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Evaluating the Effectiveness of a Mental Health Mindfulness App Among College Students and Company Workers in Japan
日本の大学生と会社員を対象としたメンタルヘルス・マインドフルネスアプリの効果検証

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Abstract

The purpose of this study is to examine the benefits and effectiveness of mental health apps. Groups of Japanese college students (Study 1) and Japanese company workers (Study 2) completed mindfulness activities via a Line app as well as measures of psychological flexibility (Study 1), mental health, and workplace productivity (Study 2). Our results demonstrated difficulty in participant retention, but also showed some evidence for a small-to-moderate increase in psychological flexibility and mental health among both college students and company workers who did not drop out. Among the meaningful patterns of app usage, we found that engaging in mindfulness activities increased psychological flexibility cumulatively, where one's history of mindfulness practice predicts current outcomes. We conclude the study with a discussion of potential improvements for future mindfulness apps.

概要

この調査の目的は、メンタルヘルスアプリの有用性と有効性を調べることです。日本の大学生グループ（研究 1）と会社員（研究 2）のグループに Line アプリを通じてマインドフルネス活動を行ってもらい、心理的柔軟性（研究 1）とメンタルヘルス及び職場の生産性（研究 2）の測定を行いました。研究の結果として、参加者が継続的にアプリを使用することが困難であることが明らかになったものの、アプリを継続的に使用した大学生と会社員の両方で、心理的柔軟性とメンタルヘルスが小から中程度に増加したといういくつかの証拠が示されました。有意義なアプリの使用パターンを調べると、マインドフルネス活動に携わる累積的な経験が、時間の経過に伴う心理的柔軟性の変動を最もよく予測することがわかりました。研究のまとめとして、今後のマインドフルネスアプリの改善の可能性について論じます。

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Key words: Digital mental health, Mental health app, Mindfulness app, Mindfulness, Acceptance Commitment Therapy
キーワード：デジタルメンタルヘルス、メンタルヘルスのアプリ、マインドフルネスアプリ、マインドフルネス、アクセプタンス・コミットメント・セラピー

1. Introduction

The mental health app industry has increased by over 8000% since 2013, with over 15,000 apps available on all major platforms (Athens, 2016). Among these, mindfulness apps such as Calm (www.calm.com) and Headspace (www.headspace.com) have led the industry in terms of number of users and profit. They boast four million and two million users worldwide, respectively. The apparent level of engagement with these successful apps has led many to believe that digitalized mental health apps have an important role to play in increasing accessibility to mental health care to an increased number of people around the world (Chandrashekar, 2018).

Although the major apps claim to be effective in increasing mental wellbeing and decreasing distress, results from meta-analyses have found a much more complex picture. The majority of apps had no research to verify their effectiveness, and among those that did, only weak evidence was found (Gál, Ștefan, & Cristea, 2021; Zhang, Xue, & Huang, 2020). From a theoretical standpoint, the mechanism that leads to increased well-being and less mental distress is unclear. In traditional forms of psychotherapy, improvements in mental wellbeing are typically fostered through gaining insight, skills, or both, in the context of a dyadic dialogue with a trained professional. How then are the alleged benefits from mental health apps generated?

Complicating this problem, most of the content of the apps are not consigned to any established psychological theory. Additionally, research findings are limited to a small, select group of participants. In order to further the research that investigates the best that mental health apps have to offer, the current study created a theoretically-sound, skills-based mindfulness app and examined its effectiveness among samples of Japanese college students (Study 1) and Japanese company workers (Study 2).

1.1 Effectiveness of Mental Health Mindfulness Apps

Mental health mindfulness apps have grown in popularity with promises of increasing accessibility to mental health treatment to a generation of internet users. Public health organizations like the UK's National Health Service (NHS) and the U.S. National Institute of Mental Health (NIMH) describe mental health apps as a promising solution to address the discrepancies in mental health treatment and treatment utilization in public and private settings. A 2015 World Health Organization (WHO) survey of 15,000 mental health apps revealed that 29% focus on mental health diagno-

sis, treatment, or support (Athens, 2016).

In particular, mindfulness apps are popular tools for improving well-being, but their effectiveness is unclear. In a recent meta-analysis conducted by Gál and colleagues (2021), a small to moderate effect was found on participants' perceived stress, symptoms of depression, and symptoms of anxiety. However, due to the small number of studies included, the authors concluded that is not possible to be certain of either the efficacy or risks associated with using these apps. Another meta-analysis that examined a set of different studies found the same results. Zhang, Xue, and Huang (2020) concluded that there was a moderate effect of mindfulness apps specifically on distress among the general population and a small effect on actually gaining mindfulness skills.

