Techno-spiritual Engagement: Mechanisms for Improving Uptake of mHealth Apps Designed for Church Members

Hye Sun Yun[1], Shuo Zhou[1], Everlyne Kimani[1], Stefan Olafsson[1], Teresa K. O'Leary[1], Dhaval Parmar[1], Jessica Hoffman[1], Stephen Intille[1], Michael Paasche-Orlow[2,3] and Timothy Bickmore[1]

[1]*Northeastern University, Boston, MA, USA*
[2]*Boston University School of Medicine, Boston, MA, USA*
[3]*Boston Medical Center, Boston, MA, USA*

Abstract

Keeping users engaged with mHealth applications is important but difficult to achieve. We describe the development of a smartphone-based application designed to promote health and wellness in church communities, along with mechanisms explicitly designed to maintain engagement. We evaluated religiously tailored techno-spiritual engagement mechanisms, including a prayer posting wall, pastor announcements, an embodied conversational agent for dialogue-based scriptural reflections and health coaching, and tailored push notifications. We conducted a four-week pilot study with 25 participants from two churches, measuring high levels of participant acceptance and satisfaction with all features of the application. Engagement with the app was higher for users considered to be more religious and correlated with the number of notifications received. Our findings demonstrate that our tailored mechanisms can increase engagement with an mHealth app.

Keywords

engagement, tailoring, field study, church communities, mHealth,

1. Introduction

Smartphones provide a useful platform for health and wellness interventions given their ubiquity and accessibility [1]. However, the use of mobile health applications (mHealth apps) typically decreases over time as users disengage and lose interest [2]. Many factors may lead to loss of engagement, such as poor interface design perceived to be too simple and generic [3]. These design problems may ultimately hinder the user from reaping the health benefits the application would otherwise provide [4].

Long-term engagement with digital health behavior change interventions, in particular, has been shown to have significant positive effects on health outcomes [5]. There are several related measures of long-term user engagement with a system in longitudinal interventions, such as the number of voluntary interactions that users choose to have over a given time period, the length of time they adhere to the system recommendations, or the number of users who complete an intervention [6]. In our work, we focus on the number of voluntary interactions by users during an intervention period.

We explore a range of strategies for maintaining user engagement with an mHealth app designed specifically for African American church communities. These communities typically have strong social support networks, common religious and spiritual practices, shared religious beliefs and attitudes, and a predominate racial identity, all of which can be leveraged to tailor the mHealth intervention, to increase its efficacy [7] and to maintain engagement with the app over time. In particular, we focus on two kinds of engagement mechanisms: 1) the incorporation of non-health related, techno-spiritual [8] functions, both social and individual, designed specifically for this community; and 2) the inclusion of a virtual agent health counselor that has both its appearance and language tailored for the church community. The virtual coach is an embodied conversational agent (ECA), an animated character that simulates face-to-face conversation using nonverbal behaviors such as facial displays of empathy along with her speech [9]. We conducted a four-week field study to assess how well the engagement mechanisms worked.

2. Related Work

Various strategies for promoting engagement with mobile health (mHealth) systems have been explored. These strategies include social support [10, 11] and reminders

Joint Proceedings of the ACM IUI Workshops 2022, March 2022, Helsinki, Finland
yun.hy@northeastern.edu (H. S. Yun); zhou.sh@northeastern.edu (S. Zhou); kimani.e@northeastern.edu (E. Kimani); stefanola@ru.is (S. Olafsson); oleary.t@northeastern.edu (T. K. O'Leary); d.parmar@northeastern.edu (D. Parmar); j.hoffman@northeastern.edu (J. Hoffman); s.intille@northeastern.edu (S. Intille); mpo@bu.edu (M. Paasche-Orlow); t.bickmore@northeastern.edu (T. Bickmore)

