

Evaluating an adjunctive mobile app to enhance psychological flexibility in acceptance and
commitment therapy

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Abstract

The primary aims of this study were to evaluate the feasibility and potential efficacy of a novel adjunctive mobile app designed to enhance the acquisition, strengthening, and generalization of acceptance and commitment therapy (ACT) skills being taught in therapy. A sample of 14 depressed/anxious clients receiving ACT used the ACT Daily app for two weeks in a pre-post, open trial design. Participants reported a high degree of program satisfaction. Clients significantly improved over the two-week period on depression and anxiety symptoms as well as a range of psychological inflexibility measures. Analyses of mobile app data indicated effects of ACT Daily skill coaching on in-the-moment measures of inflexibility and symptoms, with unique effects found for acceptance and mindfulness. Adjunctive ACT mobile apps appear promising in enhancing therapy effects on psychological inflexibility and outcomes. A tailored skill coaching approach like ACT Daily based on randomly prompted assessments may be especially promising.

Keywords: Acceptance and Commitment Therapy; Mobile App; Mindfulness; Depression; Anxiety.

Evaluating an adjunctive mobile app to enhance psychological flexibility in acceptance and commitment therapy

Acceptance and commitment therapy (ACT; Hayes, Strosahl & Wilson, 2011) is an efficacious treatment for a range of depression and anxiety disorders including generalized anxiety disorder, social anxiety disorder, and OCD-related disorders (Bluett, Homan, Morrison, Levin & Twohig, 2014; Hacker, Stone & MacBeth, 2015; Hooper & Larsson, 2015). ACT has been found to be efficacious in treating depression and anxiety disorders in at least 27 randomized controlled trials (RCTs; ACBS, 2016a; Hooper & Larsson, 2015), with meta-analyses indicating small to medium effect sizes ($g = .37-.54$) relative to control conditions for depression and anxiety outcomes (A-Tjak et al., 2015; Hacker et al., 2015) and equivalent or slightly greater effect sizes relative to traditional cognitive behavioral therapy (Bluett et al., 2014; Ruiz, 2012).

Current research also highlights areas for further improvement with ACT. For example, across 6 RCTs, ACT response rates ranged from 43% to 79% (Arch et al., 2012; Craske et al., 2014; Hayes-Skelton, Roemer & Orsillo, 2013; Kocovski, Fleming, Hawley, Huta & Antony, 2013; Losada et al., 2015; Zettle & Rains, 1989). This indicates a notable portion of clients who do not substantially improve from ACT, although response rates are similar to those found for traditional CBT (Loerinc et al., 2015). Preliminary research also suggests that ACT, similar to other evidence-based therapies, may have a drop in effect size when moving from RCTs in research settings to community-based effectiveness studies. For example, pre to post effect sizes for depression and anxiety in ACT effectiveness trials range between .31 and .87 (e.g., Forman, Herbert, Moitra, Yeomans & Geller, 2007; Lappalainen et al., 2007; Pinto et al., 2015), which is well below the average pre-post effect size found in meta-analyses of RCTs with depression (d

= 1.22) and anxiety ($d = 1.85$) (Hacker et al., 2015). These are similar challenges to other therapies, and may be due to factors such as lower fidelity to or competence implementing the therapy or treating more complex, and difficult-to-treat clients in these settings (Hans & Hiller, 2013). Thus, although ACT is effective for depression and anxiety disorders, further innovations are needed to enhance its impact, particularly when implemented in “real-world” clinics.

A strength of ACT is its well specified theory and mechanism of change research, which highlights key processes that might be targeted to augment response rates and address drop-offs in effect size with “real world” implementation. From the perspective of the psychological flexibility model (Hayes et al., 2011), depression and anxiety disorders are largely maintained by psychological inflexibility, in which one’s behavior is rigidly and excessively controlled by inner experiences or reactions to these experiences rather than chosen values or direct contingencies (Bond et al., 2011). Key subprocesses contributing to inflexibility include experiential avoidance (behaviors seeking to avoid, escape, or otherwise control unwanted inner experiences) and cognitive fusion (excessive/dominant control of literal functions of cognition over behavior; Hayes et al., 2011; Hooper & Larsson, 2015). ACT seeks to reduce inflexibility and increase psychological flexibility, the ability to engage in valued patterns of activity while being mindfully aware and accepting of whatever internal experiences may arise (Hayes et al., 2011). ACT seeks to do so by targeting a key set of subprocesses, or component skills, including acceptance (being willing to experience internal events without defense), cognitive defusion (noticing thoughts as just thoughts), present moment awareness (flexible attention to the present), and values (clarifying personal values and connecting them to action; Hayes et al., 2011).

