it easier to use.

A common recommendation was to provide more icons and give users the flexibility to choose their preferred colour and colour preferences differ from individual to individual, however, in all they found the green colour appropriate and the label well presented. Below are sample comments from participants.

"*The Icons and labels are clearly labelled, and it's user-friendly*" P8.

"*It can be seen very clearly and all instructions are well organized*" P10.

"***I found the app interesting and easy to use because the instructions on how to use it are clearly stated as you click on any icon****. The icon portrays what it stands for*" P13

"*Everything was stated clearly. Easy to navigate your way around the app*" P15.

"*The* ***icons and labels*** *are very clear; I can see them clearly without straining my eyes.*" P12.

"*The* ***icons and labels*** *were very clear, and I must confess it was fun using the SmileApp*" P44.

"*All the icons are very clear and coherent indicating the representative nature of those icons.*"P64.

"*It was* ***easy to understand, and the sound visuals*** *made it better*" P143.

"*I was able to* ***understand all well with no confusion*** *at all*" P146.

"***Each icon and label present on the app had a perfect description of what to see and expect****; they were self-explanatory.*" P174.

In terms of the app's logical flow, the majority of users had positive views, finding the app logical and intuitive. They liked how navigation within the app was easy and they were able to complete the tasks with no assistance. The overall view of participants regarding the Smile App's colour was predominantly positive. Users appreciated the well-chosen and harmonious colours that created a pleasant and engaging interface. Sample participants' comments include the following:

"*Colours say a lot and* ***the app gives off a happy vibe due to its colour***" P87.

"***It is so beautiful, and it fits in perfectly to every mood***" P93.

"*The colour combination****, green and orange, gave the app a cheerful and warm outlook****. The colours are welcoming and could make you stay relaxed while using the app.*" P15.

"*The blending of* ***the green colour with the yellow colour gave the app a nice outfit****."* P20.

"*Orange and leaf green* ***are beautiful colour combinations***" P61.

"*The* ***colours are appropriate and catchy****. I find it very interesting.*" P77.

"*The* ***colour choices are appealing and perfect*** *for this type of app.*" P116.

"*I like the yellow colour before it turns to green after smiling to complete the pattern. Also****, the colour of the smile app was top notch and very bright and beautiful****.*" P165.

On the contrary, there were a few participants who had opposing views about the app's colours and had different ideas on how and where the colour would have been placed. The comments of these participants were captured as shown below:

"*The* ***colours were too bright****, and the shade of the colours is slightly mixed.*" P10.

"*I would suggest colours like; yellow, orange and some other blend of bright, attractive and charming colour should be thought of. This is just for the green response background. I think*

I'm ok with the other colour interface. Lastly, I would suggest an option to choose colour mode should be provided on the App." P47.

Overall, the SmileApp was aesthetically appealing, and users liked the design which was expressed in their comments and quantitative data analysis.

5.3.5 Enduring Engagement: A Long-Term Connection with the App Beyond Study

We found that participants indicated a strong interest in using the app beyond the study. This finding could be attributed to the emotional benefits derived and the intriguing interest they have in the app. During the semi-structured interviews, many participants highlighted their intention to continue using the app after the study as seen in sample comments below:

"*I've gotten a lot out of this.* ***I will not stop using it****. I will not at all, because the app brings out so many good things.*" P11.

"*If there is no intention to monetize it,* ***if it will like free stuff where I can go to and release stress, I don't mind continuing using it****. It's something I can recommend to my mom for her to use.*" P19.

"*Yeah, I don't have any intention of uninstalling it. I see myself using it. You know, when I feel like I need to distract myself from maybe my daily activity.* ***Yeah, I definitely will look forward to using the app even after this study****.*" P2.

"***Will use it after the study, it helps me relieve stress****. So, on days when I have hectic work and I need to rest, I just lie on my bed, and bring the app. I'm smiling and* ***I've already recommended it to my husband****. So, when I'm done. So, if anything, the days when I'm smiling are as if the whole family is smiling with the app.*" P23.

"***Definitely will keep using it after the study. Especially PocketBuddy****. Because like I said, it informs. So sometimes you just want to play without somebody else. And yeah, I keep chatting with it. I chat with it.*" P4.

"***I will recommend it to others Because it makes people smile*** *and I want people to smile.*" P5.

5.3.6 Suggested Improvement

Despite the overwhelming positive comments from the participants, they highlighted some areas for potential improvement. One participant mentioned that "*I didn't feel like I kind of started building the connection with one specific or maybe even a group or two or three specific people because again it was anonymous*." P1. Another participant stated, "*I tried it, and I didn't get a response on time throughout the time I needed it, I think later in the day I got a lot of responses*." -P12

In this section, we highlighted the suggestions from participants that could be employed to improve SmileApp and to build other mHealth applications. These suggestions are important to us because they give a better perspective from more diverse users. These recommendations will help us finetune the SmileApp and serve as a guide for future researchers. In conclusion, the recommendations provided by the participants included several notable features to enhance SmileApp. These recommendations encompassed the incorporation of a customizable colour scheme, the inclusion of stickers akin to those found in conventional social media platforms, the integration of text-to-voice functionality for verbal interaction between users and the chatbot, as well as the capacity to detect fake smiles, offline mood tracking, and support for multi-user functionality, feedback for MyTribe messages sent and music in the background for the SmileGram feature. These valuable suggestions aimed to further augment the user experience and expand the capabilities of the app. Below are sample comments from users:

"*I would suggest an option to choose colour mode should be provided on the App.*" P47.

"*Emojis and stickers are one of the ways of making interaction more friendly, I think it should be employed, if possible, picture interaction too*" P8.

"I*'d suggest that you create an option to read Adaeze's (PocketBuddy) messages via voice I'd want to know how her voice sounds, I think it will help in the connection with the AI Sometimes, texts may not mean so much, you just want to hear a voice after going through a lot in the day. Also, For the community feature (MyTribe), users should write their feelings instead of choosing from a set of emotions, I also think there should be room for feedback from people to whom you sent support messages. I would like to know if my messages did make a change. Those little 'thank you' feedbacks are encouraging enough.*" P15.

"*The app should be restructured in such a way that it would be able to differentiate between fake and real smiles"* P69.

"*I will suggest that there will be light music playing in the background while people are doing the smiling challenge*." P116.

"*I suggest more mood emoji should be added in MyTribe*" P150.

"If it can be possible to use without internet because it's not every day, I have data but want to use the app" P173.

"*So maybe we have like 3 or maybe 5 individuals you can chat with you again. So, you choose whoever you feel like, chatting with.*" P12.

Chapter 6 : DISCUSSION

This study aimed to investigate the effectiveness of the SmileApp which was specifically designed to promote smiling and elicit a positive mood. We conducted the study in the wild with 101 participants for two weeks and analyzed the data collected. The findings extracted from this analysis helped us answer our research questions and gave insight into the areas that can be further explored and expanded on by future research. In this chapter, we discuss our findings and how they addressed our research questions. We also discuss the limitations of our study, recommend future directions of the work, and reiterate the contributions of the thesis to the body of knowledge at large.

6.1 The SmileApp design and evaluation

The SmileApp is an evidence-based app that was developed based on well-established theories of mood regulation and behaviour change systems design. In developing the SmileApp, we incorporated the Flow theory [104], Happiness model [107], PERMA model [106] and PSD Model [32] These models and theories detailed in Chapter 3 of this work provided a foundation for the development of the app, ensuring that it effectively addressed the research objectives and influenced the design considerations of SmileApp.

A decoupled architecture was used to separate components ensuring resource-intensive tasks could be offloaded to more capable devices or backend servers to allow the SmileApp to run on low-performance devices and increase a larger user base. To evaluate the effectiveness of the SmileApp and its impact on users, we mimicked real-life scenarios by allowing users to use the SmileApp in their natural environment.

6.2 Insights from SmileApp evaluation: Key Findings and Implications

In this section, we reflect on the results of our study with a key focus on how they address the five key research questions that guided this study. Here, we elaborate on the answer to each of the research questions and how they were answered, providing valuable insight into the underlying phenomena and the implications which is the contribution of the SmileApp to the HCI body of knowledge. We aim to shed light on the intricacies of our research objectives. We discuss the findings concerning each research question, exploring their significance, implications, and potential contributions to the existing body of knowledge. This section constitutes a pivotal point

in our research, wherein the elucidation of these research questions provides a pathway towards a more profound comprehension of the outcomes of our study.

6.2.1 Impact of SmileApp on eliciting positive mood

To evaluate whether the SmileApp was able to elicit positive moods, we defined RQ1 "*How effective is SmileApp for eliciting positive mood?*". As shown in Figure 5.11 of Section 5.2.3, the SmileApp was effective in improving the mood of participants by showing a statistically significant increase in positive moods and a statistically significant decrease in negative moods. We evaluated this outcome by using the Brief Mood Introspection Scale (BMIS) and the Oxford Happiness Questionnaire (OHQ) to collect extra information about mood and well-being.

The BMIS is a 4-point scale which assesses mood fluctuations and emotional reactivity which has been employed in several studies [176][177][178][179]. We measured this before and after the intervention and the result of our analysis revealed a statistically significant improvement in mood as shown in Figure 5.14 of sections 5.2.3.1. The findings of our analysis reveal that the SmileApp was effective in having significant improvement in the happiness level of participants who used the app for a longer period while participants who did not use the SmileApp above the average time of all participants showed improvement in OHQ score but it was not statistically significant see Figure 5.4 and Figure 5.5 in Section 5.2.1. Perhaps they enjoyed the game and so used it more. This reiterates the need to design interventions to engage users and encourage continuous usage over the long term. To design intervention is one thing but to get people to use it is another. Research has shown that many health interventions experience high attrition rates [183]. Our result shed light on how low engagement is also a major factor that could impact the impact of an intervention. Even when an intervention is carefully designed, employing an evidence-based approach, it will not work unless it's engaged by the users for a reasonable length of time. This stresses the importance of persuasive strategies and gamification elements that have been shown to improve engagement with interventions. By using SmileApp more, some users were able to reap the benefits. This answered the first research question RQ1, implying that the SmileApp was effective in eliciting a positive mood.