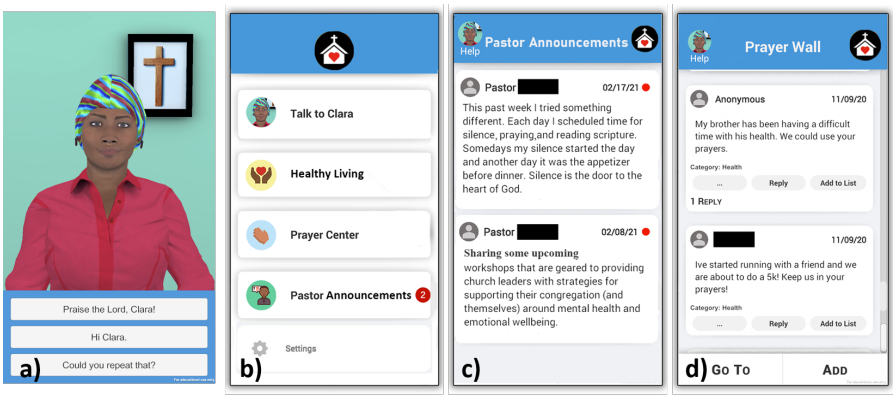

Figure 1: Screenshots of the mobile app: a) the virtual agent Clara; b) the home screen; c) the Pastor Announcements; and d) the Prayer Wall.

[12, 13]. This section explores research specifically on the use and effectiveness of these strategies for promoting engagement with mHealth systems.

Studies have shown that mobile applications for promoting healthy behaviors that implement features for social support can have positive effects on health outcomes [10, 11]. For example, a formative evaluation of a mobile cardiovascular health app designed in partnership with church-going African Americans found that a forum-style social networking feature was supportive, enjoyable, encouraging, and motivating to maintain healthy behaviors, such as diet and physical activity [14].

Push notifications have also been used in mHealth apps to increase engagement. Research has shown that users who received push notifications have better health outcomes or higher engagement with mHealth apps overall [2] than those not receiving any notifications in various mHealth contexts, such as mental disorder treatment [12] or weight loss maintenance [13]. Based on previous research, components such as notification content can be important factors to influence responsiveness to notifications [15]. Bidargaddi et al. [16] showed that notifications with tailored health suggestions improved the overall likelihood of users interacting with an mHealth app while tailored insights from self-monitored data led to greater engagement amongst frequent app users and showed the importance of tailoring content to increase engagement.

3. Application Design

In order to successfully implement the mHealth app in our stakeholders' communities, we conducted nine focus groups to better understand the participants' church communities and to gain insights into how to effectively tailor the app [17, 18, 19].

Based on these participatory design sessions, we developed an app with multiple features, including an ECA named Clara (Figure 1a). When the app is launched for the first time, Clara introduces herself to the user and provides an overview of the features and intervention content within the app. On subsequent launches, the app shows a menu of options for quick access to its core features (Figure 1b). One of the options initiates a conversation with Clara. In the first session of the day, Clara greets the user and engages in rapport building with social chat on topics ranging from the weather to movies and sharing important events that have occurred since the last time they spoke such as their church pastor posting an announcement. Finally, Clara presents a list of topics that users can choose to talk about, such as exercise, nutrition, or scriptural meditation.

The mHealth functions of the app promote nutrition, including fruit and vegetable consumption and healthy hydration, and physical activity. These are primarily provided by coaching from the ECA following the stages-of-change model as a theoretical framework [20], with goal setting and behavior logging for users in later stages of change. Several of the topics related to healthy living are designed to provide users with the tools they need to feel motivated to improve their health, to set goals, and to keep track of their progress. Each topic has an introduction where Clara provides information on the topic at hand, for example, the current recommendations for exercise or fruit consumption, as well as getting to know the user's current engagement in these health-related behaviors. Clara encourages the user to engage in conversation about health behavior change by asking them what they think about exercise or healthy eating, their reasons for change and why they are interested in change, how they would like Clara to help them, and the benefits of the health behavior for them personally. The

conversations are tailored according to the user's stage of change, which indicates their intentions to change their health behavior [20].

4. Design of Engagement Mechanisms

To encourage members of church communities to regularly use the mHealth app, we implemented six engagement mechanisms that are community-based and religiously tailored. These are the ECA, Prayer Center, Pastor Announcements, Bible Story of the Day, Scriptural Meditation, and push notifications.

4.1. Embodied Conversational Agent (ECA)

The ECA speaks using a synthesized voice and her dialogue is driven by a hierarchical task network-based dialogue manager. Her non-verbal behavior is automatically generated using BEAT [21]. We implemented a religiously tailored social chat module and representations of agent-led faith-based activities, as well as designing the agent dialogue to include both a community-situated greeting (e.g., "Hello Sister Kathy!") and farewell (e.g., "Blessings to you. Take care!"). At the end of each conversation, Clara shares a scripture verse in the same way that church members often end church-based activities.