Consistent with this theory, at least 10 RCTs indicate that the impact of ACT on depression and anxiety disorders is mediated by improvements in psychological inflexibility/flexibility

(Hooper & Larsson, 2015). Furthermore, these ACT component skills appear to have active psychological effects on relevant outcomes in isolation and combination (Levin, Hildebrandt, Lillis & Hayes, 2012). Thus, the effects of ACT may be augmented by enhancing the acquisition, strengthening, and generalization of these component skills (e.g., acceptance, defusion, present moment awareness, values) to increase psychological flexibility and reduce inflexibility.

Mobile apps provide a promising method for enhancing skills training in ACT (Lindhiem, Bennett, Rosen & Silk, 2015; Torous, Levin, Ahern & Oser, in press). For example, apps can deliver low intensity/high frequency skill coaching due to the ready availability of phones throughout the day. By providing brief and frequent skill coaching, apps can ensure regular repetition to support skill acquisition/strengthening as well as in vivo skill coaching when its most needed and helpful (for generalization). In addition, apps can support using the most effective skill for the moment, by personalizing coaching to one's current context based on assessment data and algorithms. In combination with face-to-face therapy, such an adjunctive app could enhance effective use of ACT skills to improve psychological flexibility.

Preliminary research suggests adjunctive mobile apps can improve therapy. A meta-analysis of 10 RCTs indicated a significant small effect size ($d = .27$) when adding adjunctive mobile apps to treatment as usual (TAU) versus TAU alone (Lindhiem et al., 2015). Although there has been less research on ACT apps specifically, preliminary results indicate ACT apps can increase psychological flexibility (Ly, Dahl, Carlbring & Andersson, 2012) and behavioral outcomes such as smoking cessation (Bricker et al., 2014). However, no adjunctive ACT apps have been researched to date for enhancing the efficacy of face-to-face therapy.

An adjunctive ACT app could be used to indiscriminately prompt and support the use of any ACT skills in the moment. However, the psychological flexibility model specifies a set of

component skills, which theoretically have unique functions that may be more or less applicable to specific situations and challenges. For example, research shows that acceptance increases willingness to experience emotions without engaging in maladaptive avoidance strategies (e.g., Levitt, Brown, Orsillo & Barlow, 2004). Defusion has been found to reduce excessive believability and behavioral control from unhelpful thoughts (e.g., Masuda, Hayes, Sackett & Twohig, 2004). Mindful awareness of the present has been found to reduce rumination and enhance attention regulation (e.g., Broderick, 2005). Values clarification has been found to increase sense of meaning and behavioral persistence (e.g., Low, Stanton & Bower, 2008; Branstetter, Cushing, & Douleh, 2009). Thus, an adjunctive ACT mobile app might be more effective if it also guides what ACT skills would be most effective for a particular situation. However, research to-date has not directly examined whether certain ACT skills are actually more effective than others in the moment based on relevant variables. Such clinical decision making questions have implications for how ACT apps are implemented as well as for clinicians using ACT more broadly (when to use what skills with clients).

In the current study we report the pilot test results of a mobile app called ACT Daily, an adjunctive program for clients receiving face-to-face ACT therapy. The ACT Daily app is designed to provide high frequency, low intensity, personalized ACT skill coaching through an ecological momentary intervention (EMI) approach. This includes randomly checking-in throughout the day on variables that might then inform a tailored skill coaching suggestion to practice specific ACT skills in the moment. An initial prototype of ACT Daily was created for this study to pilot test the feasibility and potential efficacy of a tailored ACT skill coaching delivered through a mobile app.

In this study the ACT Daily mobile app was evaluated using a pre-post open trial with 14 depressed/anxious clients receiving ACT from a therapist. The first aim was to evaluate the feasibility of the ACT Daily app, with the hypothesis that participants would report high rates of program satisfaction and demonstrate a high degree of program engagement. The second aim was to evaluate the potential efficacy of ACT Daily. This was examined first by testing the hypothesis that clients would improve on psychological outcomes and processes of change over a two week period using the app. Second, we hypothesized that clients would report immediate, in-the-moment, improvements after practicing ACT skills through the mobile app, and that the specific areas of improvement would vary based on what ACT skill component was used (e.g., acceptance skills would be more effective at reducing “fighting feelings” than other ACT skills). This latter hypothesis is critical to testing the potential efficacy of the key features of ACT Daily, which assume that ACT skill coaching can have immediate effects in-the-moment for clients, and that certain skills are better for certain situations (suggesting the need for tailored skill coaching). Achieving these aims would provide preliminary support for the potential feasibility and efficacy of using mobile apps to deliver *tailored* skill coaching for clients receiving ACT.