6.2.2 The Usability of SmileApp in Fostering Positive Mood

Studies have shown that the usability of a system is linked to its usefulness and this influences how users evaluate the system [184]. In our study, we investigated the usability of the SmileApp using the second research question RQ2 "*How engaging and Usable is the SmileApp for users to accomplish their goals of activating positive mood?*". We employed the system usability scale (SUS) and User Experience Questionnaire (UEQ) to evaluate usability and user experience.

The System Usability Scale (SUS) is a widely used questionnaire-based instrument employed in measuring the perceived usability of a system which assesses the user's subjective perception of the system's ease of use, efficiency, learnability, and overall user satisfaction. It provides valuable insights into users' perceptions of usability, allowing researchers and designers to understand how usable their system is. The result from our analysis showed that the average SUS score was significantly higher than the average SUS score of an average of 500 studies (68) [185] [180] as shown in Table 5.18 Section 5.2.3.1. The result of our analysis also showed a positive statistically significant improvement in the UES score across 3 subscales (Usability, Aesthetics, and Reward) as shown in Table 5.18 in Section 5.2.4 this shows a strong indication that users perceived the SmileApp to be usable, aesthetically appealing and rewarding, this reinforces the finding of the SUS. However, the result also showed low focused attention.

The results also indicated that the intervention's ability to sustain users' attention may not influence its perceived usability and usefulness. Despite low focused attention, users perceived the SmileApp to be aesthetically appealing, usable, and rewarding. Although SmileApp includes engaging activities to capture users' attention, we were unable to control other contexts that may impact participants' attention levels such as the participants' surrounding environment as the study was conducted in a naturalistic setting. A study has shown that task demand and surrounding context can influence users' attention [186]. The data collected from the app usage showed that participants used the app more during work hours (Figure 5.23) hence we recommend considering users' surroundings by future researchers in this area for example, participants who work or spend most of their time in a fast-paced environment like a security guard or chef may find it difficult to concentrate on the app in such environment. In general, users find SmileApp easy to use and had a good experience using it which made them happy and suggest that they are likely to use it in the

future. This answered the second research question RQ2 and showed that users found the SmileApp usable and engaging to elicit positive moods.

6.2.3 Impact of SmileApp in Promoting Social Connectivity

Studies have shown that computer-mediated social interaction can benefit users (i.e., reduce negative mood) [187]. Our app was designed to have a social component (MyTribe) that promotes social connectedness as a means to improve users' moods. We made this our third research question RQ3 "*How effective is SmileApp in helping users find social support?"*, to investigate if SmileApp was efficient in promoting social connectedness. The result of our study shows a significant improvement in the feeling of social connectedness by participants over the 2 weeks Figure 5.7 and Figure 5.8 in Section 5.2.2. This supports RQ3. The findings of my study have revealed that social connectedness can also be achieved through the reception of supportive messages from anonymous users in a one-way communication context. This discovery serves as a significant insight for HCI researchers and developers of interventions aimed at enhancing social connectedness, suggesting that incorporating this strategy into their interventions may be beneficial.

6.2.4 Continued use of the SmileApp.

In the study, we were also interested in knowing the participants' position on prolonged use of the SmileApp. We added this as the fourth research question "*How effective is the Smile App for motivating continued use?"* to guide the measurement of future intent to use the SmileApp. This will guide us to understand the motivation behind this intention to use the SmileApp and to know whether it is intrinsic and or influenced by external factors. From Table 5.20 in Section 5.2.5, we can see the scores of FIS and IMI were significantly higher than the neutral value, indicating a strong intention to continue using the SmileApp. Also, the IMI result confirmed that participants were intrinsically motivated to use the SmileApp. The result from the qualitative analysis showed that users enjoyed using the SmileApp and users indicated interest to continue using the app as seen in section 5.3.1.2 and section 5.3.5 thereby answering RQ4. The high scores in future intention and intrinsic motivation indicate participants' readiness to adopt a novel approach in their pursuit of mental well-being. This finding highlights the proactive behaviour exhibited by individuals in their efforts to achieve their goals related to mental well-being. The study findings also emphasized the significance of incorporating enjoyable and engaging elements into mHealth apps rather than maintaining a monotonous user experience. HCI researchers should actively

consider integrating fun features within the design of mHealth apps to foster prolonged user engagement and adherence to the intended usage. This recommendation underscores the importance of creating a positive and enjoyable environment within the app to enhance user satisfaction and promote sustained utilization.

6.2.5 Persuasiveness of SmileApp.

We addressed the fifth research question ("*How persuasive and useful is SmileApp in improving user's mood?*") by investigating the perceived persuasiveness of SmileApp. We collected persuasiveness data for each of the three main features on the SmileApp (SmileGram, PocketBuddy and MyTribe).

First, we checked if the features were significantly persuasive. The result from our study showed that each of the three features of the SmileApp (SmileGram, PocketBuddy and MyTribe) were all statistically significant above the midpoint of 4 as shown in Table 5.21 implying that participants perceived the three features to be significantly persuasive. From the result, SmileGram emerged as the most persuasive feature to the participants, followed by Mytribe, and lastly PocketBuddy. Although all three features were perceived to possess a statistically significant level of persuasiveness, SmileGram garnered the highest ratings in terms of its impact and influence on user behaviour. This observation highlights the varying degrees of persuasive effectiveness exhibited by different features within the app, underscoring the importance of tailoring and optimizing the design of each feature to maximize its persuasive potential. Also, we went further and compared the mean differences of the persuasiveness of each of the features which showed only a statistically significant difference between the means of the PocketBuddy feature and the MyTribe feature. The results obtained from the persuasive scale, the IMI (Intrinsic Motivation Inventory) value/usefulness subscale, and the themes from qualitative data, as presented in Section 5.3.3, provided valuable insights and facilitated the comprehensive response to Research Question 5. These combined findings shed light on various aspects related to the effectiveness, user perception, and qualitative experiences associated with SmileApp.

The high persuasiveness score of SmileApp reinforced that the app features and design elements were effective in capturing users' attention enhancing their engagement, and ultimately driving them towards continued use. This reinforced the fact that low focused attention recorded is most likely not a function of the SmileApp but other contextual factors such as users'

environment. HCI researchers and mHealth app developers can leverage this insight to further optimize persuasive elements within the SmileApp or utilize similar strategies in designing future persuasive interventions.

6.2.6 Summary.

In summary, my study significantly contributes to the field of HCI by advancing knowledge on how persuasive mHealth apps can be designed to promote a positive mood. I conducted this study to show the practical implications and effectiveness of SmileApp. From Figure 5.21 the SmileGram feature was the most used. The insights gained from this thesis have the potential to drive further research, inform decision-making, and foster advancements in both academia and industry players in the mHealth domain.

6.3 Research Contributions and Recommendations

This thesis makes several contributions to the field of HCI. Firstly, it expanded our understanding of other approaches to elicit a positive mood. By providing innovative insights for encouraging people to smile more often and its impact on users. I conducted a rigorous study and analysis and identified key themes from users' responses which were previously unexplored. This sheds light on the effectiveness of the app and the user's reaction to it.

Secondly, this thesis contributes to the design, development, and evaluation of an approach for encouraging people to smile more often (as a way to fight off stress and improve mental health) by applying well-established psychological theories to designing persuasive systems. By incorporating smiles as gaming control and unlocking social messages, we defined a new way users can be persuaded to smile. This is beyond improving the mood of users but also improves the level of happiness. This approach of getting users to smile and elicit a positive mood will pave the way for more innovative designs in future studies.

Thirdly, by leveraging the usage log data, our study has provided valuable insights into the utilization behaviour of participants, shedding light on feature preferences, day-to-day variations, and temporal usage patterns across genders. These findings contribute to our understanding of user engagement with SmileApp and can inform future design considerations and personalized interventions.

By delving into the utilization patterns of male and female participants, our study has uncovered gender-related differences in app engagement on weekends as male participants appear to engage the SmileApp more on weekends unlike female participants, while usage during weekdays remained relatively consistent between male and female users. The observed discrepancy in user engagement with the SmileApp during weekends, as discerned through gender-based analysis, may potentially be attributed to the temporal constraints experienced by women stemming from their comparatively larger share of domestic responsibilities and household chores [188]. However, there was generally high engagement with SmileApp between the hours of 7 a.m. and 4 p.m. The use of the SmileApp during participants' reported work hours (as shown in Figure 5.22), which were identified as the most stressful period of their day, as indicated by participant P15's statement, "***Well, maybe if I am working and then I'm not getting the result I needed. I will feel stressed. So I am mostly stressed with work***" suggests that users turned to SmileApp as a coping mechanism to combat stress during their hectic schedules. This notion is further exemplified by the remarks of another participant, P7, who stated, "***There are times you know I'm choked up with work and all of that, so it helps to relieve stress for me***. *Yes. So because you have to force yourself to smile even if you don't want to do so.*"

Notably, these findings suggest that gender may influence the temporal dynamics of app usage to a lesser extent. These insights contribute to a more comprehensive understanding of user behaviour within the SmileApp context and can inform HCI researchers and mHealth app developers of targeted strategies for improving user experience and engagement.

Furthermore, our study introduces a new approach to designing mHealth apps that target the promotion of emotional well-being. The SmileApp comes as a suite of gaming features (SmileGram), a generative AI chatbot (PocketBuddy) and a supportive anonymous community (MyTribe) combined into one app and the positive feedback from users, provide actionable insights that can inform and guide mHealth app developers and future researchers on the possibility of combining the different genre of applications into one to achieve better outcomes.