4.2. Prayer Center

We implemented a set of features collectively referred to as the Prayer Center that enables users to connect with their fellow congregants. The first feature is the Prayer Wall, where users can post textual messages that include requests for prayers or praise (e.g., expressions of gratitude or joy) to share with other members of their church (Figure 1d). The messages are displayed as cards, similar to posts on a forum, and can be updated, replied to, and added to one's own private list of prayers. The second feature is a private Prayer List to remind users of the prayers they intend to say for others, allowing use of the app as a tool to support private prayer practices. Users can add their own prayers to the list manually and remove them or add prayer requests and praise reports from the Prayer Wall.

4.3. Pastor Announcements

To further engage app users with their church community, we developed a mechanism for the church pastors to reach out to members in a one-way broadcast communication. These Pastor Announcements give church leaders the means to provide members with news and information and engage with them through regular updates (Figure 1c). Whenever a new pastor announcement is received, the user receives a push notification if they are not currently using the app, and sees a numbered indicator in the main app screen showing the number of new and unread announcements.

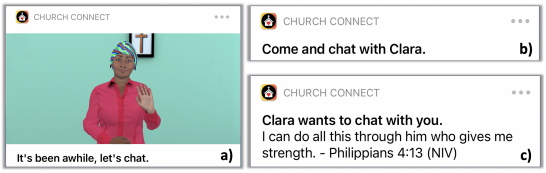

Figure 2: The variants of push notification content to remind users to talk to Clara: a) first person voice; b) third person voice; and c) third person voice with a Bible verse.

4.4. Bible Story of the Day & Scriptural Meditation

To incorporate scriptures as a way to engage users, we implemented the Bible Story of the Day and Scriptural Meditation features. When users select the option to talk to Clara, they are provided with an option to either hear a Bible story or engage in scriptural meditation led by Clara. For the Bible Story of the Day, all users are presented with the same Bible story for a particular day to encourage discussing the story with others in their church. Clara provides a summary of the story and allows the user to engage by providing various responses to the story. For the Scriptural Meditation, users have the option to choose the Bible passage they would like to read and are guided by Clara through the process of reflection and meditation.

4.5. Push Notifications

The final engagement mechanism we designed is the ability to send push notifications to users' mobile devices. We tailored the push notifications to encourage users to engage with the health features or the other religiously tailored engagement mechanisms. We used Google's Firebase Cloud Messaging to send three different types of push notifications to both iOS and Android devices with a server-based notification service and decision rules.

Reminder Notifications: To remind users to regularly engage with Clara, we send check-in reminders to talk to her if the user has not used the app or received other notifications in the past 24 hours. We religiously tailored the push notifications by randomly assigning certain notifications to include a Bible verse. To further diversify the content of these notifications, we randomly delivered different variations of messages by framing some in first

person with an image of Clara and others in third person without an image. Figure 2 shows some examples of the variations.

Social Notifications: We also designed notifications to encourage users to engage with features that serve social functions, such as the Pastor Announcements and the Prayer Center. Users receive a notification when the church pastor posts an announcement and when new prayers are posted on their church's Prayer Wall in the app. Instead of receiving a notification every time a prayer request is posted, these notifications are combined into two batches per day to avoid burdening users with many notifications. Lastly, the app notifies the user when a member of the church engages with the user's prayer post by either replying or adding the prayer to a private prayer list.

Health Notifications: Notifications related to the health behavior interventions were sent when users had set a physical activity or nutrition goal. Reminder notifications were sent when they should check-in with the ECA regarding their physical activity goal, while notifications for nutrition goals included relevant tips for fruit and vegetable intake and hydration. The tips also address user-reported barriers to goal attainment.

5. Evaluation Study

We evaluated the effectiveness of our religiously tailored engagement strategies in keeping users engaged with our smartphone-based mHealth app in a single-group, quasi-experimental field study. The duration of the study was four weeks (28 days), with continuous logging of system usage and weekly self-report assessments of engagement and satisfaction. The study was approved by our institution's IRB.