Methods

Participants

A sample of 14 depressed/anxious clients currently receiving ACT from a therapist in the United States were recruited. Eligibility criteria included current enrollment in face-to-face ACT treatment, over the age of 18, current depression and/or anxiety disorder, fluency in English, owning an Android phone (or being able to borrow one from our laboratory if a local participant), and clinical stability (i.e., not currently suicidal or experiencing manic or psychotic

symptoms). Therapists were asked to provide recruitment materials only to clients who met this criteria, and thus, were relied upon to confirm diagnosis and clinical stability.

A total of 14 depressed/anxious clients contacted the research team to participate, across 22 therapists who agreed to provide flyers to clients receiving ACT. All 14 of these clients met eligibility criteria and were enrolled in the study. The first participant was dropped from the sample (final $n = 13$) due to significant technological issues experienced with ACT Daily.

The sample ($n = 13$) was 69% female with an average age of 29 ($SD = 11.55$, Range = 18 – 55). The sample was 100% white, with 0% indicating being of Hispanic/Latino ethnicity. Based on cutoff scores with the Depression, Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 1995), 92% fell within the extremely severe anxiety range and 62% fell within the extremely severe depression range. The remaining participants were in the moderate to severe range on the DASS depression and anxiety subscales. Participants varied widely with regards to how long they have been working with their therapist (range = 3 weeks to 4 years, median = 7.85).

Procedures

After completing a phone screening, interested clients were scheduled for an in-person appointment (local participants $n = 6$) or sent an online link (non-local participants $n = 7$) to complete initial study steps. The only difference between local and non-local participants was whether initial steps were completed in-person or online.

During the in-person appointment, local participants completed informed consent and an online baseline assessment administered through Qualtrics (a web-based survey platform). Next, a researcher assisted the participant in downloading the ACT Daily app and provided a brief orientation on how to use the app. Non-local participants completed informed consent and the

baseline assessment online through an emailed link. Online instructions were then provided on how to download the app and a brief training video (7 minutes) reviewed how to use the app.

Orientation to the app (for both local and non-local participants) covered topics including how to complete prompted check-ins through ACT Daily, various features available in the app, and expectations for app usage. Participants were asked to use the app at least once per day for the following two weeks. Every participant also received a brief (2-3 minute) check-in call 24 hours later to confirm the app was working properly.

Two weeks after the baseline survey, participants were emailed a link to the online post assessment. After completing the post assessment, participants completed a 30-minute phone interview on experiences with the app. Participants received a \$50 gift card for participating.

ACT Daily

ACT Daily is an EMI-based mobile app designed to check-in with users on key variables that might guide what ACT skills to use in the moment. By doing so, ACT Daily seeks to enhance acquisition, strengthening and generalization of ACT skills, including the use of specific skills based on how a client is struggling with psychological inflexibility in the moment (e.g., are they fused with thoughts or disconnected from their values?). The primary components of ACT Daily in its current prototype form include 1) an initial library of ACT skill coaching sessions, 2) a check-in system, and 3) skill suggestions and browsing features.

The prototype ACT Daily program included 28 skill coaching sessions divided into four ACT components: acceptance, defusion, mindful awareness, and values. Each component included 5 quick skills, which provided very brief, text instructions on how to practice an ACT skill in the moment (taking a minute or less to complete). These were designed so that clients could easily try out a randomly selected quick skill in the moment. Each ACT component also

included 2 depth skills, which provided 3-5 minute exercises that spanned multiple pages including mindfulness exercises (e.g., mindful breathing) and interactive exercises (e.g., a series of pages guiding users through how to practice defusion with a specific thought).

Skill coaching could be accessed only by completing a check-in. The check-in system provided semi-random prompts 3 times each day between 9am and 9pm (once each between 9am-1pm, 1pm-5pm, and 5pm-9pm). If a user did not respond, reminder prompts were provided 5 and 10 minutes later. Users could also launch the app themselves to check-in at any time.

The check-in included six items assessing symptoms and core ACT skill components (see Figure 1). A prompt at the top asked “How much are you...” with two items for symptoms (i.e., “feeling depressed,” “feeling anxious”) and one each for experiential avoidance (“fighting your feelings”), cognitive fusion (“stuck in thoughts”), lack of mindfulness (“on autopilot”) and lack of values connection (“disconnected from values”). Each item was rated on a visual analogue scale from 0 to 100. These items were kept purposefully brief to ensure that the check-in could easily be completed, for frequent, repeated use. The meaning of each item was reviewed during the initial orientation to the app. A “?” symbol next to each item opened a popup window that further clarified the construct being assessed. These items were reviewed with ACT clinicians and clients during previous formative evaluation stages to further ensure comprehension.