Lastly, this thesis contributes to the field of HCI by showcasing the effectiveness and applicability of SmileApp in answering important research questions, which will help future researchers adapt our approach to design technological interventions targeting similar mental health problems and industry partners can build mental health products based on the outcome of our findings.

6.4 Recommendations

From our comprehensive analysis of the data extracted from SmileApp evaluation and the insightful findings therein, we offer some recommendations that will help both researchers and mHealth application developers who want to design an app that elicits positive emotions and better well-being. These recommendations are targeted at addressing key challenges and feedback from participants through qualitative data to give future researchers insight into future work and promote better outcomes in the next iteration of the SmileApp design (SmileApp 2.0). Leveraging on the expertise of the research team and the synthesis of the research findings, we list the recommendations below highlighting their relevance and potential impact on future research. Implementation of these recommendations has the potential to increase the acceptability, adoption and insight for future study.

1. Include User-Customizable features

The need to make the SmileApp features customizable arises from the idea that users have diverse preferences and requirements as expressed in the qualitative data. By enabling users to customize app features such as colour, notification time, avatar, and emoji according to their preferences, the app can cater to a wider range of user choices that cannot be predicted during the design phase and make the app have a personal feel and user feel a sense of ownership of the SmileApp. Users should be given the option to express how they feel instead of just picking from the list of already coded emotions. Our qualitative data shows that users preferred to be able to express themselves and how they feel using freestyle typing instead of being restricted to selecting from a list of emotions which may not be comprehensive enough or may not capture exactly what users want to express. This makes them feel restricted and not in control as shown by this sample comment from participants' interviews: "*Users should write their feelings instead of choosing from a set of emotions, I also think there should be room for feedback from people to whom you sent support messages.*" Therefore, we recommend that designers of technological intervention should increase users' feeling of a sense of control by allowing them the freedom to express their emotions in their own words. HCI research has emphasized the importance of designing interactive applications that empower users to build their sense of control [189] as it has the potential the increase engagement and user experience [190].

2. *Design to Accommodate Offline Mode*

Based on the findings and insights gained from this research study, we strongly recommend HCI researchers and mHealth app developers should design apps to accommodate offline use. The incorporation of an offline mode within the app serves as a crucial response to a significant user requirement, guaranteeing uninterrupted functionality and accessibility, particularly in scenarios where internet connectivity is limited or unavailable. The inclusion of offline mode contributes to promoting diversity and inclusion, as it acknowledges that not all individuals possess consistent financial resources to access the internet at all times. This sentiment was echoed by one of the study participants (P173), who emphasized the importance of being able to utilize the app without internet access, stating, "*If it can be possible to use without internet because it's not every day, I have data but want to use the app.*" By accommodating such user needs through the implementation of an offline mode, the app can better cater to a broader user base, enhancing inclusivity and user satisfaction.

Due to the real-time collection of usage data in our study, we were unable to implement the offline mode within SmileApp. Nonetheless, we acknowledge the indispensability of this mode as an essential component. The inclusion of an offline mode empowers users to maintain engagement with the core features and functionalities of the SmileApp, including activities such as playing SmileGram and accessing supportive messages, regardless of their online status. By providing offline access, users can experience the positive benefits of mHealth apps and regulate their moods without relying on a stable internet connection. This capability holds the potential to expand the user base, fostering greater inclusivity and diversity among the app's users.

3. *Include Background Music*

A notable recommendation derived from the findings of this research study involves the incorporation of background music into the SmileGram feature, particularly when users are engaging in the SmileGram game and actively participating in the smile challenge. One participant (P116) expressed their suggestion, stating, "*I will suggest that there will be light music playing in the background while people are doing the smiling challenge.*" It is proposed that the inclusion of entertaining music or tones during the game can enhance the overall experience and engagement of users. This recommendation emphasizes the potential benefits of incorporating background music to create a more immersive and enjoyable environment during the SmileGram activity. Adding background music can significantly enhance the user experience, creating a more

immersive and engaging environment for users. Carefully selected and well-designed background music can evoke emotions as studies have shown that music enhances mood [191] and giving users the ability to select their music will make the use of the SmileGram feature more compelling to users.

Incorporating background music and allowing a user to choose their music can tap into the powerful influence of sound on human emotions and perception. Studies have shown that familiar music has the potential to increase task enjoyment without compromising behavioural performance [192]. The music can create a sense of familiarity, comfort, or excitement and promote positive emotion which is the purpose of the SmileApp. It will also make SmileApp more enjoyable and memorable for users.

4. Allow Chatbot to Assume Multiple Users

Through the thorough analysis of the collected qualitative data, we discovered a distinct necessity to expand the range of personae available within the AI chatbot, allowing users to select the specific AI entity they prefer to engage with. This recommendation was expressed by one of the participants (P12), who suggested, "So maybe we have like 3 or maybe 5 individuals you can chat with again. So, you choose whoever you feel like, chatting with." By incorporating multiple personae into the AI chatbot, users will experience an elevated level of interactivity, offering them a broader spectrum of choices and customizable pathways during their conversations with the chatbot. This enhancement will foster greater user engagement and personalization, allowing individuals to tailor their interactions according to their preferences and needs.

Furthermore, different personae will contribute to improving user engagement and satisfaction by allowing users to feel actively involved in choosing who they converse with. It is likely to enhance the perception that the chatbot is a buddy because in real-life people choose their friends. They can be able to customize the look of the avatar and name it as they wish. They may decide to name it a friend or parent and the AI agent can adapt its conversion accordingly depending on the persona chosen by the user. The conversion tone could change depending on what role the AI agent assumes. This will not only increase user interaction, but also strengthen the bond between users and the chatbot, leading to higher levels of trust, loyalty, and continued use.

5. Ability to Detect Real and Fake Smiles

Although some research has shown that real and fake smiles have the same impact of reducing the intensity of the body's stress response, regardless of whether a person feels happy [31], users indicated an interest in SmileApp detecting real and fake smiles. The capacity to distinguish between a real and a fake smile is a feature participants will want to see. By incorporating this feature, the app can significantly enhance its functionality and offer users a more personalized and engaging experience.

The incorporation of a smile detection feature aligns with the principles of user-centric design, as highlighted by a participant's recommendation: "*The app should be restructured in such a way that it would be able to differentiate between fake and real smiles*" (P69). By integrating this capability, the app can effectively discern between genuine and simulated smiles, thereby enhancing its ability to comprehend and respond to users' emotions and intentions more accurately. This user-centric approach demonstrates a commitment to providing an intuitive and responsive user experience, fostering a deeper level of engagement and interaction with the app. By accurately distinguishing between real and fake smiles, the app can tailor its responses and notifications. This also has the potential to foster genuine connections and deliver a more immersive and personalized experience. This recommendation aligns with the expectations of users, as seen in the qualitative analysis.

Chapter 7 : LIMITATIONS AND FUTURE WORK

In this section, I highlight the limitations of our work and offer some directions for future work. My findings show that the SmileApp was successful in meeting the research goals and answering the research questions, however, there are several limitations in our study which can lead to potential future research direction. Below is a list of the limitations encountered during this research.

First, self-reporting tools are the main limitation of our study. Even though we informed participants that they should understand and answer the questionnaires as it applies to them and reflect on their experience in the consent form, we understand there are chances for bias. Human perception is not always perfect.

Second, the study was conducted in the wild which improves the ecological validity of our intervention. However, this also poses some limitations as there could have been the chance that users may have allowed their friends to use the app because it is innovative and interesting. This is also another limitation to our work because there is no way we could monitor or verify who uses the app as such monitoring has the potential to violate participant's privacy.

A third limitation is the demographic characteristics of our participants. As shown in Table 5.2, the demographic data of participants were not balanced. For Age, we had 47%, 38%, 15% and 1% respectively in the 4 different categories. Gender had 36%, 63% and 1% respectively in the 3 categories while Academic qualification had 24%, 51%, 11%, 8%, and 6% respectively in the 5 categories. These unbalanced demographic representations made it difficult to draw some insight from the demographic data. This imbalance has the potential to introduce bias and thereby limit the generalization of these findings.

It is also worth noting that in the design of the SmileApp, I did not consult an expert in psychology which is also a form of limitation. Future research in this area should consider involving an expert in psychology while designing similar interventions.

7.1 Future Work

In this section, we suggest potential avenues that hold promise for further exploration and development in the area of HCI. Based on the insights and findings of this study, several areas

emerge as potential directions for future research. By exploring these research gaps, we can deepen our understanding, expand existing knowledge, and contribute to the advancement of mHealth app development. The following subsections outline some key areas for future investigation.

Clinical Trial: A very important direction for future research in this area is to conduct a clinical trial of the SmileApp, having participants in a controlled environment. This will aim at knowing the exact time it takes for the body to release neuropeptides while participants use the SmileApp. This will give objective data on the impact of SmileApp and measuring this timeframe will open a new horizon for developing mHealth apps targeted at emotional and mood enhancement. Future mHealth app developers can leverage this outcome to develop a more tailored mood regulation app that will add to knowledge and be beneficial to industry practitioners.

Personalization: Another promising area for future research in promoting positive emotion using the design approach of the SmileApp is to explore the option of personalizing the features. Personalizing the features will further reveal which combination of features has the most impact and was most used. For example, conversational AI should have more knowledge of the user to interact more personally. Users should be able to choose custom images on SmileGram.

Demographic Factors: We encourage future researchers to put deliberate measures in place to ensure balanced demographic data. This will further deepen the understanding of SmileApp's impact on each demographic stratum. Ensuring diverse representation across various demographic groups will help future researchers obtain more robust and reliable findings that apply to a broader population. Balancing demographic factors helps minimize biases and ensures that the results are more representative of the true population. This will also further enable researchers to uncover potential differences, nuances, and interactions among different groups, leading to a more comprehensive and accurate understanding of the impact of SmileApp.