Looking deeper into some of these findings, the results become more mixed and heterogenous. In Zhang et al.'s (2020) meta-analysis, twelve of their sixteen effect sizes included "0" within the 95% confidence interval, which means that these apps were not likely efficacious. Other studies concluded that features of the apps predicted whether or not users would gain positive mental health outcomes. For instance, apps that were actively delivered in a virtual classroom or some other social context had higher engagement rates and better mental health outcomes (Taylor, Strauss, & Cavanagh, 2021). Chandrashekar (2018) also found that the improvement rate of psychological distress substantially increased when the engagement rate among users is high. Likewise, the results of these studies varied by population, with working adults gaining more benefits than student samples (Zhang et al., 2020). Although psychological theory or approach was not included as a factor examined in any of these studies, it seems reasonable that there would be an increase in mental well-being and a decrease in mental distress when a given app is using an already established treatment with previously established efficacy.

1.2 Acceptance Commitment Therapy

In order to address the issue of basing the content of a mindfulness apps on an established treatment, we incorporated Acceptance Commitment Therapy (ACT) as our theoretical model. ACT was first developed in the 1980s, by clinical psychologist, Dr. Stephen C. Hayes, who claimed acceptance, mindfulness, and values are the key psychological skillset needed to transform one's life (Hayes, Strosahl, & Wilson, 2011). Specifically, ACT aims to improve psychological flexibility, which includes focusing on what you are doing, expanding your awareness to see your thoughts and emotions objectively, and acting according to your values. Skills that support psychological flexibility were eventually conceptualized to be divided into six components: (1.) Acceptance, (2.) Cognitive Defusion, (3.) Being Present, (4.) Self-as-Context, (5.) Values, and (6.) Committed Action (Hayes, 2020).

Acceptance refers to willingly engaging with unpleasant experiences for the sake of our values,

rather than avoiding them. Cognitive Defusion describes distancing oneself from one's thoughts and feelings in order to see them as they are. Being Present requires focusing on the "here and now" of one's unfolding experience. Self-as-context is to view oneself as a container for one's life experiences rather than using life experiences as an identity. Values guide our direction in life by teaching what we truly care about. Finally, Committed Action describes the strategies we use to turn our values into concrete behaviors (Luoma, Hayes, & Walser, 2007).

ACT is considered an evidence-based treatment for a long list of psychiatric disorders and concerns, including anxiety, depression, obsessive-compulsive disorder, bipolar disorder, and schizophrenia (Hayes, 2020). Studies suggest that it may be particularly useful in patients with mild to moderate depression (Bai, Luo, Zhang, Wu, & Chi, 2020). In addition, ACT is said to be effective for chronic pain (Feliu-Soler et al., 2018) and dementia patients (Davison, Eppingstall, Runci, & O'Connor, 2017), demonstrating usefulness not only for the patients themselves, but also for the family and caregivers (Losada et al., 2015). In this way, ACT increases mental wellbeing by helping people choose value-oriented behaviors, even in difficult situations, while dealing effectively with mental distress.

1.3 Current Studies

For the purposes of the current research, we developed 36 1-minute mindfulness guide videos (six videos corresponding to each of the six core components of ACT). These videos consisted of white text on a black screen that provided instructions and questions as appropriate. The instructions included activities such as "imagining listening to your thoughts on the radio," "forgiving a younger version of yourself," "taking ten deep breaths," and "taking a step with purpose."

The app was built as a chatbot on the messaging app, Line, and sent mindfulness activities randomly throughout waking hours during the day (approximately four times each day). Once per day, a survey was sent to assess for psychological flexibility and mental well-being. Activity usage was recorded, and activities were deactivated after four hours. Given that prior research has found that naming chatbots with human names increases utilization (Hardy, Paranjape, & Manning, 2021), we named the app "Fred," in honor of Burris Frederick Skinner, a pioneer in behavioral psychology.

In Study 1, we examine "Fred's" effectiveness in increasing psychological flexibility and mental well-being among Japanese college students. We hypothesized that an increase in app usage would result in subsequent increases in psychological flexibility and mental well-being. In Study 2, we applied Study 1's methodology to a sample of company employees, also measuring their workplace productivity. As in Study 1, we hypothesized that an increase in app usage would result in subsequent increases in psychological flexibility, mental well-being, and workplace productivity.