Due to COVID-19 restrictions, participants were enrolled into the study via video conference sessions during which they provided consent, were guided on installation and use of the app, and filled out baseline questionnaires. They were asked to use the app every day during the four-week study. After each of the first three weeks, electronic surveys were emailed to participants to measure their satisfaction with the app.

After four weeks, participants completed a final exit questionnaire and were invited to participate in an optional qualitative interview with a member of the research team. Participants were paid a fixed amount once, at the end of the study; they were not paid based on how much they used the app.

5.1. Measures & Data Collection

We assessed user engagement and satisfaction using self-reported measures and system-logged usage metrics. Technology literacy was assessed at the beginning of the study with the following questions: (1) "About how many texts and/or messages via applications do you send in a day?" and (2) "Which applications are currently installed on your smartphone or tablet?" The religiosity and spirituality of the participants were assessed using the Brief Multidimensional Measure of Religiousness/Spirituality (BMMRS) [22]. Specifically, the sub-scale measuring individuals' private religious practices (five-item, eight-point composite measure) was used as it aligned well with predicting the use of the religiously tailored engagement mechanisms in our app. Assessments of health behavior change were conducted with pre-post measures following the Transtheoretical Model [20], including stage of change, decisional balance, and self efficacy for each health behavior the app addressed.

Satisfaction with each engagement mechanism and the overall app was assessed using a four-item, seven-point composite measure (Anchors 1="not at all satisfied", Anchor 7="very satisfied") per mechanism. The number of logins, sessions with the ECA, interactions with different features, and push notifications were all derived from data logged by the system for each individual user.

Seventeen participant post-evaluation interviews were audio recorded and transcribed by a professional transcription service. We conducted a deductive analysis guided by sensitizing concepts which focused on participant satisfaction with each engagement mechanism, authenticity of the religious components, and participant usage of the system. We used elements of grounded theory method, including open coding, selective coding, and memoing [23].

5.2. Participants

A total of 25 participants from two churches were recruited for the study (14 from Church A and 11 from Church B). Participants self-identified primarily as Black (19 Black, 2 Black & Hispanic, 2 Black & Native American, 1 Hispanic/Latinx, 1 White). Eighteen of the participants identified as women, 5 identified as men, 1 as genderqueer, and 1 as non-binary/third gender. Participants were aged 19 to 75 (Mean=55, Median=62, SD=18). All participants but one had at least some post-secondary education.

5.3. Results

5.3.1. Usage Statistics and Satisfaction

During the four-week study period, participants (N=25) used the app a total of 560 times with each participant logging in to the app an average of 22 times (Min=4, Max=54, SD=13.3). They logged in to the app, on average, half of the 28 study days. Participants posted 82 prayer requests,

Table 1
Mean, minimum, maximum, and standard deviation of user sessions per user and mean satisfaction scores for the app overall and for each engagement feature, respectively. Mean satisfaction scores were calculated based on four-item composite scales. Anchors: 1="not at all satisfied" to 7="very satisfied". One-sample t-tests demonstrating scores significantly different from neutral of 4.

Feature	Mean	Minimum	Maximum	SD	Mean Satisfaction Score	p-value
Application	22.4	4	54	13.3	5.2	$p < 0.001^*$
ECA (Clara)	8.2	0	31	8.3	5.1	$p < 0.01^*$
Prayer Center	6.8	0	27	7.0	5.4	$p < 0.001^*$
Pastor Announcements	1.4	1	2	0.5	5.1	$p < 0.001^*$
Scriptural Meditation	3.4	0	17	4.9	6.0	$p < 0.001^*$
Bible Story of the Day	2.0	0	13	3.0	6.0	$p < 0.001^*$

added 43 prayer requests to private prayer lists, and wrote 45 replies to prayer requests. Participants in Church A each received 1 pastor announcement, whereas Church B received 2 pastor announcements. Each participant engaged with the ECA 8 times on average, comprising 36.6% of their sessions with the app. During their sessions with the ECA, they chose the topic of Scriptural Meditation 84 times, Bible Story of the Day 50 times, Physical Activity 26 times, and Nutrition 25 times. Furthermore, participants engaged with the health behavior tracking features (e.g., tracking of physical activity, hydration, etc.) a total of 801 times, with each participant, on average, using the feature 32 times. Overall, participants were satisfied with the app features, as well as the overall app, scoring significantly higher than a neutral rating for all features (Table 1).