After completing a check-in, users could navigate to a suggested ACT skill or end the session. Skill suggestions were based on the users’ check-in responses, with whatever skill component was rated the highest being the indicated component for coaching (e.g., if “stuck in thoughts” was rated the highest of the four components, then defusion skills would be recommended). One way to access a suggested skill was to select “quick skills” which would automatically direct the user to a randomly selected quick skill within the skill component

indicated for the user. Alternatively, users could select “browse skills” which would allow them to access a quick or depth skill of their choice, with the suggested ACT component highlighted.

After completing a skill coaching session, users completed a post check-in assessment, which mirrored the items from the initial check-in. Users could then end their app session or go to a new quick or depth skill based on their new responses to the post check-in.

Online Survey Measures

Depression, Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 1995). The 21-item DASS assessed primary psychological outcomes, rated on three distinct subscales (i.e., depression, anxiety, and stress). Items are rated on a 4-point scale ranging from 0 “did not apply to me at all” to 3 “applied to me very much or most of the time.” Previous research has supported the reliability and validity of this measure (e.g., Lovibond & Lovibond, 1995), in addition to its sensitivity to detecting ACT treatment effects in web-based interventions (e.g., Levin, Pistorello, Hayes & Seeley, 2014). Adequate internal consistency was observed across all three subscales in the current study: DASS-Depression $\alpha = .86$, DASS-Anxiety $\alpha = .78$, and DASS-Stress $\alpha = .78$.

Acceptance and Action Questionnaire-II (AAQ-II; Bond et al., 2011). The AAQ-II is a 7-item measure of overall psychological inflexibility (i.e., the primary pathological process targeted by ACT). Items are rated on a 7-point scale ranging from 1 “never true” to 7 “always true.” The AAQ-II has displayed adequate reliability and validity in previous research (Bond et al., 2011). Within the current study, the AAQ-II displayed good internal consistency ($\alpha = .81$)

Cognitive Fusion Questionnaire (CFQ; Gillanders et al., 2014). The CFQ is a 7-item measure of cognitive fusion, a sub-process of psychological inflexibility that is specifically targeted by the skills provided within ACT Daily. Items are rated on a 7-point scale ranging from 1 “never true” to 7 “always true.” While the CFQ is a new measure, results from the initial

validation study displayed adequate reliability and validity with a variety of populations (Gillanders et al., 2014). The CFQ had good internal consistency ($\alpha = .90$) in the present study.

Valuing Questionnaire (VQ; Smout, Davies, Burns & Christie, 2014). The VQ is a 10-item measure of valued action, another therapeutic subprocess that is targeted by ACT Daily. Each item is rated on a 7-point scale ranging from 0 “not at all true” to 6 “completely true.” The VQ consists of two subscales; progress on valued living and obstruction to valued living. The VQ is a new measure, but preliminary research supports its validity and reliability (Smout et al., 2014). In the current study, both VQ subscales displayed questionable internal consistencies approaching acceptable levels: VQ-Obstacles $\alpha = .69$ and VQ-Progress $\alpha = .68$.

Philadelphia Mindfulness Scale (PHLMS; Cardaciotto, Herbert, Forman, Moitra & Farrow, 2008). The PHLMS is a 20-item measure of mindfulness, with subscales for present moment awareness and acceptance. Both of these subscales are core sub-processes of ACT targeted by skills presented within ACT Daily. Items are rated on a 5-point scale ranging from 1 “never” to 5 “very often.” The PHLMS has displayed adequate reliability and validity in past research (Cardaciotto et al., 2008). Good internal consistency was observed within both PHLMS subscales in the current study: PHLMS-Awareness $\alpha = .85$ and PHLMS-Acceptance $\alpha = .83$.

System Usability Scale (SUS; Tullis & Albert, 2008). The SUS is a 10-item measure of program usability and acceptability that was provided at the post time point only. Each item is rated on a 5-point scale ranging from 1 “strongly disagree” to 5 “strongly agree.” Findings across 206 research studies support SUS items loading onto a single latent factor, excellent internal consistency (Cronbach’s $\alpha = .91$), and effective differentiation between more and less usable programs (Bangor, Kortum & Miller, 2008). The SUS has also been found to discriminate between more and less satisfactory online ACT programs (Levin et al., 2014; in press). In the

current study, SUS internal consistency approached acceptable levels ($\alpha = .67$). An additional set of items adapted from previous online ACT trials (Levin et al., 2014; in press) were included to further assess aspects of program satisfaction including global satisfaction, perceived helpfulness, ease of use, and whether they would recommend the app to others.

Data analysis

For the first aim (testing program feasibility), descriptive statistics were examined for mobile app usage and satisfaction rates. Open responses to survey questions and interviews were further examined for themes regarding areas requiring revision.