Improved Focused Attention: To enhance the focused attention of users within SmileApp and elevate the overall immersive experience, various potential strategies can be explored. These strategies encompass a range of possibilities aimed at optimizing user engagement and concentration within the app. Through careful consideration and implementation of these strategies, it is anticipated that users will be better able to sustain their attention and involvement, thereby maximizing the benefits and outcomes derived from their interaction with SmileApp.

Captivating Music: Including captivating music in the SmileGram feature can help create a more engaging and immersive environment for users. Carefully selected music that aligns with the app's purpose and enhances the desired mood can capture users' attention and evoke emotional responses.

Feedback from Community Members: Allowing users to receive feedback from other community members when they send supportive messages can enhance the sense of connection and engagement within the app. Positive feedback and validation from others can motivate users to continue participating and increase their engagement with the app.

Multi-player Mode: Extending SmileGram to a multi-player mode can introduce a social and interactive aspect to the app. This can enable users to engage in collaborative activities, share experiences, and compete with others in a friendly manner. Multi-player features can create a sense of community and foster engagement, leading to improved focused attention.

It is important for future researchers and developers to carefully evaluate the implementation of these features and gather feedback from users to ensure they enhance the focused attention and overall user experience. Conducting user studies, usability testing, and iterative design processes can help identify the effectiveness and impact of these enhancements on user engagement and attention.

Study design: In this study, we employed a within-subject approach. However, we encourage future researchers to employ a between-subject design separating participants based on the three major features of the SmileApp (SmileGram, PocketBuddy and MyTribe). This design can offer a powerful approach to investigating the impact of each of the features on participants. This becomes necessary as shown by the utilization of the features that participants spend more time on the SmileGram and less time on MyTribe. By assigning participants to different features, researchers can observe and compare the effects of each feature. Utilizing a between-subject design allows for a clear and direct comparison between groups, providing valuable insights into the causal relationships and effects of variables under investigation. Additionally, this design reduces the potential for carryover effects or order biases that may occur in within-subject designs. By embracing a between-subject design, future researchers can enhance the internal validity of

SmileApp evaluation, improve the ability to generalize findings to larger populations and deepen our understanding of the phenomena being studied.

These future research directions provide valuable opportunities for further inquiry, extending the knowledge base and offering potential solutions to unresolved questions within the field. By pursuing these avenues, researchers can make significant contributions to the advancement of SmileApp evaluation, ultimately leading to practical implications and real-world impact.

Chapter 8 : CONCLUSION

This thesis undertook the design, implementation, and evaluation of the SmileApp, an innovative intervention aimed at promoting positive mood through the utilization of positive emotion (Smile) while integrating gaming elements, conversational AI, and a social community within a mobile health (mHealth) application. The primary objective of this research was to investigate the potential of harnessing technology to exert a positive influence on the emotional well-being of users. By merging these distinct components into a cohesive platform, the study aimed to explore novel avenues for enhancing emotional well-being through the effective utilization of technology-driven interventions.

Through a detailed review, we established that our approach is novel and by conducting an empirical investigation, this study has demonstrated the effectiveness of SmileApp for eliciting positive mood among users. Our findings provide valuable insights into the role of technology and how it can be creatively employed to promote emotional well-being and have significant implications for the design and development of future mHealth applications. The integration of Smile as a game control in the SmileGram feature, which focused on incorporating gamification elements such as rewards, challenges, and progress tracking, was shown to be highly successful in enhancing positive moods. The unique and engaging nature of the SmileGram not only increased user motivation but also fostered a sense of enjoyment and accomplishment, leading to a positive emotional state.

Moreover, the integration of a smile as a mechanism to unlock supportive messages exchanged among users in the MyTribe feature, alongside the presence of a conversational AI companion (PocketBuddy), provided users with a perceived sense of a dependable support system. This notable inclusion exhibited a profound impact on the emotional well-being of users. By leveraging these features, SmileApp fostered a nurturing environment where users felt supported, enabling them to experience a positive emotional shift and enhance their overall well-being. The synergistic effect of the smile-based unlocking mechanism and the conversational AI component contributed to the establishment of a trusted and beneficial support network within the app, thereby yielding significant implications for users' emotional states. These features enabled users to feel socially connected and reduce the feeling of isolation which contributed to an overall uplifted mood.

The results of our study highlight the potential of mHealth mobile apps as effective tools for promoting emotional well-being. The integration of SmileGram, PocketBuddy and MyTribe creates a holistic approach to positive mood elicitation, combining elements of gamification and social interaction to engage and empower users. This innovative process has the potential to significantly improve the quality of life for individuals who may benefit from emotional support and well-being enhancement.

In conclusion, this research contributes to the field of HCI by demonstrating the effective utilization of technology-mediated processes, specifically those that integrate positive emotion. SmileApp has demonstrated the capacity to elicit a positive mood. By combining technological advancements with the intentional incorporation of positive emotional elements, SmileApp effectively engages users in a manner that promotes the generation of positive affective states. This integration of technology and positive emotion represents a novel approach that holds promising potential for fostering and enhancing positive mood experiences. The findings of this research shed light on the effectiveness of such processes within SmileApp, providing valuable insights into the broader implications of leveraging technology to elicit positive emotional states.

As mHealth continues to evolve, the incorporation of user-centred design principles, evidence-based interventions, and innovative features will be crucial in developing effective applications that promote emotional well-being. By leveraging technology thoughtfully and purposefully, we can create powerful tools to support individuals in their journey toward enhanced emotional health and overall well-being.

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APPENDICES

Appendix A: Recruitment Notice

Study Title: SmileApp: Persuasive technology in promoting smiling and eliciting a positive mood.
Lead Researcher: Joseph Ufiem Orji, Master of Computer Science, Faculty of Computer Science, Dalhousie University
Academic supervisor: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University
Contact Person: Joseph Ufiem Orji, joseph.orji@dal.ca

Hi, I am a Master's student at Dalhousie University. You are invited to participate in my study to evaluate the impact of technology on promoting people to smile more. The world of today is full of stressors, and we are seeking a solution to a ubiquitous approach in fighting off stress through technology. Hence, your participation is very much appreciated.

The study will contribute to the research area of Persuasive Technology for Healthy Behavior Change and you can help us make this happen. To participate in this study, you have to:

1. Be 18 years or older: This is to allow independent consent for participation.
2. Be proficient in the English language: The SmileApp and measurement instruments are designed in English. Hence, the ability to read and write in the English language is a criterion to be part of the study
3. Have access to a smartphone: The SmileApp is a mobile app. Hence, every participant should have access to a smartphone (android or iOS).
4. Have access to the internet: Participants should have access to the internet to respond to the surveys which will be completed online.

In this study, you will be using our newly developed app for 2 week which involves the following activities:

- Sustaining a smile for a short period (at least 20 seconds daily)
- Sharing empathic and supportive messages with other users
- Unlocking supportive messages from the app daily with a smile

- Interacting with an artificial intelligence (AI) bot and giving feedback on how happy that made you feel

After the 14th day, you will be expected to fill in questionnaires about your experience with the app. The app will not request any personal details. All data will be de-identified and handled with utmost confidentiality. You can also choose to participate in an optional interview (approximately 40 minutes) after the 2 weeks. This study is totally voluntary, and you can withdraw at any point without any form of penalty or providing an explanation to the research team.
The entire study will take a total of 203 minutes (approximately 3 hours) within two weeks as follows:

Part 1: Pre-study questionnaire -- this is the consent from and the demographics questionnaire which will take approximately 24 minutes.

Part 2: App use -- this is the 2-week study where the participants use the app as often as possible each day to meet the target (which is supporting other users who needs empathic messages and smile cumulatively for approximately 5mins). This will take a total of 90 minutes within the two weeks of this study.

Part 3: Post-study questionnaire – this will take approximately 39 minutes.

Part 4: Optional interview. This will take 50 minutes.

Each participant will be compensated whether or not they complete the study will receive a $10.00 Amazon gift card or its equivalent (which may be Starbucks gift card, MTN card for participants in Nigeria or any $10 worth gift that can be given to participant) as compensation for their time. This compensation is for the entire study (including the optional interviews). Participants won't incur any expenses for participation.
Please feel free to contact Joseph Orji (joseph.orji@dal.ca) if you have any questions about the study.

If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca and reference REB file: 2023-6481

If you are interested in participating in this study, kindly click on this link: [link to screening question].

APPENDIX B - Consent Form for the Survey

DALHOUSIE UNIVERSITY

Project title: SmileApp: Persuasive technology in promoting smiling and eliciting a positive mood.

Lead researcher: Joseph Ufiem Orji, a graduate student at the Faculty of Computer Science, Dalhousie University.
Contact Information: Joseph Ufiem Orji, joseph.orji@dal.ca)

Supervisor: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University, rita.orji@dal.ca

Introduction

We invite you to participate in a research project being done by Joseph Orji, a Dalhousie University master's student. Participation in this study is entirely voluntary. It's possible that participating in the study you will learn something that will help others, but it's also possible that it will not benefit you. The following information explains what the research entails, what you'll be asked to perform, and any benefits, risks, inconvenience, or discomfort you could encounter. Please contact the lead researcher (Joseph Orji, joseph.orji@dal.ca) if you have any queries afterwards.

Purpose and Outline of the Research Study

The purpose of this study is to design and implement a mobile application that will help fight off stress by promoting smiles and positive moods leveraging artificial intelligence (AI), gamification and social interaction. The study may contribute to the research area of Persuasive Technology for Healthy Behavior Change, health, and wellness. To achieve this, you will be asked to explore a mobile app (SmileApp) which involves the following activities for 14 days:

- Sustaining smile for a short (at least 20 seconds daily)
- Sharing empathic and supportive messages with other users
- Unlocking supportive messages from the app daily with a smile

- Interacting with an artificial intelligence (AI) bot and giving feedback on how happy that made you feel

After the 14-day period, you will be asked to respond to the post-study questionnaire (which will take approximately 39 minutes) regarding your experience with using the app. If you would like to be contacted for an interview to provide additional feedback, you can indicate by checking a box on the questionnaire provided and you will be contacted by the lead researcher with more information via the email address you provided.