The ECA was the most-used part of the app (Table 1). During the post-study interview, participants reflected on their perceptions of Clara and her role.

> **P7**: It may seem like a script because it...she was programmed to do this, but it still felt good, because it just felt genuine, because she asked so many questions to kinda gauge you, kinda like, where are you at right now, how can I help to get you in that direction type of thing. That's the feeling that I liked a lot. The feeling like, god man, I appreciate you.

One participant viewed Clara as a member of the church who took part in the culturally-situated practices: "*Clara felt like home. Even if we are laughing and rolling on the floor. We still end in prayer.*" P11 explored how details of the interaction, e.g., Clara ending the conversation with scripture, or Clara discussing Bible stories, mirrored how physical church events were run in her church. Participants said that Clara was able to gain their trust by not only signaling values but being factually accurate, especially around health topics. Furthermore, participants who were retired or near retirement age expressed how Clara resonated with them while younger participants did not necessarily view Clara to be very relatable.

Bible stories told by Clara were viewed as calming, relaxing, and reflective. P7 stated, "*Clara gave me room to think.*" They were seen as accurate and increased participants' confidence in Clara more generally. Satisfaction with the Bible Story of the Day was positively related with satisfaction of Clara (rho=0.479, $p<0.05$). In addition, perception by the participants of Clara being religious, spiritual, and of faith was positively correlated with their satisfaction of the Scriptural Meditation feature (rho=0.774, $p<0.001$). However, participants expressed wanting to see more scriptures related to different topics or categories so that they could easily find personally tailored scriptures for what they were feeling in any given moment. Some participants felt the stories were limited and child-like and would like some tailoring based on level-of-knowledge.

The second-most-used part of the app was the Prayer Center (Table 1). In general, the Prayer Center increased opportunities for the religious practice of supporting the community in prayer, because participants were able to interact with the prayer wall anytime and anywhere. It also served as a memory aid because participants were able to use the prayer list to keep track of their prayer concerns. P2 said, "*I don't have to remember, what I want to pray for is right there.*" Participants stated that initially they were interested in seeing who from the church was using the Prayer Center and wanted to connect with other members through the feature. All participants reported wanting more of a critical mass and wanting a notification system that would remind them to pray. P3 said, "*It's nice to be connected to the church, especially right now. I just wish more members had been there.*"

For health features such as setting health goals with Clara or tracking health behaviors, we observed that 22 out of the 25 participants used at least one health feature. Among the 22 participants who used the health features, users who rated high in the private religious practices sub-scale of the BMMRS had higher usage of

Table 2
Top 5 notification types leading to the most app use. Click-through rate is the ratio of number of push notifications clicked/tapped over number of push notifications received.

Push Notification Type	Click-through Rate
Social: Pastor announcement	31.8%
Reminder: Check-in with the ECA	31.3%
Health: Physical activity goal check-in	27.3%
Social: Prayer added to prayer list	25.0%
Social: Prayer request reply	18.4%

health features within the app (mean=50.7) compared to those who rated low (mean=23.3), based on a two-sample t-test ($p<0.05$). Private religious practices ratings were categorized into high and low based on the median score.

5.3.2. Push Notifications

For the four weeks of the study, a total of 635 push notifications were sent and 17.5% (N=111) of those were clicked on by participants. Each participant received a mean of 25.4 notifications in total (Min=15, Max=48, SD=8.5) and, on average, clicked on 17.2% of those notifications (Mean=4.4, Min=0, Max=23, SD=6.3). Push notifications that promoted engagement with Pastor Announcement, the Prayer Center, and talking to the ECA, led to the most app use (Table 2). Notifications alerting users of new pastor announcements had the highest click-through rate (=31.8%).

Participants were satisfied with the notifications they received, scoring significantly above neutral on a satisfaction rating scale (Mean=5.3, seven-point composite scale with 4=neutral, parametric test, $p<0.001$). Participants were also asked about their perceived pleasantness of notifications (single-item scale, Anchor 1="Unpleasant", Anchor 7="Pleasant"). The ratings were significantly different from neutral (=4), with a median score of 5 (one-sample Wilcoxon signed rank test, $p<0.01$), indicating they felt receiving notifications was a mostly pleasant experience.