For the second aim (testing potential efficacy), paired sample *t*-tests were first conducted to test improvements in outcomes and processes of change over the two-week intervention period. Although this is confounded with participation in therapy, two weeks represent a relatively brief period of time defined by using the app, and thus might provide a very preliminary estimate of the impact of the ACT Daily app on depression, anxiety, and psychological inflexibility.

Additional analyses were conducted with the ACT Daily app data to more specifically examine the potential efficacy of tailored, in-the-moment, app skill coaching on psychological inflexibility and depression and anxiety outcomes. These analyses were conducted using the ACT Daily check-in assessment completed after each login as well as the post skill coaching check-in completed immediately after each ACT Daily skill session. App data was analyzed using multilevel modeling (MLM; Raudenbush & Bryk, 2002) with Maximum Likelihood estimation for missing data (MLE; Enders, 2001). MLM is used to account for the nested error structure when multiple observations are taken within participants, as well as to model the effects of time-varying and time-invariant variables. The present analyses incorporated a three-level structure in which observations were nested within coaching sessions (pre and post-intervention

pairs), which in turn were nested within participants. In the context of missing data, MLE has the advantage of incorporating cases with complete and incomplete data in estimating the most likely parameters to have produced the observed data (Enders, 2001).

In the first set of MLM analyses, we examined the overall, immediate effects of the ACT daily interventions combining all types of skill coaching sessions. We used MLM to examine the average difference from pre- to post-skill coaching for each app-based outcome using a random slopes model. This difference was tested using a dummy variable designating the post-intervention score within each coaching session. These results were used to test whether participants' psychological inflexibility and depression/anxiety decreased immediately after completing any skill coaching session – suggesting an immediate effect of using the app.

In a second series of MLM we tested the additional hypothesis that each ACT component skill has unique effects on specific facets of psychological inflexibility (supporting a tailored coaching approach in which certain skills are more effective for certain contexts). To examine the differential effects of the four types of intervention, separate MLMs were run in which dummy codes were used to distinguish the effects of the tailored interventions from those of the non-tailored interventions. Tailored interventions were defined as the ACT skill component most directly linked to the targeted facet of psychological inflexibility (e.g., acceptance skills were hypothesized to have a greater immediate effect on “fighting feelings” than other ACT skills). In each model, the outcome variable was regressed on the post-intervention dummy variable and interactions between this dummy variable and dummy variables for each of the non-tailored interventions. The coefficient associated with the post-intervention dummy variable indicated the effect of the tailored intervention on the target outcome, e.g., the effect of acceptance skills on “fighting with feelings.” The coefficients associated with the interaction terms indicated the

differential effects of the non-tailored interventions, e.g., the difference in the effects of mindfulness and defusion skills on the outcome “stuck in thoughts.” These analyses were tested whether each specific ACT component skill, had a greater, targeted impact on the associated aspect of psychological inflexibility relative to other component skills (e.g., acceptance producing a greater pre to post coaching reduction in “fighting feelings” than defusion, mindfulness or values coaching skills). In other words, these analyses tested whether there is a benefit to suggesting certain ACT skills over others based on what aspects of psychological inflexibility are more or less relevant (e.g., acceptance when struggling with fighting with feelings versus values when struggling with being disconnected with what matters).

Results

Aim 1 – Feasibility: Mobile app usage

Participants completed an average of 32.54 check ins over the 14 day period ($SD = 14.30$, range = 7 – 51 check ins). Most participants actively and regularly engaged in using the app with 85% completing an average of at least one check in a day and 69% completing an average of two check ins or more a day.

Participants completed an average of 27.75 skill coaching sessions over the two week testing period ($SD = .97$, range = 7 – 58). In relation to check ins, participants completed approximately .97 skill coaching sessions per check in ($SD = .41$) with a range from .53 to 1.81 (some participants completed multiple skill coaching sessions after each check-in). In terms of type of skill, participants completed 16.50 quick skills on average ($SD = 8.37$) and 11.25 depth skills ($SD = 12.66$). The lowest used skill category were the meditation depth skills (i.e., breathing mindfulness, acceptance of emotions, leaves on a stream), with only 4.63 meditations completed on average ($SD = 6.67$, 25% completing no meditation sessions). Combining across quick and

depth skills, participants used defusion skills the most ($M = 8.75$, $SD = 4.83$) with similar rates for values skills ($M = 6.25$, $SD = 5.15$), acceptance skills ($M = 6.38$, $SD = 4.90$) and present moment skills ($M = 6.38$, $SD = 6.55$). Overall, these results indicate a fairly high rate of engagement with the app in terms of both check-in assessments and skill coaching sessions.