The entire study will take a total time of 203 minutes (approximately 3 hours) within two weeks as broken down below:

Part 1: Pre-study questionnaire -- this is the consent from and the demographics questionnaire which will take approximately 24 minutes.

Part 2: App use -- this is the 2-week study where the participants use the app as often as possible each day to meet the target (which is supporting other users who needs empathic messages and smile cumulatively for approximately 5mins). This will take a total of 90 minutes within the two weeks of this study.

Part 3: Post-study questionnaire – this will take approximately 39 minutes.

Part 4: Optional Interview. This will take 50 minutes.
The interview is optional. You may decide to be part of the study and not participate in the interview. If you are interested in the interview and opted for it, you will be asked to fill in a separate consent form for the interview.

Who Can Take Part in the Research Study

To participate in this study, you must be 18 years and above, have access to an Android or iOS smartphone and access to the internet. You should also be able to read and write English, and have a device that is compatible with the Microsoft Teams app.

Possible Benefits, Risks and Discomforts

There are no known risks associated with participating in this study, as the research team will ensure all communication are empathic and not offensive before they are delivered to participants by discarding any potential offensive message.

The chatbot used in this study is trained to generate positive messages only, it is not any form of expert system for health purposes and should not be expected to give any recommendation for any health related issues. The chatbots is strictly a form of companion, just like a "friend next door". It (the chatbot) will not initiate conversation on its own but only respond to user's input, hence it is unlikely to discuss sensitive topics. You can stop the use of the chatbot at any time or decide not to use it at all and use other features as it is not mandatory to use this chatbots as a participant. Always know that you can reach out to the research team at any time.

This study does not collect personally identifiable data except email address for which will be used to invite participants who opted for the optional interview and also to give the compensation to all participants. Only the lead researcher has access to email addresses and does not have plans to share it with anyone because it is for the purpose of contacting participants who opted for the optional interview and will be used to inform participants that the results are ready if they are interested in reading about it.

You may gain new ideas about designing mHealth apps. An indirect benefit is that you would be contributing to new knowledge that would help design better mHealth apps.

The researchers will use their Dalhousie University credentials for the Microsoft Teams meeting, which will ensure that the Teams meeting recordings are securely stored in Canada. During the live Teams meeting, audio and video content is routed through the United States, and therefore may be subject to monitoring without notice, under the provisions of the US Patriot Act while the meeting is in progress. After the meeting is complete, meeting recordings made by Dalhousie are stored in Canada and are inaccessible to US authorities.

Use of Quote

In this study, your quote may be used fully de-identified, without citing you because all participants are anonymous, and participant's data are not linked to them.

Compensation / Reimbursement

Each participant will be compensated whether or not they complete the study will receive a $10.00 Amazon gift card or its equivalent (which may be Starbucks gift card, MTN card for participants in Nigeria or any $10 worth gift that can be given to participant) as compensation for their time. This compensation is for the entire study (including the optional interviews). Participants won't incur any expenses for participation.

How your information will be protected:

Your responses to the survey will be anonymous. This means that there are no questions in the study that ask for identifying details such as your name. All responses will be saved on a secure Dalhousie server and password-protected computers to be used for analysis. Only the lead researcher and supervisor (i.e., Joseph Orji and Dr. Rita Orji) will have access to the data (including your email-id). The collected data would be retained for the period until the data is analyzed, and results are shared in conferences or journal publications. The lead researcher (i.e., Joseph Orji) will destroy all the survey responses and information 5 months after reporting the results. During the study, your voice, or the information you provide might be identifiable only by the researcher and such identifiable information would not be disclosed.

All data will be store on Dalhousie Server, the app data stored in AWS Canada will be moved (and deleted from AWS) to OneDrive immediately participants completes the 14 days.

If You Decide to Stop Participating

If you wish to stop participating, at any point, you can do so by closing the browser. Incomplete responses will not be included in the study.

How to Obtain Results

We plan to disseminate this result by publications and also, aggregated data (in form of statistics) might be published in the Persuasive Computing Lab website (www.pcl.cs.dal.ca), and everyone can access it. Participants can find out by reading this publication. The lead researcher will send out an email broadcast with a link to the publication to all participants.

Non-Abusive communication

By consenting, you agree to share only empathic, supportive and none-offensive message to participants. If you send any abusive or offensive comments to other users, the research team is at liberty to remove you from the study.

Questions

We are happy to answer any question you may have as regards to your participation in this research study. Kindly contact Joseph Orji (joseph.orji@dal.ca) at any time with questions, comments, or concerns about the research study. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca and reference REB file: 2023-6481

Signature

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand that I have been asked to complete the survey at any time of my choice. I understand that my responses may be used for research purpose without revealing my identity.

I agree to take part in this study. My participation is voluntary, and I understand that I am free to not complete the survey if I choose. I also understand and agree that my quotes will be used fully de-identified without citing me."

I Consent ● Yes ● No

Email_____

APPENDIX C: Consent Form For The Optional One-On-One Interview

DALHOUSIE UNIVERSITY

Project title: SmileApp: Persuasive technology in promoting smiling and eliciting a positive mood.

Lead researcher: Joseph Ufiem Orji, a graduate student at the Faculty of Computer Science, Dalhousie University.
Contact Information: Joseph Ufiem Orji joseph.orji@dal.ca (+1-9024027821)

Supervisor: Dr. Rita Orji, Faculty of Computer Science, Dalhousie University, rita.orji@dal.ca

Co-Investigator:

Introduction

We invite you to participate in a research project being done by Joseph Orji, a Dalhousie University master's student. Participation in thesis study is entirely voluntary. It's possible that participating in the study will learn something that will help others, but it's also possible that it will not benefit you. The following information explains what the research entails, what you'll be asked to perform, and any benefits, risks, inconvenience, or discomfort you could encounter. You should talk to Joseph about any questions you have concerning this study, and you are welcome to ask as many questions as you like. Please contact the lead researcher or co-investigator if you have any queries afterwards.

Purpose and Outline of the Research Study

The purpose of this study is to design and implement a mobile application that will help fight off stress by promoting smiles and positive moods leveraging artificial intelligence (AI), gamification and social interaction. The study may contribute to the research area of Persuasive Technology for Healthy Behavior Change, health, and wellness. To achieve this, you will be asked to explore a mobile app (SmileApp) and answer a series of questions based on your perception of the app in an

interview which will be conducted on Microsoft teams. This interview will last about 30 minutes and questions will be on your view about the app and how it helped improve your emotions and manage stress. You are expected to stay in a quiet place where no one can hear you for this interview to ensure the privacy of your responses. There will be no right or wrong answer, what you think about the app is all we will be interested to know and any possible recommendation.

Who Can Take Part in the Research Study

To participate in this study, you must be 18 years and above, have completed the app study. You should and have a device that is compatible with Microsoft Teams app

Possible Benefits, Risks and Discomforts

There is a possibility of feeling uncomfortable during this interview. Always know that you are at liberty to opt out of the interview at any point and participants are not under any obligation to answer any question or share any detail they are not comfortable with.

There may be a risk of data security due to the use of virtual software and security vulnerability of the networks. Participants are advised to use a secure network during the interview and stay in a quiet place where no one can eavesdrop on the interview.

You may gain new ideas about designing mHealth apps. An indirect benefit is that you would be contributing to new knowledge that would help design better mHealth apps.

The researchers will use their Dalhousie University credentials for the Microsoft Teams meeting, which will ensure that the Teams meeting recordings are securely stored in Canada. During the live Teams meeting, audio and video content is routed through the United States, and therefore may be subject to monitoring without notice, under the provisions of the US Patriot Act while the meeting is in progress. After the meeting is complete, meeting recordings made by Dalhousie are stored in Canada and are inaccessible to US authorities. If your local law does not permit this, you may want to opt out of the optional interview.

Use of Quote

In this study, your quote may be used fully de-identified, without citing you because all participants are anonymous, and participant's data are not linked to them.

Compensation / Reimbursement

There will be no additional compensation for this interview as all participants of this study will only receive a $10.00 Amazon gift card or its equivalent as compensation for their time whether they participate in the optional interview or not.

How your information will be protected:

No participant's identifiable detail like name, address or telephone number will be collected, only email address will be needed to invite the participant to the interview. Only the lead researcher who will be sending out the invite will have access to participant's email addresses, and this (the email address) will be discarded immediately after the interview is conducted.

The researchers will use their Dalhousie University credentials for the Microsoft Teams meeting, which will ensure that the Teams meeting recordings are securely stored in Canada. During the live Teams meeting, audio and video content is routed through the United States, and therefore may be subject to monitoring without notice, under the provisions of the US Patriot Act while the meeting is in progress. After the meeting is complete, meeting recordings made by Dalhousie are stored in Canada and are inaccessible to US authorities.

If You Decide to Stop Participating

You are at liberty to stop participating at any point, however, if the analysis has started, participant may not be able to withdraw from the study at that point, which is about two weeks after the study.

How to Obtain Results

The lead researcher will send a broadcast email to participants informing them of the result or any publication from the study. Also, details might be published in the Persuasive Computing Lab website (www.pcl.cs.dal.ca) and everyone can access it. Also, if the work is published in any academic venue, participants can also access it from there.

Raw data will not be presented in the publications, except de-identified quoted texts.

Questions

We are happy to answer any question you may have as regards to your participation in this research study. Kindly contact Joseph Orji (joseph.orji@dal.ca) at any time with questions, comments, or concerns about the research study. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca and reference REB file # 2023-6481

Signature

"I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time. I also understand and agree that my quotes will be used fully de-identified without citing me."

Participant

I Consent ¡ Yes ¡ No

Email Address: _____

Thank you.