STUDY 1

2.1 Study 1 Method

2.1.1 Participants

Seventy-seven Japanese undergraduate students from a mid-sized private school in Western Japan participated in this study as a part of their coursework in a semester-length class teaching psychological flexibility skills via the ACT model. 55% ($n = 42$) of students identified as women, and the average age was 18.4 ($SD = 0.2$). Students listened to an explanation of the purposes of the study orally during the first lesson and signed an informed consent. At the end of the class, they were given access to their data, and after reviewing it, once again signed a document giving permission for the research team to use their data in the current project. Out of the 77 students, none withheld permission.

2.1.2 Measures

2.1.2.1 Total Engagement. To measure the degree to which participants completed the mindfulness activities, we recorded how long they observed the video in their Line application. If the amount of time a video was viewed was greater than 80% of the length of the video, we scored it at a view. Views were summed per day to create the engagement measure.

2.1.2.2 Psychological Flexibility. The PsyFlex questionnaire is a six-item measure examining psychological flexibility in a brief and context-sensitive manner. Each item refers to one of the core skills of ACT. Items are rated on a scale from 5 (“very often”) to 1 (“very rarely”) and then summed. The score is then interpreted such that higher scores represent higher psychological flexibility. It has been translated into over 30 languages and has showed comparable reliability and validity across research populations (Gloster et al., 2021). Students completed a base rate measure of psychological flexibility approximately two weeks before the trial began. The Cronbach’s alpha score for the PsyFlex across administrations was .84, indicating adequate item reliability.

2.2 Procedure

Students received an explanation of the app, completed an informed consent, and were assisted in signing up for the app all on their first day of class. They were instructed to continue using the app until the end of the semester, although the trial lasted only 70 days. The app randomly sent the PsyFlex survey once a day and sent mindfulness activities at random times up to three times per day.

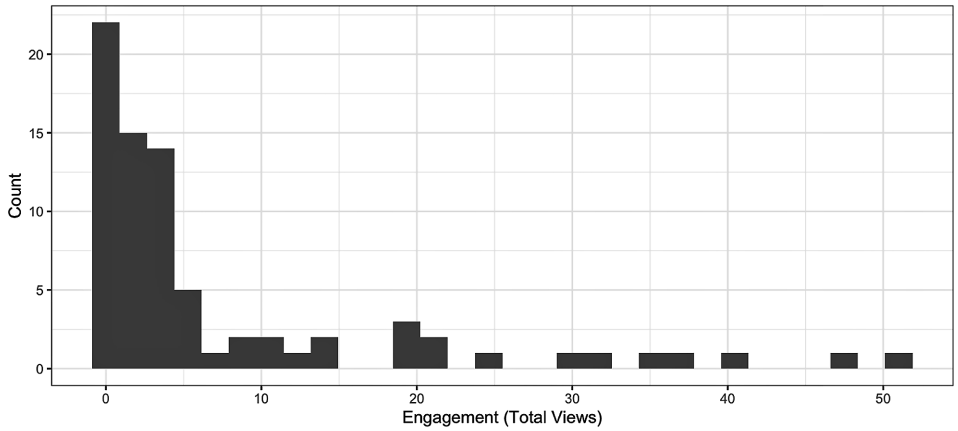
2.3 Study 1 Results

2.3.1 Engagement Statistics

On average, participants watched 3.5% ($SD = .18$) of the mindfulness videos sent to them via the

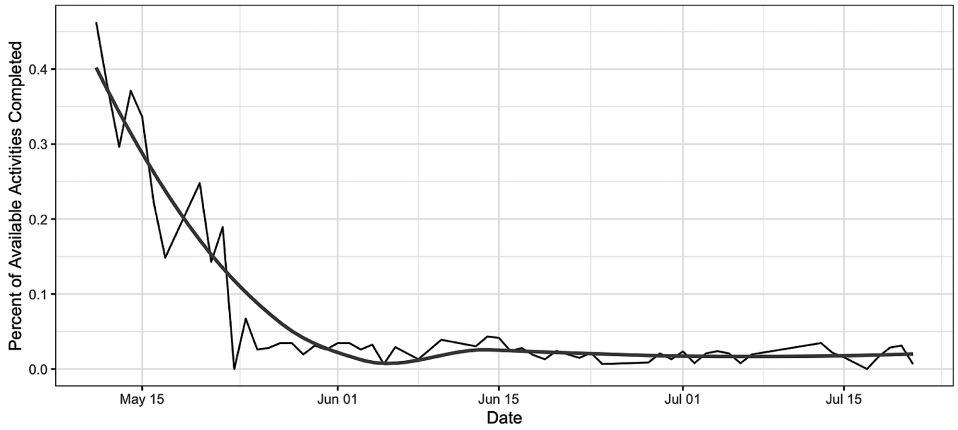
"Fred" application. The total number of videos viewed by participants varied widely with 22 participants (28.5% of the sample) not participating at all. Among the remaining participants, each completed an average of 10.5 (SD = 12.76) mindfulness activities during the 70-day study. Please see Figure 1 for a distribution of total Engagement.