Aim 1 - Feasibility: Mobile app satisfaction

Participants provided high usability ratings for the mobile app based on the SUS ($M = 89.08$, $SD = 7.69$), which is consistent with an “excellent” rating (Bangor et al., 2008). This is higher than previous online ACT trials using the SUS, which have ranged from 71.13 (Levin et al., in press) to 85.14 (Levin et al., 2015). Satisfaction ratings were also consistently high for individual items (See Table 1). Almost all participants (92%-100%) gave positive responses (at least “slightly agree”) on facets including satisfaction, perceived helpfulness, and ease of use. The most frequently identified areas for revision based on user feedback included that the app did not have enough content and became repetitive over time (suggesting the need for more, varied content), the reminder prompts occurred too often or at inconvenient times (suggesting less frequent prompting, or the ability to have a “snooze” or scheduling feature), and skill coaching required too much reading (suggesting use of more visual and audio elements).

Aim 2 – Efficacy: Pre to post changes in outcomes and psychological flexibility

Paired sample t -tests indicated significant improvements over two weeks on depression, anxiety, experiential avoidance, cognitive fusion, obstruction to valued living, and mindful acceptance (see Table 2). A non-significant trend was found for improvements on stress. Effect sizes ranged between .45 and 1.13. Reliable change index rates for clinically significant improvement ranged from 14% to 29% on symptom measures and 29% to 71% on psychological inflexibility measures. No effects were found on values progress or mindful awareness.

Aim 2 – Efficacy: Mobile app analyses

Do clients demonstrate immediate improvement after practicing ACT skills through the app?

The results of MLM analyses testing the immediate effects of ACT Daily skill coaching on app check-in assessments are presented in Table 3. Statistically significant reductions in outcomes from pre- to post-intervention were observed in each model, as illustrated by the negative coefficients associated with the post-intervention dummy variable (Post). This indicates that on average across all skill coaching sessions, participants experienced an immediate improvement in each symptom and psychological inflexibility variable from check-in to directly after a skill coaching session. These findings further support the potential benefits of ACT Daily on psychological inflexibility and depression/anxiety as a result of in-the-moment skill coaching.

Does each ACT skill component have a differential effect on immediate outcomes? A series of MLMs were conducted to determine whether each ACT skill component had a uniquely stronger effect on its related facet of psychological inflexibility, which would support a tailored skill coaching approach (e.g., cognitive defusion is most indicated when someone is struggling particularly with being stuck in thoughts [fused]). Results of the MLMs for each app check-in variable are presented in Table 4.

Each tailored app intervention produced statistically significant pre-post reductions in the target outcome variables, with the exception of values skills on being disconnected from values ($p = .055$). Acceptance and mindfulness each demonstrated the strongest differential effects, such that post-intervention changes associated with these tailored interventions were significantly larger than changes produced by the non-tailored interventions on the same target outcome (as illustrated by positive, significant coefficients associated with the non-tailored skills in Table 4). Thus, acceptance had a significantly greater pre-post effect on improving “fighting with

feelings” than any other ACT components (13.18 more than defusion, 9.17 more than mindfulness, 13.77 more than values). Similarly, mindfulness had a significant (or at least trending) greater effect on “being on autopilot” than any other ACT components.

The effects of the Defusion and Values clarification interventions were not significantly different from those of non-tailored interventions for their target outcomes (stuck in thoughts, disconnected from values). This suggests that values may be no more effective than other ACT component skills at reducing being “disconnected from values,” while defusion may be no more effective than other ACT component skills at reducing being “stuck in thoughts.” Overall, these findings provide support for the potential unique impact of specific ACT skill components on related aspects of psychological inflexibility, suggesting certain ACT skills may be more or less effective based on what aspects of psychological inflexibility are most relevant in the moment.

Discussion

This study sought to evaluate the feasibility and potential efficacy of an adjunctive ACT mobile app to enhance ACT skill use among depressed and anxious clients. Results indicated that clients found the app to be acceptable with high ratings for satisfaction and engagement rates. Preliminary indications of potential efficacy were found, with participants improving over the two-week period on depression and anxiety symptoms as well as a range of psychological flexibility measures. Results from the mobile app data provided further support for the potential utility of an app focused on high frequency, low intensity, personalized skill coaching. Participants appeared to improve in the moment on components of psychological flexibility and psychological symptoms after completing coaching sessions. Furthermore, preliminary support was found for the potential benefits of providing personalized skill coaching, with app data

indicating that acceptance and mindfulness skill coaching sessions were more effective for targeting “fighting feelings” and “being on autopilot” respectively relative to other ACT skills.