During the post-study interviews, participants found the reminder notifications helpful.

> **P7**: I did get some notifications from time-to-time since there were times I would forget it, but I would get a notification from Clara, and I'm like, you know what, I'm sorry shorty, forgot, hold on!

Also participants found notifications related to the Prayer Center and Pastor Announcements bringing them back to the app because they wanted to see what was going on.

For participants who received health tip notifications, they appreciated them overall. However, participants found it difficult to refer back to the tips as they disappeared after being viewed, and some were not necessarily sent during a time participants could actively act on them. Participants also suggested other types of health tips such as congratulatory messages that would allow them to know what goal they had reached (P3), and accountability notifications to help get them to their goals (P2).

5.3.3. Engagement: Usage Over Time

To explore which factors led to the most longitudinal use of the app, we developed a multilevel model, to account for individual differences. The intraclass correlation coefficient (ICC) was calculated to be 15.4% for daily number of logins, indicating that the majority of the variance existed within a user. The best fitting model was selected based on Akaike information criterion (AIC) and Bayesian information criterion (BIC) values and model interpretability. The number of logins on any given day was modeled as a linear pattern of change, with study day, daily number of notifications received, and participants' religiosity based on the private religious practices sub-scale from the BMMRS [22] as predictors. For the selected model, intercept and slope for study day were modeled as random effects to capture individual differences at baseline and over time. Table 3 shows the fixed effects parameter estimates of the selected model for predicting daily number of logins. The final equation is:

$$\texttt{Daily \# Of Logins} = 0.696 - 0.039 * \text{SD} + 0.164 * \text{N} + 0.117 * \text{R}$$

where SD is the study day, N is the daily number of notifications, and R is the private religious practices score.

Participants' religiosity ratings were centered at the lowest score (coded as 0-7). Study day was centered at the first day (day 0). The intercept can be interpreted as the estimated number of logins on the first day, for a participant who received no notification on that day, and

Table 3
Fixed parameter estimates of the selected model for predicting daily number of logins.

Parameter	Value	Std. Error	p-value
Intercept	0.696	0.276	$p < 0.05^*$
Study Day	-0.039	0.007	$p < 0.001^*$
Daily Number of Notifications Received	0.164	0.039	$p < 0.001^*$
Private Religious Practices Score	0.117	0.052	$p < 0.05^*$

rated the lowest on the private religious practices subscale. Based on the model, the number of notifications received on a given day has a positive effect on the outcome, as with 1 unit increase, the outcome increases by 0.164 ($p<0.001$, Table 3). Study day has a negative effect on the outcome, as usage decreases slightly over time. Religiosity has a positive effect on daily number of logins, as with 1 unit increase on the private religious practices sub-scale, the outcome increases by 0.117 ($p<0.05$, Table 3).

Using Pearson's r correlation tests, we observed that participants with lower technology literacy had higher private religious practices scores ($r=-0.477$, $p<0.05$). Similarly, those who were older had higher private religious practices scores ($r=0.748$, $p<0.001$). These findings showed that participants who were older or used fewer smartphone-based messaging technologies, were more active in their private religious practices and logged into the app more often when notifications were sent to them.

5.3.4. Health Behavior Change Outcomes

We found no significant pre-post changes in health attitude or health behavior measures in our pilot study.

6. Conclusions and Limitations

Maintaining user retention with mobile interventions is essential for affecting longitudinal outcomes in health, education, and other application domains. Utilizing well-tailored engagement mechanisms that meet the interests and needs of a priority population may be useful in maintaining engagement with the app over time and more effective at providing help and interventions to users. We explored a range of religiously tailored engagement strategies that can be used to motivate church community members to interact with a smartphone-based mHealth app.

We described and evaluated six religiously tailored engagement mechanisms in this pilot study: an ECA, Prayer Center, Pastor Announcements, Bible Story of the Day, Scriptural Meditation, and push notifications. We demonstrated that push notifications were effective at driving the use of the app, with the number of notifications per day and the user's private religious practices score being significant factors in predicting the number of user logins per day throughout the study. We found that user satisfaction with all elements of the app was high with several participants finding Clara to be relatable and having personal resonance with the religiosity, spirituality, and role she exhibits. Our study demonstrated that religiously tailored engagement mechanisms that fulfill techno-spiritual functions can help religious users engage with an mHealth application.