Figure 1. Distribution of Total App Engagement in Student Sample



Engagement trends also varied as a function of time. Most app users completed all their total activities within the first several days of the study. When looking at the engagement of all possible activities, participation fell precipitously within the first fourteen days and maintained a steady 2-4% until the end of the study. Upon further investigation, the steady completion rate was attributed to thirteen participants (17% of the total sample) who persevered to the end of the study without first dropping out. Please see Figure 2 for a representation of Engagement Statistics over time.

Figure 2. Percentage of Completed Activities Over Time in Student Sample

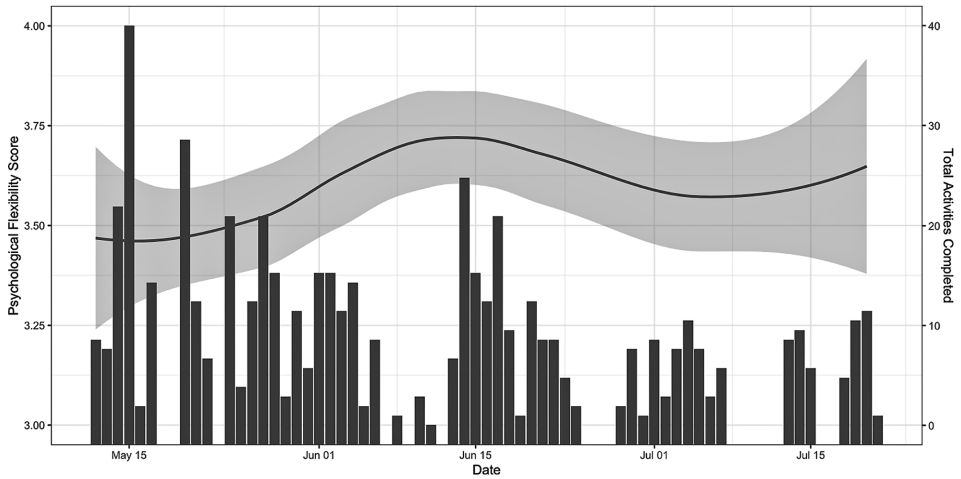


2.3.2 Psychological Flexibility

Given the app engagement patterns, we first examined if there were any statistically significant differences in psychological flexibility between the thirteen participants who remained active until the study's end and the 42 who did not. A one-way ANOVA revealed no differences between groups (F [1, 972] = 1.27, p = 0.26), and therefore the whole sample of 55 responders were grouped together for subsequent analyses. These participants, scored an average of 3.41 (SD = .86) on psychological flexibility two weeks prior to using the app, and had an average score of 3.61 (SD = .96) while using the app. The increase in psychological flexibility was statistically significant (F [1, 972] = 9.59, p = .002).

Although the general trend in scores before and after the app was introduced suggest that app usage is related to increases in psychological flexibility, it is important to carefully examine covarying role of app engagement over time. Figure 3 is a visual representation of changes in psychological flexibility as well as the number of mindfulness activities completed on each day. A close examination suggests the possibility that a time-lagged cumulative effect could explain changes in psychological flexibility over time over and above a concurrent linear effect.