This is the first study to suggest that an adjunctive ACT app might enhance face-to-face therapy effects for depression and anxiety. The app leveraged key features provided by mobile phones through the use of high frequency check-ins to provide personalized, low intensity skill coaching in the moment. Arguably, a simpler approach to tailored skill coaching could be used in which an app randomly prompts clients to practice ACT skills, with an open “toolbox” of various ACT skills made available. However, preliminary results from this study suggest that indeed there are more and less effective skills in the moment based on one’s current sources of psychological inflexibility. For example, mobile app data indicated that acceptance skills were more effective for reducing “fighting with feelings” (i.e., experiential avoidance with emotions), suggesting this may be the ideal skill to use in the moment. By providing a brief check-in and skill suggestions, users were able to become more aware of these contextual factors and linked skills, which might improve their future use of the most effective skill for the moment (a more sophisticated version of skill generalization).

This first app prototype used a fairly basic approach for making skill suggestions – selecting skill components based on whatever associated source of psychological inflexibility was most elevated in the moment. Future research should aim to systematically research and refine a more complex algorithm that incorporates additional variables including person-level moderators (presenting problem, level of inflexibility, familiarity with each ACT skill component), other immediate contextual variables (e.g., whether alone or not), and past app usage (e.g., preferred app skill sessions and features). Furthermore, it is worth considering the use of both passive monitoring tools (e.g., monitoring heart rate, GPS) and just-in-time adaptive

intervention methods that might lead to more personalized and automated coaching over time (e.g., predicting and prompting when a user might benefit from coaching automatically).

Developing a highly refined algorithm could lead to more effective and engaging personalized coaching over time. Furthermore, this research can simultaneously help to further inform broader ACT theory and practice, significantly refining our understanding of what ACT components/skills are most effective to what clients under which conditions.

The use of an adjunctive app like ACT Daily could improve several dimensions of mental health services including increasing response rates, the efficiency or effectiveness of treatment, and the consistency of treatment effects across providers. For example, such an app can help ensure that clients receive standardized, evidence-based coaching materials, while also being supported through therapist interactions. This blended approach might be particularly ideal in both enhancing face-to-face therapy and ensuring engagement in mHealth programs.

One of the most notable negative findings from this trial was the surprising difficulty encountered in recruiting clients through therapists. Although 22 therapists agreed to provide flyers to clients, only 14 clients ended up participating over a 14 month recruitment period. This in part likely reflects acceptability challenges with regards to therapists referring clients to apps and clients following up on such referrals. A recent survey of ACT practitioners (Pierce, Twohig & Levin, in press) similarly found that very few refer clients to mobile apps, despite high perceived usefulness of apps and their wide availability online (Torous et al., in press). Thus, although an adjunctive ACT mobile app appears promising and desirable to therapists, there are likely additional barriers to implementation that need to be addressed and warrant further study.

Interestingly, participants reported spontaneously using the app with their therapists, despite the prototype not having any therapist integration components. Future iterations of ACT

Daily or other adjunctive apps would benefit from including features such as a therapist dashboard to monitor ongoing app usage and responses to check-ins. This could help therapists monitor clients' improvements with ACT skills and therapy targets as well as supporting their clients' ongoing adherence to using the app (e.g., following up if a client stops using the app).

Given this was a small pilot study, there were notable limitations. The largest limitation was the use of a pre-post open trial design, which in the context of clients also in therapy, significantly reduces the conclusions that can be made regarding the degree to which (if any) the mobile app contributed to improvements on outcome and process measures. The relatively short assessment window (2 weeks) and findings with in-the-moment mobile app coaching provide some additional assurance the app may have improved targeted variables, but ultimately a well-controlled RCT is needed. Future research would benefit specifically from testing whether TAU plus the app is more efficacious than TAU alone. It would also be important for future research to further examine how an adjunctive mobile app enhances therapy variables beyond use of ACT skills. For example, research could examine whether use of a mobile app enhances therapeutic alliance, client engagement in-session, client satisfaction with therapy, and so on.

The study sought to evaluate an initial prototype of ACT Daily, which was particularly limited with regards to app features and content. For example, the final version of ACT Daily would also incorporate committed action and self-as-context skills. Similarly, ACT Daily would eventually include a much larger library of skill sessions. Even in a two week period, many participants reported that the app became repetitive, suggesting the final app will need substantially more content. These limitations may have reduced the impact of ACT Daily on putative processes of change, helping to explain why two process measures (mindful awareness and progress in valued action) did not improve over the two-week intervention period.

The study was limited in terms of testing clinically significant effects given the short time window of two weeks for using the app and assessing outcomes. Future research is needed to evaluate the impact of the app over a longer time period and in terms of follow up assessment. This short time window also limited the ability to assess long-term engagement in the app. It is likely that clinicians would want clients to use the app for more than two weeks and thus trials are needed to test whether clients do continue to use the app over time. Longer time periods would also allow for examination of whether intervention effects differ over time using the app (maybe getting larger due to practice effects or weakening due to diminishing returns from similar exercises), which would inform future app design and implementation.