We did not find that the use of the app led to significant pre-post improvements in health attitudes or behaviors, likely due to the short duration of the study and a small convenience sample. We plan to evaluate the effectiveness of our app in improving health behaviors through future studies and used this pilot study to mainly evaluate the engagement mechanisms. Also, due to the participants of our pilot study being financially compensated, we can expect some level of response bias where engagement and satisfaction with our app can partly be associated with being compensated rather than the engagement mechanisms. In addition, we did not explore the duration of ECA sessions or scrolling through the Prayer Wall as a measure of engagement. Measuring session duration in light of app suspension, exits, and interrupts is very error-prone, and we felt that these data were too noisy to warrant analysis. Finally, this pilot study lacked a control condition, and a series of studies to systematically evaluate each engagement mechanism relative to a control is ultimately needed.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No.1831755. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] T. W. Bickmore, E. Kimani, H. Trinh, A. Pusateri, M. K. Paasche-Orlow, J. W. Magnani, Managing chronic conditions with a smartphone-based conversational virtual agent, in: Proceedings of the 18th International Conference on Intelligent Virtual Agents, IVA '18, Association for Computing Machinery, New York, NY, USA, 2018, p. 119–124. URL: https://doi.org/10.1145/3267851.3267908. doi:10.1145/3267851.3267908.

[2] N. Bidargaddi, D. Almirall, S. Murphy, I. Nahum-Shani, M. Kovalcik, T. Pituch, H. Maaieh, V. Strecher, To prompt or not to prompt? a microrandomized trial of time-varying push notifications to increase proximal engagement with a mobile health app, JMIR mHealth and uHealth 6 (2018) e10123. URL: https://mhealth.jmir.org/2018/11/e10123. doi:10.2196/10123.

[3] T. McCurdie, S. Taneva, M. Casselman, M. Yeung, C. McDaniel, W. Ho, J. Cafazzo, mhealth consumer apps: the case for user-centered design, Biomedical instrumentation & technology 46 (2012) 49.

[4] G. J. Norman, M. F. Zabinski, M. A. Adams, D. E. Rosenberg, A. L. Yaroch, A. A. Atienza, A review of ehealth interventions for physical activity and dietary behavior change, American journal of preventive medicine 33 (2007) 336–345.

[5] S. Michie, L. Yardley, R. West, K. Patrick, F. Greaves, Developing and evaluating digital interventions to promote behavior change in health and health care: Recommendations resulting from an international workshop, J Med Internet Res 19 (2017) e232.

[6] T. Bickmore, D. Schulman, L. Yin, Maintaining engagement in long-term interventions with relational agents, Applied Artificial Intelligence 24 (2010) 648–666. URL: https://doi.org/10.1080/08839514.2010.492259. doi:10.1080/08839514.2010.492259, pMID: 21318052.

[7] R. P. Hawkins, M. Kreuter, K. Resnicow, M. Fishbein, A. Dijkstra, Understanding tailoring in communicating about health, Health education research 23 (2008) 454–466.

[8] G. Bell, No more sms from jesus: Ubicomp, religion and techno-spiritual practices, in: P. Dourish, A. Friday (Eds.), UbiComp 2006: Ubiquitous Computing, Springer Berlin Heidelberg, Berlin, Heidelberg, 2006, pp. 141–158.

[9] J. Cassell, Embodied conversational agents: representation and intelligence in user interfaces, AI magazine 22 (2001) 67–67.

[10] J. M. Petersen, E. Kemps, L. K. Lewis, I. Prichard, Psychological mechanisms underlying the relationship between commercial physical activity app use and physical activity engagement, Psychology of Sport and Exercise 51 (2020) 101719. URL: https://www.sciencedirect.com/science/article/pii/S1469029219308568. doi:https://doi.org/10.1016/j.psychsport.2020.101719.

[11] F. D. Barber, Social support and physical activity engagement by cancer survivors., Clinical Journal of Oncology Nursing 16 (2012) E84 – E98. URL: http://libproxy.clemson.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=a2h&AN=76169513.