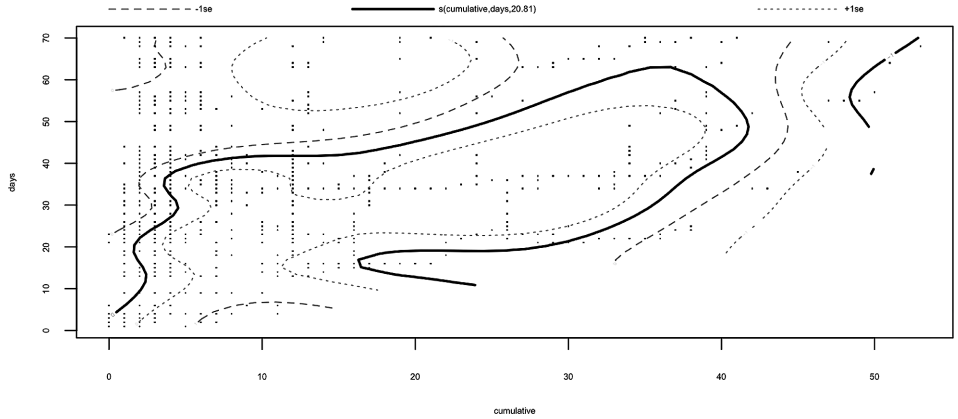
Figure 3. Changes in Psychological Flexibility (Left Axis) and Total Activity Completion (Right Axis) in the Student Sample



To account for the non-linearity of each variable as well as include a cumulative effect for activity completion, we constructed a generalized additive model (GAM) that accounted for participant differences and changes over time. With these effects in place, we examined the influence of time, activity completion over time, and cumulative activity completion over time. Only cumulative activity completion was statistically significant (eDF [26.38] = 22.8, F = 1.88, p = .003), indicating that changes in psychological flexibility may be related to the total amount of mindfulness activi-

ties a participant completed over time. Specifically, participants who "front loaded" by completing about 20-40 mindfulness activities in the first 30 days seemed to increase in psychological flexibility. Please see Figure 4 for a graphical representation of this relationship.

Figure 4. GAM Model Results for Cumulative Activity Completion Over Time in the Student Sample



2.4 Study 1 Discussion

Study 1 examined the effectiveness of a mindfulness app in increasing psychological flexibility. The main findings highlighted difficulties with engagement, as evidenced by 28.5% of the sample never participating and a sharp decrease in participation during the first two weeks. However, among those who persevered, the app was successful in increasing psychological flexibility over time through the cumulative influence of the mindfulness activities. In particular, those participants who front-loaded their activity completion, saw gains in psychological flexibility throughout the duration of the study.

The results of Study 1 revealed key limitations in the study design and generalizability. First, although psychological flexibility is related to improvements in mental health as well as work/study habits, it would be prudent to study these outcome variables directly. Second, it would also be important to expand the sample beyond students given that the engagement and benefit of the app to an older population may differ. To account for these limitations, Study 2 measured mental well-being as well as work productivity directly, and contained a sample of company employees.

STUDY 2

3.1 Study 2 Method

3.1.1 Participants

Thirty-seven pharmaceutical company employees (76% female) participated in the current study.

Among employees, 19% (n = 7) were production line workers, 2.7% (n = 1) were line managers, and 78.3% (n = 29) were administration.

3.1.2 Measures

3.1.2.1 Psychological Flexibility. Same as in Study 1. Chronbach's alpha in the current sample was .87.

3.1.2.2 Well-Being. The WHO-5 Well-being Index (Topp, Østergaard, Søndergaard, & Bech, 2015) is a short self-reported measure of current mental wellbeing. The WHO-5 has been found to have adequate validity in screening for depression and in measuring outcomes in clinical trials. Item response theory analyses in studies of younger persons and elderly persons indicate that the measure has good construct validity as a unidimensional scale measuring well-being in these populations. The WHO-5 has been translated to many languages. For the current study, we used the validated Japanese version of the measure. The Chronbach's alpha score for the current sample was .91, indicating good item reliability.

3.1.2.3 Workplace Performance. Workplace performance was measured using the daily output of the assembly line that each worker was associated with compared to a baseline established the previous year. When the assembly line outperformed the average daily production from that season the previous year, the score was over 1.0. When the assembly line underperformed, the score was below 1.0.