Appendix D : Demographic Questionnaire

- Choose your age group

○ 18-25 years

○ 26-35 years

○ 36-45 years

○ Over 46 years

○ Prefer not to answer

- Choose your gender:

○ Man

○ Woman

○ Prefer to self-describe

○ Prefer not to answer

- What is the highest level of education you have completed?

○ Less than high school

○ High school graduate

○ College diploma

○ Bachelor's degree

○ Master's degree

○ Doctorate degree

○ Prefer not to answer

Other: _____

Appendix E: Oxford Happiness Questionnaire (OHQ) [145] (Happiness measurement scale)

On a scale of 1 – 6 (1 = strongly disagree, 6 = strongly agree), please indicate your level of agreement with each of the following statements.

1. I don't feel particularly pleased with the way I am

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

2. I am intensely interested in other people

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

3. I feel that life is very rewarding

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

4. I have very warm feelings toward almost everyone

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

5. I find most things amusing

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

6. Life is good

1	2	3	4	5	6
Strongly					Strongly

Disagree Agree

7. I do not think that the world is a good place

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

8. I laugh a lot

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

9. I am very happy

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

10. I find beauty in some things

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

11. I always have a cheerful effect on others

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

12. I often experience joy and elation

1 2 3 4 5 6

Strongly Strongly

Disagree Agree

13. I feel I have a great deal of energy

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree

14. I do not have fun with other people

1	2	3	4	5	6
Strongly					Strongly
Disagree					Agree
Agree					

Appendix F: Social Connectedness Scale [146]

For each of the following statements, please indicate your level of agreement, using the following scale:

1 2 3 4 5 6

Agree Disagree

1. I feel disconnected from the world around me.
   1 2 3 4 5 6
   Agree Disagree
2. Even around people I know, I don't feel that I really belong
   1 2 3 4 5 6
   Agree Disagree
3. I feel so distant from people
   1 2 3 4 5 6
   Agree Disagree
4. I have no sense of togetherness with my peers.
   1 2 3 4 5 6
   Agree Disagree
5. I don't feel related to anyone
   1 2 3 4 5 6
   Agree Disagree
6. I catch myself losing all sense of connectedness with society
   1 2 3 4 5 6
   Agree Disagree
7. Even among my friends, there is no sense of brother/sisterhood.
   1 2 3 4 5 6
   Agree Disagree
8. I don't feel I participate with anyone or any group.
   1 2 3 4 5 6
   Agree Disagree

Appendix G: Positive and Negative Affect Schedule (PANAS-SF) [147]

For each of the following statements, please indicate to what extent it affects you, using the following scale:

Indicate the extent you have felt this way over the past week	Very slightly or not at all 1	A little 2	Moderately 3	Quite a bit 4	Extremely 5
Interested					
Distressed					
Excited					
Upset					
Strong					
Guilty					
Scared					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
155nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Appendix H: System Usability Scale (SUS) [139]

On a scale of 1 -5 (1 = strongly disagree, 5 = strongly agree), please indicate your level of agreement with each of the following statements.

1. I think that I would like to use this app frequently.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

2. I found the app unnecessarily complex.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

3. I thought the app was easy to use.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

4. I think that I would need the support of a technical person to be able to use this app.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

5. I found the various functions in this app were well integrated.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

6. I thought there was too much inconsistency in this app.

1	2	3	4	5
Strongly				Strongly

Disagree Agree

7. I would imagine that most people would learn to use this app very quickly.

1	2	3	4	5
Strongly Disagree				Strongly Agree

8. I found the app very cumbersome/awkward to use.

1	2	3	4	5
Strongly Disagree				Strongly Agree

9. I felt very confident using the app.

1	2	3	4	5
Strongly Disagree				Strongly Agree

10. I needed to learn a lot of things before I could get going with this app.

1	2	3	4	5
Strongly Disagree				Strongly Agree

Please share your opinion or comments below:

11. Are the icons and labels clear? Please expand.

12. Is the interaction logical? Please expand.

13. Are the colours appropriate? Please expand

14. Do you have any suggestions for improving the app?

Appendix I: User Engagement Scale (UES-SF) Short form [148]

On a scale of 1 – 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), please indicate your level of agreement with each of the following statements.

1. I lost myself in this experience.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

2. The time I spent using the SmileApp just slipped away.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

3. I was absorbed in this experience.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

4. I felt frustrated while using the SmileApp.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

5. I found the SmileApp confusing to use.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

6. Using the SmileApp was taxing.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

7. The SmileApp was attractive.

   1 2 3 4 5

   Strongly Strongly

   Disagree Agree

8. The SmileApp was aesthetically appealing.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

9. The SmileApp appealed to my senses.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

10. Using SmileApp was worthwhile.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

11. My experience was rewarding.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

12. I felt interested in this experience.

1	2	3	4	5
Strongly				Strongly
Disagree				Agree

Appendix J: Intrinsic Motivation Inventory (Value/Usefulness) [149]

For each of the following statements, please indicate how true it is for you, using the following scale:

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I believe that using the SmileApp could be of some value to me.

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I think that using this SmileApp is useful to improve my mood

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I think the SmileApp is important to do because it can help improve my mood

1 2 3 4 5 6 7

Not at all somewhat Very

True True Tru

I would be willing to use the SmileApp again because it has some value to me.

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I think using the SmileApp could help me to fight off stress

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I believe using the SmileApp could be beneficial to me.

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

I think this is an important App.

1 2 3 4 5 6 7

Not at all somewhat Very

True True True

Appendix K : Future intention questionnaire [193]

On a scale of 1 – 5 (1 = Won't, 2 = unlikely, 3 = neutral, 4 = likely, 5 = will), please indicate your level of willingness with each of the following statements.

If there is a need for eliciting positive mood in the future, I will use the SmileApp

1 2 3 4 5

Won't Will

In addition to necessary use in the future, I will also actively increase the frequency of use of SmileApp to elicit positive mood

1 2 3 4 5

Won't Will

I would suggest to others to use the SmileApp to elicit positive mood

1 2 3 4 5

Won't Will

Appendix L: Persuasive Scale [194]

On a scale of 1 – 7 (1 = strongly disagree, 7 = strongly agree), please indicate your level of agreement with each of the following statements.

1. This app would influence me to improve my mood.

1	2	3	4	5	6	7
Strongly						Strongly
Disagree						Agree

2. This app would convince me to improve my mood.

1	2	3	4	5	6	7
Strongly						Strongly
Disagree						Agree

3. This app would be personally relevant to me.

1	2	3	4	5	6	7
Strongly						Strongly
Disagree						Agree

4. This app will make me reconsider my mood.

1	2	3	4	5	6	7
Strongly						Strongly
Disagree						Agree

Appendix M: Interview Questions Guide

1. How do you feel about your experience with the app?
2. What do you think about the app?
    - What were the positives?
    - What were the negatives?
3. Are there any specific features you like about the app? Why?
4. Are there any specific features you do not like about the app? Why?
5. Did you find this SmileApp useful? Why?
6. Do you have any recommendations for improving the app?
    - Do you have any suggestions for improving the content?
    - How about the Functionality?
7. Would you recommend the app to someone else? Why or why not?
8. Do you feel socially supported using the SmileApp "myTribe" feature?
   If yes, why?
9. How easier was it for you to smile with the SmileApp?
10. Do you see yourself using the SmileApp after this study? Why or why not?
11. When do you feel most stressed?
    - What makes you stressed?
    - Where do you feel most stressed?
    - What time of day do you feel most stressed?
12. Do you have any other thoughts you would like to share about your experience of the app?

Appendix N: Brief Mood Introspection Scale. [150]

How do you feel after using the app today?

I feel...	definitely do not feel	do not feel	NA	slightly feel	definitely feel
Lively					
Happy					
Sad					
Tired					
Caring					
Content					
Gloomy (feeling distressed)					
Jittery (nervous)					
Drowsy (half asleep)					
Grouchy (irritable)					
Peppy (lively)					
Nervous					
Calm					
Loving					
Fed up					
Active					