[12] F. Gravenhorst, A. Muaremi, J. Bardram, A. Grünerbl, O. Mayora, G. Wurzer, M. Frost, V. Osmani, B. Arnrich, P. Lukowicz, et al., Mobile phones as medical devices in mental disorder treatment: an overview, Personal and Ubiquitous Computing 19 (2015) 335–353.

[13] A. Hernández-Reyes, F. Cámara-Martos, G. M. Recio, R. Molina-Luque, M. Romero-Saldaña, R. M. Rojas, Push notifications from a mobile app to improve the body composition of overweight or obese women: randomized controlled trial, JMIR mHealth and uHealth 8 (2020) e13747. URL: https://mhealth.jmir.org/2020/2/e13747. doi:10.2196/13747.

[14] L. C. Brewer, A. Kumbamu, C. Smith, S. Jenkins, C. Jones, S. N. Hayes, L. Burke, L. A. Cooper, C. A. Patten, A cardiovascular health and wellness mobile health intervention among church-going african americans: Formative evaluation of the faith! app, JMIR Formative Research 4 (2020) e21450. URL: https://formative.jmir.org/2020/11/e21450. doi:10.2196/21450.

[15] A. Mehrotra, M. Musolesi, R. Hendley, V. Pejovic, Designing content-driven intelligent notification mechanisms for mobile applications, in: Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing, UbiComp '15, Association for Computing Machinery, New York, NY, USA, 2015, p. 813–824. URL: https://doi.org/10.1145/2750858.2807544. doi:10.1145/2750858.2807544.

[16] N. Bidargaddi, T. Pituch, H. Maaieh, C. Short, V. Strecher, Predicting which type of push notification content motivates users to engage in a self-monitoring app, Preventive medicine reports 11 (2018) 267–273.

[17] T. K. O'Leary, E. Stowell, E. Kimani, D. Parmar, S. Olafsson, J. Hoffman, A. G. Parker, M. K. Paasche-Orlow, T. Bickmore, Community-based cultural tailoring of virtual agents, in: Proceedings of the 20th ACM International Conference on Intelligent Virtual Agents, IVA '20, Association for Computing Machinery, New York, NY, USA, 2020. URL: https://doi.org/10.1145/3383652.3423875. doi:10.1145/3383652.3423875.

[18] E. Stowell, T. K. O'Leary, E. Kimani, M. K. Paasche-Orlow, T. Bickmore, A. G. Parker, Investigating opportunities for crowdsourcing in church-based health interventions: A participatory design study, in: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, 2020, p. 1–12. URL: https://doi.org/10.1145/3313831.3376833.

[19] T. K. O'Leary, E. Stowell, J. A. Hoffman, M. Paasche-Orlow, T. Bickmore, A. G. Parker, Examining the intersections of race, religion & community technologies: A photovoice study, in: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, 2021, p. 1–19. URL: https://doi.org/10.1145/3411764.3445418.

[20] J. O. Prochaska, W. F. Velicer, The transtheoretical model of health behavior change, American Journal of Health Promotion 12 (1997) 38–48. URL: https://doi.org/10.4278/0890-1171-12.1.38. doi:10.4278/0890-1171-12.1.38, pMID: 10170434.

[21] J. Cassell, H. H. Vilhjálmsson, T. Bickmore, Beat: the behavior expression animation toolkit, in:

H. Prendinger, M. Ishizuka (Eds.), Life-Like Characters: Tools, Affective Functions, and Applications, Springer Berlin Heidelberg, Berlin, Heidelberg, 2004, pp. 163–185. URL: https://doi.org/10.1007/978-3-662-08373-4_8. doi:10.1007/978-3-662-08373-4_8.

[22] K. S. Masters, Brief Multidimensional Measure of Religiousness/Spirituality (BMMRS), Springer New York, New York, NY, 2013, pp. 267–269. URL: https://doi.org/10.1007/978-1-4419-1005-9_1577. doi:10.1007/978-1-4419-1005-9_1577.

[23] J. M. Corbin, A. Strauss, Grounded theory research: Procedures, canons, and evaluative criteria, Qualitative sociology 13 (1990) 3–21.