3.1.3 Procedure

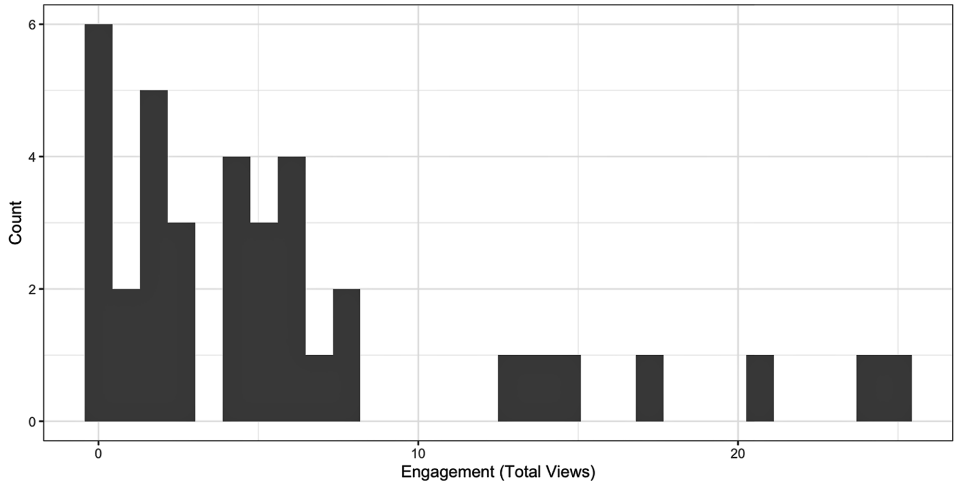
Company workers were recruited from a company-wide announcement from the HR director. Participants interested in joining received an explanation of the app, signed an informed consent, and were given a QR code that linked to login information. As with Study 1, the trial was 70 days long. The PsyFlex and WHO-5 questionnaire was sent out once per day and the mindfulness activities were sent randomly up to three times per day.

3.2 Study 2 Results

3.2.1 Engagement Statistics

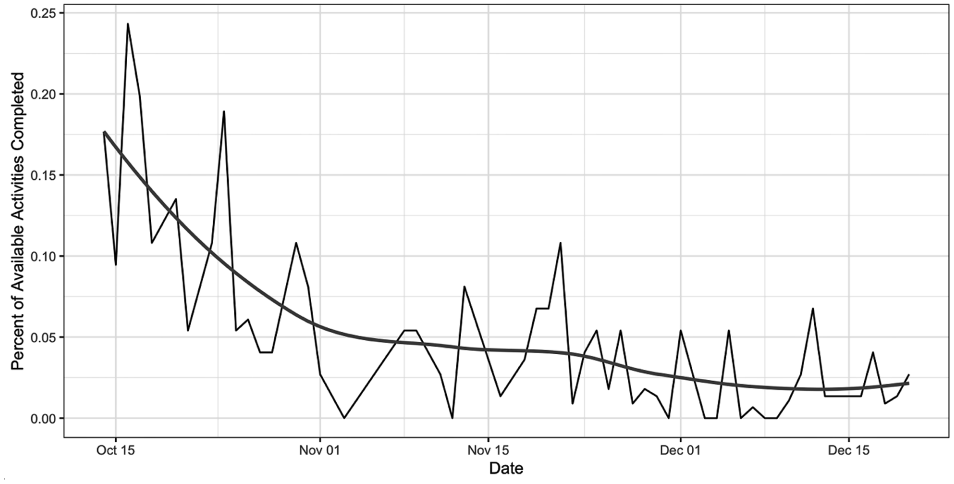
On average, participants watched 5.3% (*SD* = .22) of the mindfulness videos sent to them. Six participants (16.2% of the sample) did not complete any activities at all and therefore were removed from subsequent analyses. Among the remaining participants, each completed an average of 7.35 (*SD* = 6.76) mindfulness activities during the 90-day study. Please see Figure 1 for a distribution of total Engagement.

Figure 5. Distribution of Total App Engagement in Employee Sample



As in the student sample, engagement trends decreased over time. Most app users completed all their total activities within the first two weeks of the study. When looking at the engagement of all possible activities, participation fell precipitously within the first fourteen days and maintained a steady 1-4% until the end of the study. The consistency in the completion rate was attributed to three participants (8% of the total sample) who persevered to the end of the study by completing a few activities every several days. Please see Figure 6 for a representation of Engagement Statistics over time.