Appendix O: Social Media recruitment Material

Appendix P: Screening Questions

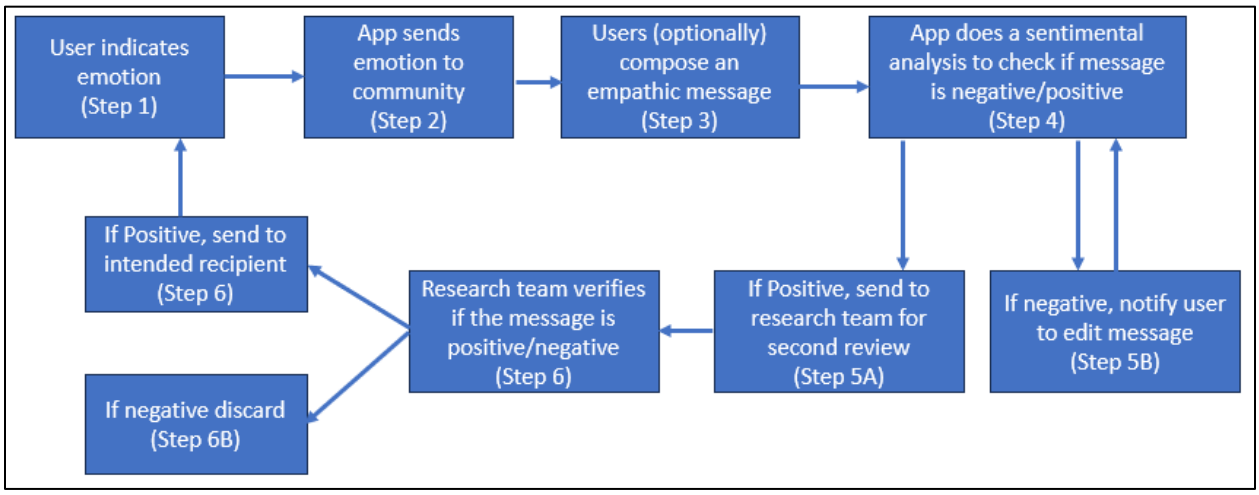
[1] I own a smartphone

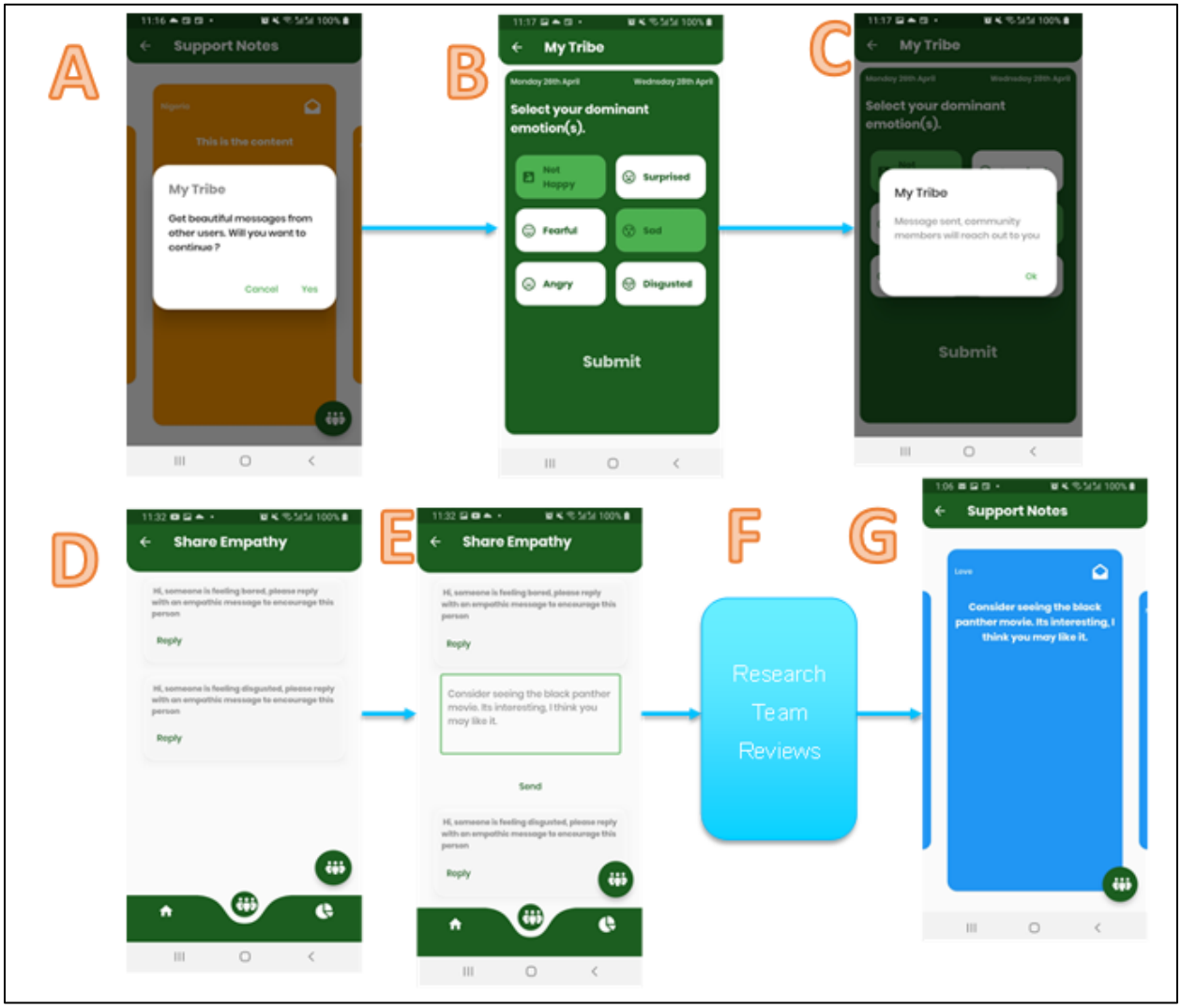
[2] I have access to the internet

[3] I am over 18 years old

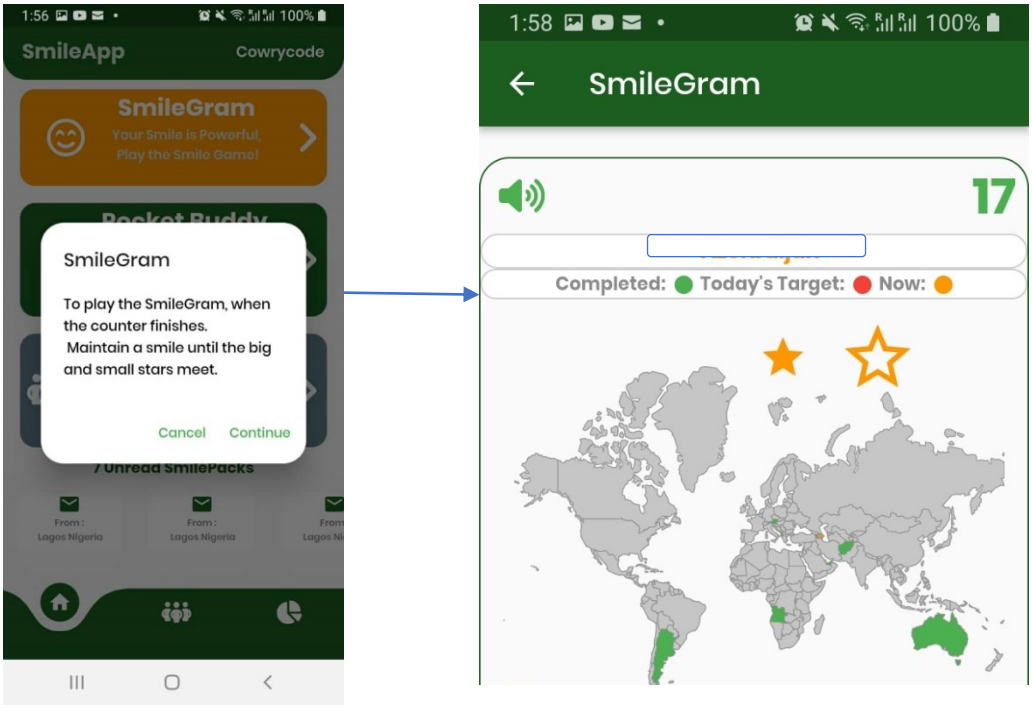
[4] I am proficient in the English language