Finally, this study was limited with regards to the use of a small, homogeneous sample. Although MLM is less impacted by a smaller sample size provided there are a large number of observations per participant, as was the case in this study, the limited sample has notable implications for generalizability. It is unclear whether the findings regarding program acceptability, increases in psychological flexibility, and decreases in depression/anxiety are due to the unique sample in this study, or if results would generalize to broader, more diverse samples of clients receiving ACT.

Despite these limitations, this pilot trial was successful in meeting its aims. The results provided a preliminary test that does support the potential acceptability and efficacy of an adjunctive ACT app. Several “lessons learned” were identified for future app development and evaluation. Although more controlled research is now needed, this study provides preliminary support for the concept of using adjunctive ACT mobile apps to support clients in therapy.

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Table 1. Program satisfaction ratings

Satisfaction Item	<i>M (SD)</i>	% \geq 4 “slightly agree”
Overall, I was satisfied with the quality of the app	5.23 (.83)	92%
The app was helpful to me	5.23 (.73)	100%
The app was easy to use	5.54 (.88)	92%
I felt the app was made for someone like me	5.38 (.87)	92%
I would like to use the app again in the future	5.15 (.90)	92%
I think the app would be helpful for other clients in therapy	5.69 (.48)	100%
I would recommend the app to a friend who was struggling	5.62 (.51)	100%
The app helped me work on things I’ve been learning in therapy	5.38 (1.19)	92%
I’d recommend my therapist use this app with other clients like me	5.54 (.66)	100%

Note: Satisfaction items were rated on a 6-point scale from 1 “strongly disagree” to 6 “strongly agree.”

Table 2. Descriptive statistics and paired sample *t*-test results from baseline to post (two weeks later).

Measure	Baseline	Two-Week	<i>t</i>	Cohen's <i>d</i>	RCI
	<i>M</i> (<i>SD</i>)	Post <i>M</i> (<i>SD</i>)			
DASS-Depression	31.54 (9.17)	25.23 (5.45)	3.20**	.84	29%
DASS-Anxiety	29.54 (9.13)	25.69 (8.08)	2.24*	.45	14%
DASS-Stress	34.31 (7.87)	30.77 (4.94)	1.79†	.54	29%
AAQ-II	32.77 (7.84)	25.08 (5.63)	3.26**	1.13	50%
CFQ	37.46 (6.19)	32.08 (5.01)	3.00*	.96	71%
VQ-Obstacle	23.62 (5.04)	19.08 (3.64)	2.90*	.84	36%
VQ-Progress	21.46 (3.86)	22.85 (4.56)	-.81	.33	57%
PHLMS-Acceptance	36.38 (5.25)	31.77 (7.11)	2.69*	.74	29%
PHLMS-Awareness	33.46 (7.18)	34.38 (6.19)	-.54	.14	36%

†*p* < .10, **p* < .05; ***p* < .01. DASS = Depression, Anxiety and Stress Scale, AAQ = Acceptance and Action Questionnaire, CFQ = Cognitive Fusion Questionnaire, VQ = Valuing Questionnaire, PHLMS = Philadelphia Mindfulness Scale. RCI = Reliable change index, reported in terms of the percent of the sample demonstrating reliable improvements (T-score > 1.96) over the two week app testing period.

Table 3. Results of MLM assessing overall ACT Daily coaching session effectiveness.

Model	Pre to Post Skill Check-In Change
Depression	-5.54**
Anxiety	-3.57*
Fighting Feelings	-4.41**
Stuck in Thoughts	-8.47**
On Autopilot	-4.73**
Disconnected from Values	-5.54*

* $p < .01$, ** $p < .001$.

Table 4. Results of the four multilevel models assessing differential intervention effectiveness.

Outcome	Pre-Post Tailored Skill	Vs. Accept	Vs. Defusion	Vs. Mindful	Vs. Values
Fighting with feelings	-14.11**	-	13.18**	9.17**	13.77**
Stuck in thoughts	-10.41**	4.25	-	3.43	4.45
On autopilot	-10.44**	6.00†	8.57†	-	8.10*
Disconnected from values	-6.72†	-1.14	4.11	-0.30	-

*Note. Each row represents a separate model testing the impact of each skill component on a specific facet of psychological inflexibility. The tailored skill represents the pre-post effect of the skill component that is theoretically most relevant to the facet of inflexibility (e.g., defusion for being stuck in thoughts). † $p < .10$, * $p < .01$, ** $p < .001$.*

Figure caption

Figure 1. Screenshot of the ACT Daily check in assessment.