Figure 6. Percentage of Completed Activities Over Time in Employee Sample

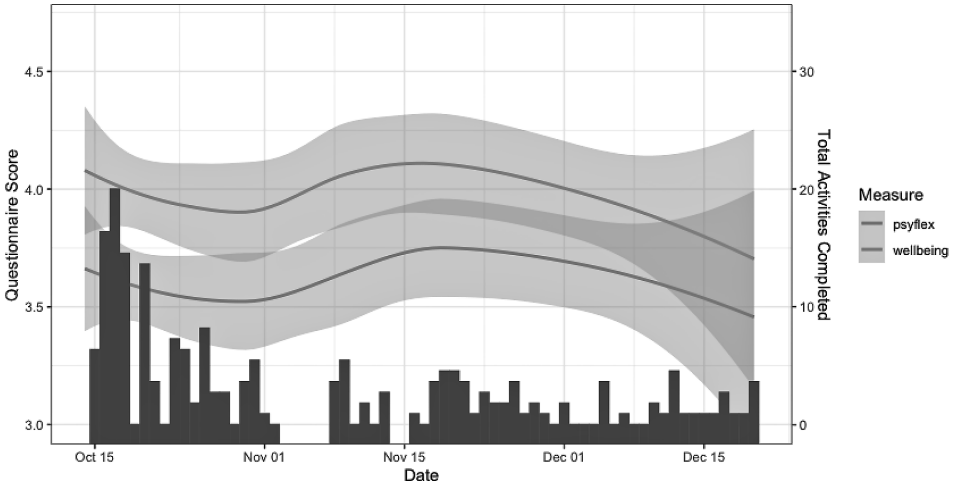


3.2.2 Psychological Flexibility and Mental Well-being

The low number of participants who completed to the end of the study did not provide the statistical power for a test of between group differences. We necessarily grouped all participants who completed any number of activities together in the same group. These participants scored an average of 3.42 (SD = .69) on psychological flexibility prior to using the app, and had an average score of 3.63 (SD = .96) while using the app. However, the increase in psychological flexibility was not statistically significant (F [1, 333] = 0.11, p = .742). This pattern was repeated for mental well-being, which had a pre-intervention mean of 3.74 (SD = .97) and a during intervention mean of 4.00 (SD = .96). The difference was not statistically significant (F [1, 333] = 0.23, p = .632). Importantly, psychological flexibility and mental well-being were highly correlated with each other over time (r = .77, t = 21.68, p < .001)

We plotted both psychological flexibility and mental well-being alongside the number of completed activities over time as in Study 1. According to Figure 7, both psychological flexibility and mental well-being decrease in the first two weeks, before increasing again toward the middle of the study, and then finally decrease again at the end. This curvilinear trend is more complex than the one found in Study 1 and explains why a simple base-rate comparison could not accurately capture changes in these two variables over time. In fact, a simple cumulative model would also not likely explain the trend very well, given the decreases in psychological flexibility and mental well-being both at the beginning of the study and at the end. In an attempt to capture this trend, we measured rolling cumulative scores that looked at the total number of activities completed in a week across every possible week during the study. We examined the effect of time, activity completion, cumulative activity completion, and rolling cumulative activity completion in our subsequent Generalized Additive Model.

Figure 7. Changes in Questionnaire Score (Left Axis) and Total Activity Completion (Right Axis) in the Employee Sample



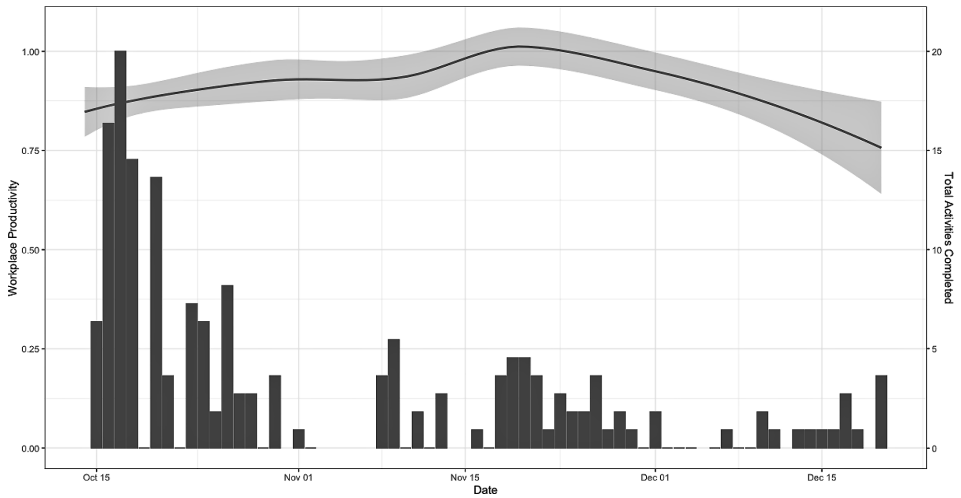
The GAM results showed that only cumulative activity completion was statistically significant (*eDF* [17.14] = 13.78, $F = 1.64$, $p = .03$), whereas time, activity completion, and rolling cumulative completion were not. Our trend plot was too sparse to discern any theoretically meaningful patterns, meaning that in this case, we know little more than "more activities are better."