Appendix Q: MyTribe Feature

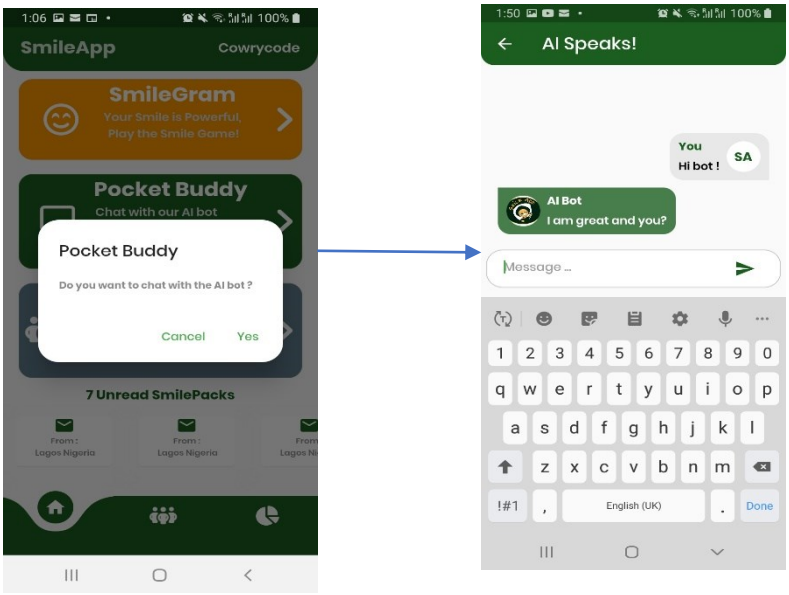




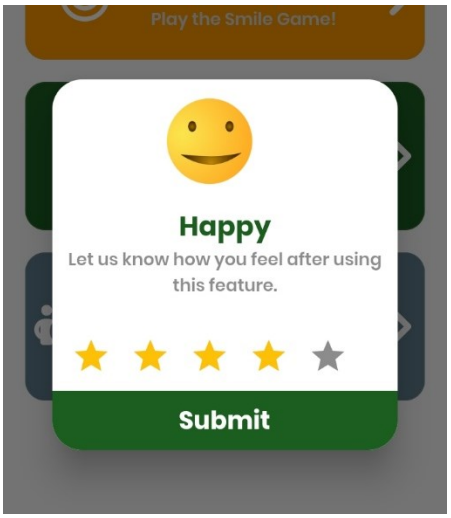
Appendix R: SmileGram Feature



Appendix S: PocketBuddy Feature

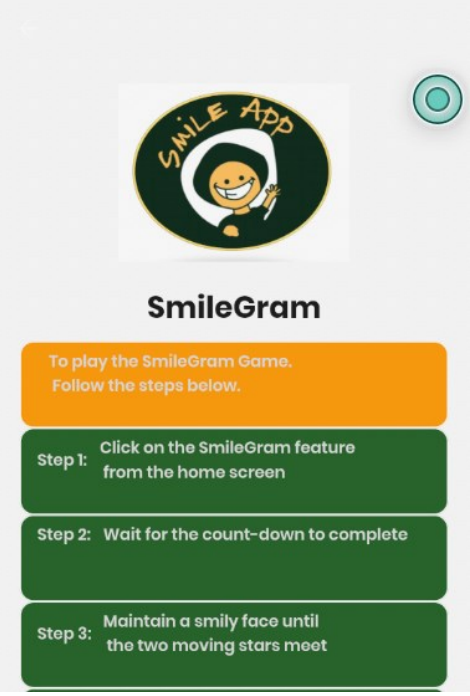


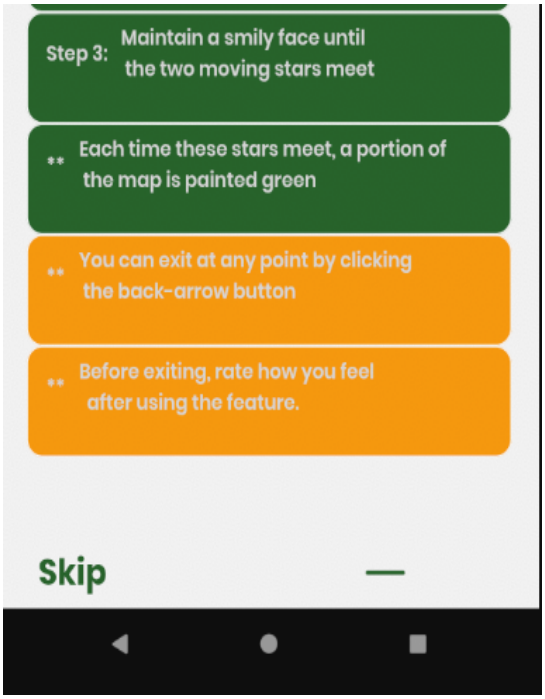
Appendix T: Feature Rating

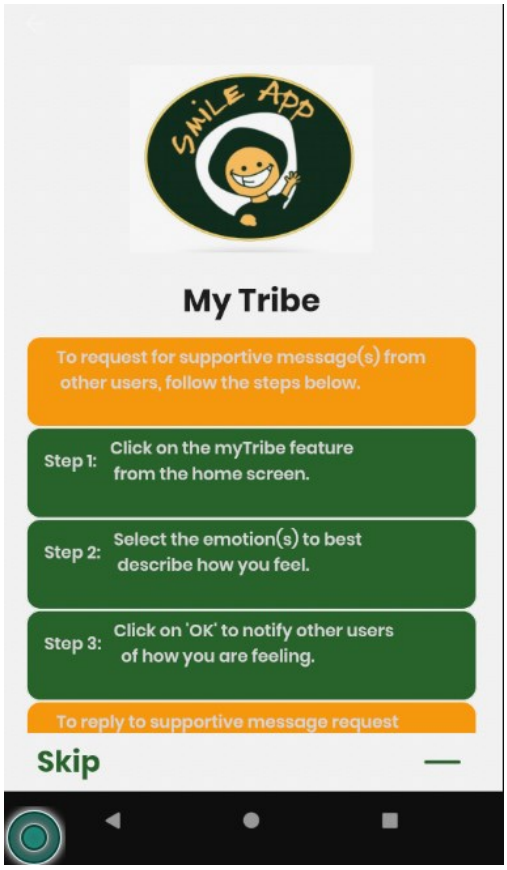


Appendix U: Features Instructions

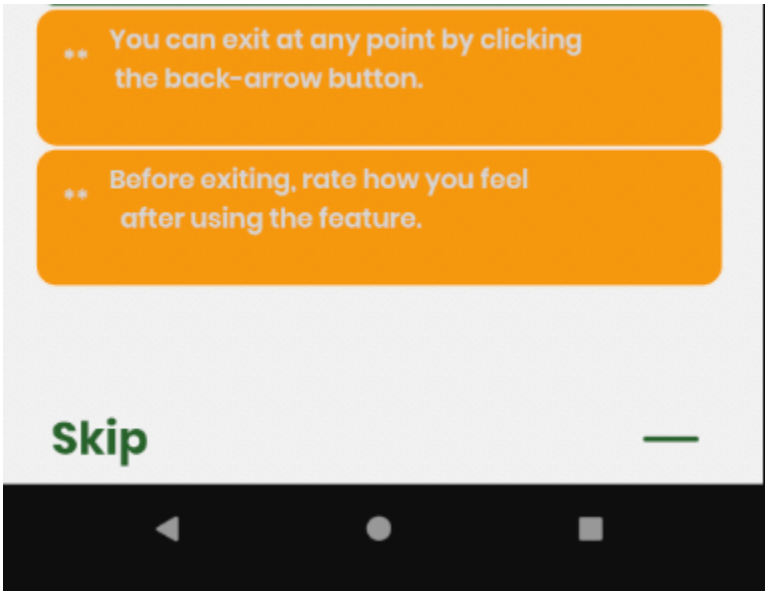
Below are the user instruction for **SmileGram**, **MyTribe** and **PocketBuddy** features.






My Tribe
To request for supportive message(s) from other users, follow the steps below.
Step 1: Click on the myTribe feature from the home screen.
Step 2: Select the emotion(s) to best describe how you feel.
Step 3: Click on 'OK' to notify other users of how you are feeling.
To reply to supportive message request
Skip


To reply to supportive message request from other users, follow the steps below.
Step 1: Click on the 'Group Icon' at bottom center of the navigation bar in the home screen.
Step 2: Click on 'Reply' to any of the request(s), type your message then click on 'Send'.
To read supportive message from other users, follow the steps below.
Step 1: Click on the 'closed envelope' icon on the home screen.
Step 2: Smile to show the content of the supportive message


** You can exit at any point by clicking the back-arrow button.
** Before exiting, rate how you feel after using the feature.
Skip

Appendix V: Ethics Approval

Social Sciences & Humanities Research Ethics Board
Letter of Approval

February 16, 2023
Joseph Ufiem Orji
Computer Science\Computer Science

Dear Joseph Ufiem,

REB #: 2023-6481
Project Title: SmileApp: Persuasive technology in promoting smiling and eliciting a positive mood.

Effective Date: February 16, 2023
Expiry Date: February 16, 2024

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Dr. Megan Bailey
Chair, Social Sciences and Humanities Research Ethics Board
Dalhousie University

Post REB Approval: On-going Responsibilities of Researchers

After receiving ethical approval for the conduct of research involving humans, there are several ongoing responsibilities that researchers must meet to remain in compliance with University and Tri-Council policies.

1. Additional Research Ethics approval

Prior to conducting any research, researchers must ensure that all required research ethics approvals are secured (in addition to Dalhousie approval). This includes, but is not limited to, securing appropriate research ethics approvals from: other institutions with whom the PI is affiliated; the institutions of research team members; the institution at which participants may be recruited or from which data may be collected; organizations or groups (e.g. school boards, Indigenous communities, correctional services, long-term care facilities, service agencies and community groups) and from any other responsible review body or bodies at the research site.

2. Reporting adverse events

Any significant adverse events experienced by research participants must be reported **in writing** to Research Ethics **within 24 hours** of their occurrence. Examples of what might be considered "significant" include: a negative physical reaction by a participant (e.g. fainting, nausea, unexpected pain, allergic reaction), an emotional breakdown of a participant during an interview, report by a participant of some sort of negative repercussion from their participation (e.g. reaction of spouse or employer) or complaint by a participant with respect to their participation, report of neglect or abuse of a child or adult in need of protection, or a privacy breach. The above list is indicative but not all-inclusive. The written report must include details of the situation and actions taken (or proposed) by the researcher in response to the incident.

3. Seeking approval for changes to research

Prior to implementing any changes to your research plan, whether to the risk assessment, methods, analysis, study instruments or recruitment/consent material, researchers must submit them to the Research Ethics Board for review and approval. This is done by completing the amendment request process (described on the website) and submitting an updated ethics submission that includes and explains the proposed changes. Please note that reviews are not conducted in August.

4. Continuing ethical review - annual reports

Research involving humans is subject to continuing REB review and oversight. REB approvals are valid for up to 12 months at a time (per the Tri-Council Policy Statement (TCPS) article 6.14). Prior to the REB approval expiry date, researchers may apply to extend REB approval by completing an Annual Report (available on the website). The report should be submitted 3 weeks in advance of the REB approval expiry date to allow time for REB review and to prevent a lapse of ethics approval for the research. Researchers should note that no research involving humans may be conducted in the absence of a valid ethical approval and that allowing REB approval to lapse is a violation of the

University Scholarly Misconduct Policy, inconsistent with the TCPS and may result in the suspension of research and research funding, as required by the funding agency.

5. Final review - final reports

When the researcher is confident that all research-related interventions or interactions with participants have been completed (for prospective research) and/or that all data acquisition is complete, there will be no further access to participant records or collection of biological materials (for secondary use of information research), a Final Report (available on the website) must be submitted to Research Ethics. After review and acknowledgement of the Final Report, the Research Ethics file will be closed.

6. Retaining records in a secure manner

Researchers must ensure that records and data associated with their research are managed consistent with their approved research plans both during and after the project. Research information must be confidentially and securely retained and/or disposed of in such a manner as to comply with confidentiality provisions specified in the protocol and consent forms. This may involve destruction of the records, or continued arrangements for secure storage.

It is the researcher's responsibility to keep a copy of the REB approval letters. This can be important to demonstrate that research was undertaken with Board approval. Please note that the University will securely store your REB project file for 5 years after the REB approval end date at which point the file records may be permanently destroyed.

7. Current contact information and university affiliation

The lead researchers must inform the Research Ethics office of any changes to contact information for the PI (and supervisor, if appropriate), especially the electronic mail address, for the duration of the REB approval. The PI must inform Research Ethics if there is a termination or interruption of their affiliation with Dalhousie University.

8. Legal Counsel

The Principal Investigator agrees to comply with all legislative and regulatory requirements that apply to the project. The Principal Investigator agrees to notify the University Legal Counsel office in the event that they receive a notice of non-compliance, complaint or other proceeding relating to such requirements.

9. Supervision of students

Faculty must ensure that students conducting research under their supervision are aware of their responsibilities as described above and have adequate support to conduct their research in a safe and ethical manner.