3.2.3 Workplace Productivity

Participants scored an average of .84 ($SD = .26$) on workplace productivity prior to using the app, and had an average score of .92 ($SD = .30$) while using the app. The increase in workplace productivity was statistically significant (F [1, 436] = 5.77, $p = .016$). However, correlations with psychological flexibility and mental well-being over time were negative in direction, low in magnitude, and not statistically significant.

We re-ran our Generalized Additive Model using workplace productivity as the outcome variable. Time, Activity Completion, Cumulative Activity Completion, and Rolling Cumulative Activity Completion were all not related to changes in workplace productivity over time. This finding implies that the base rate comparison results may not be a valid representation of workplace productivity increases during app usage. Please see Figure 8 for the curvilinear trend.

Figure 8. Changes in Workplace Productivity (Left Axis) and Total Activity Completion (Right Axis) in the Employee Sample



3.3 Study 2 Discussion

Study 2's examination of the effectiveness of a mindfulness app in increasing psychological flexibility mirrored Study 1 in many ways. The main findings highlighted difficulties with engagement, with an even lower completion rate than the student sample. The dropout rate and dropout timeline, however, were about the same as the student sample. For psychological flexibility and mental well-being, as would be expected, we found a strong, statistically significant relationship between the two variables with one another, but no meaningful trend over time. Importantly, we did find that cumulative activity completion influenced scores of both psychological flexibility and mental well-being, but the data was too sparse to extract any meaningful patterns, meaning we do not even know if activity completion increased or decreased psychological flexibility over time. Workplace productivity increased over the course of the study. However, this increase was due to external factors given that it was not correlated with activity completion or any other measure.

The results of Study 2 demonstrated a failure to replicate and generalize the positive outcomes of Study 1. Although the concerns related to dropout replicated in the company worker sample, it is not clear if the app helped increase psychological flexibility, mental well-being, or workplace productivity. One key limitation in Study 2 was the small sample size. Thirty-seven people completing only a handful of activities may not be sufficient to test the efficacy of this program. If the study were to be replicated, doubling, or tripling the sample size would be recommended.

4. General Discussion

In our two studies, we attempted to test the efficacy of a mindfulness app built on a solid theoretical model with Japanese college students (Study 1) and Japanese company workers (Study 2). Overall, our results mirrored the results of previous studies. We found evidence that suggested that mental well-being and mindfulness skills increase based on cumulative app usage. The effect was consistent with previous studies (Gál et al., 2021; Zhang et al., 2020), which showed small to moderate improvements in mental well-being and mindfulness skill.

Strikingly, 28.5% of our student sample did not even participate. Among those who did, many dropped out within the first two weeks; our company worker sample had an even lower completion rate than the students. Both Study 1 and Study 2 had issues related to dropout, yet were still able to detect some positive results for those who persevered until the end. The results from the student sample indicated that changes in psychological flexibility may be related to the total amount of mindfulness activities participants complete over time. Specifically, participants who ”front-loaded” by completing approximately 20 to 40 mindfulness activities in the first 30 days appeared to be more psychologically flexible even at the end of the study.

High dropout rates undermine the effectiveness of mental health apps (Torous, Lipschitz, Ng, & Firth, 2020), and it appears that the app created for the current study was no exception. Therefore, a key objective for future research on mental health app design should be to discover ways to increase user retention. To that end, we recommend three ways to potentially reduce the dropout rate. The first is to increase human-to-human or human-to-machine interaction. As pointed out in the meta-analysis done by Taylor et al. (2021), the shift from passive communication to active communication increases the efficacy of the app. For instance, in the event that the user does not know how to use the app, they would be able to ask another user for guidance.

The second recommendation is to provide an interim report. Given that these apps are often intended for long-term use, it is possible that the user needs additional motivation periodically. By seeing one’s results more frequently in the process, the user gains a better understanding of their own mental state and change over time, likely leading to increased motivation. This may be able to be further optimized by immediately seeing the results of user performance on the app.

Finally, receiving feedback and encouragement from others is likely to increase motivation and user retention. More than just increasing interactive communication, it is possible that by receiving feedback from others on the results gained at a particular time would foster more social support and positive social reinforcement leading to a better experience with the app.

Each of these solutions include communicating directly to others, rather than relying solely on apps to complete activities beneficial for one’s mental health. This brings up the overarching question of what role mental health apps will play in the future of supporting an individual’s well-

being. The extant findings, including those of the current study, show that mental health mindfulness apps alone only bring small benefits to users. However, when combined with supportive listening from a peer, and/or counseling or formal psychotherapy, we may see a complementary effect.

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