2017

The acceptance and commitment therapy matrix mobile app: A pilot randomized trial on health behaviors

Michael Levin
Utah State University

Benjamin Pierce
Utah State University

Benjamin Schoendorff

The acceptance and commitment therapy matrix mobile app: A pilot randomized trial on health behaviors

Michael E. Levin [a*], Benjamin Pierce [a], & Benjamin Schoendorff [b]

[a] Utah State University, Department of Psychology, 2810 Old Main Hill, Logan, UT 84322.

[b] Contextual Psychology Institute in Montreal, QC, Canada

* Corresponding author. Utah State University, 2810 Old Main Hill, Logan, UT 84322, United States. Phone: +001 (541) 531-3892; Fax: +001 (435) 797-1448, E-mail address: Michael.Levin@usu.edu.

Abstract

Mobile apps provide a promising format for delivering acceptance and commitment therapy (ACT) to improve diet/exercise. This pilot trial evaluated a novel ACT-based app for health behaviors based on the matrix approach. A sample of 23 community adults were randomly assigned to use the app for two weeks or to a waitlist condition. Findings indicated a high degree of satisfaction with the app and acceptable adherence. Although the intent-to-treat sample indicated few intervention effects, when focusing on program engagers only, health behaviors significantly improved in the app condition relative to waitlist. There were no differences between conditions on valued action or experiential avoidance. However, the rate of valued actions increased over days using the app. This was moderated by baseline values and experiential avoidance, suggesting those more psychologically flexible benefit more from the matrix app. An ACT matrix app appears promising for improving health behaviors, but additional revisions and research is needed.

Keywords: Acceptance and Commitment Therapy; Mobile App; Obesity; Exercise; Diet

The acceptance and commitment therapy matrix mobile app: A pilot randomized trial on health behaviors

Diet and exercise are two key health behaviors that predict a variety of health problems and mortality (Loef & Walach, 2012; Mozaffarian, Wilson, & Kannel, 2008; Wang, Li, Chiuve, Hu, & Willett, 2015). Although improving healthy diets and exercise can have substantial benefits (Loef & Walach, 2012; Mozaffarian et al., 2008), they also are difficult to initiate and maintain over time (Forman & Butryn, 2015). Innovative interventions are needed to enhance long-term diet and exercise change.

A growing body of research indicates the efficacy of acceptance and commitment therapy (ACT; Hayes, Strosahl, & Wilson, 2011) for improving healthy diet and exercise behaviors (Forman & Butryn, 2015; Lillis & Kendra, 2014). ACT is a contextual cognitive behavioral therapy that emphasizes acceptance, mindfulness, and values-based strategies to address a wide range of psychological and behavioral health problems (Hayes et al., 2011). ACT has been found in eight published randomized controlled trials to improve diet, exercise, and/or weight relative to waitlists (Katterman, Goldstein, Butryn, Forman, & Lowe, 2014; Lillis, Hayes, Bunting, & Masuda, 2009; Tapper et al., 2009), education control groups (Butryn, Forman, Hoffman, Shaw, & Juarascio, 2011), treatment as usual (Weineland, Arvidsson, Kakoulidis, & Dahl, 2012), a walking program with pedometer (Moffitt & Mohr, 2015), and standard behavioral treatment for weight loss (Forman et al., 2013, in press).

The vast majority of these studies have examined face-to-face ACT programs involving up to 37 hours of in-person group sessions over 40 weeks (Forman et al., 2013). Although more intensive programs are likely necessary in the context of structured weight loss interventions (Forman & Butryn, 2015; Lillis & Kendra, 2014), evaluating ACT in briefer formats is also

important for informing lower intensity health promotion programs that might be offered more broadly to enhance public health.

Mobile apps are a logical format for broadening the reach of ACT health interventions, providing a cost effective medium for increasing access to interventions across a population. These apps may be ideal for health behavior change interventions given the combination of low intensity, high frequency interactions that can occur throughout someone's day on their smartphone (Heron & Smyth, 2010). This not only provides a convenient, less-demanding format to learn ACT skills, but it also encourages generalization of ACT skills to everyday situations, including critical decision points for diet and exercise. Initial research indicates ACT can be effectively delivered in a mobile app format for smoking cessation (Bricker et al., 2014), but no research has been published on how to deliver ACT for diet and exercise change.

Theory can be a useful guide when translating more intensive, face-to-face interventions to briefer, technology-based formats. ACT primarily seeks to improve diet/exercise behaviors by decreasing experiential avoidance (i.e., away moves) and increasing valued actions (i.e., toward moves) (Lillis & Kendra, 2014). Theoretically, unhealthy eating habits and lack of exercise can serve a core experiential avoidance function of avoiding/escaping unwanted inner experiences (e.g., thoughts, feelings, cravings, sensations) (e.g., Juarascio, Forman, Timko, Butryn, & Goodwin, 2011; Schaumberg et al., 2016; Vartanian & Shaprow, 2008). These are referred to as away moves since they seek to "get away from" internal experiences. In addition, to reducing experiential avoidance, ACT seeks to help individuals clarify their values and link these values to one's actions (including diet and exercise) (Forman & Butryn, 2015; Lillis & Kendra, 2014). This provides a long-term motivator and guide for actions including diet and exercise (and are referred to as toward moves because they "move towards" values).

The matrix (Polk & Schoendorff, 2014) is an ACT protocol that may be especially apt for efficiently targeting towards and away moves in a mobile format. The matrix is often worked with visually, involving two intersecting lines composing four quadrants, which provide a "point of view" on one's actions and psychological experiences. The horizontal line is labeled "away" (on the left) and "toward" (on the right), referring to away from inner experiences (experiential avoidance) and towards values (valued action). The vertical line is labeled "mental experiencing" (on the bottom), referring to inner experiences such as thoughts and feelings, and labeled "five-sensing experiencing" (on the top), referring to the outside world we experience through our five senses (including overt actions like toward and away moves).

The matrix theorizes that simply discriminating one's experiences and the function of one's actions in relation to these four quadrants (e.g., noticing toward and away moves) can, over time, significantly reduce experiential avoidance and increase valued activities. As clients learn and repeatedly practice noticing the function of their actions in relation to the matrix, they naturally shift their behavior in the direction of moving towards their values. These moments of noticing may offer an opportunity to consider the purpose of one's actions in relation to one's values and goals. This may reduce away moves linked to unhealthy patterns (e.g., emotional eating, exercise avoidance) or ineffective weight loss behaviors (e.g., overly restrictive dieting), while increasing healthy behaviors linked to one's values that might be more successful and sustainable. However, since the matrix is relatively new, there are few published empirical studies to-date (Polk & Schoendorff, 2014).

The matrix highlights an ideal target for simplifying ACT into a low intensity, high frequency mobile app. Self-monitoring health behaviors such as diet and exercise is a commonly used and efficacious behavioral health intervention (Butryn, Webb, & Wadden, 2011;

Dombrowski et al., 2012), which may be even more efficacious when implemented through technology (Ross & Wing, 2016). For example, a meta-analysis of 42 RCTs found that the inclusion of self-monitoring strategies in interventions for weight change predicted greater treatment effects (Dombrowski et al., 2012). A recent study specifically tested the effects of technology-based self-monitoring tool on weight loss, finding greater weight loss achieved using technology-based monitoring tools (Ross & Wing, 2016). Although self-monitoring the form/frequency of health behaviors has clear benefits, the matrix also suggests an alternate approach to tracking, in which the focus is on the function of the behavior (i.e., towards values or away from internal experiences), rather than the topography (e.g., the amount and type of food eaten, exercise frequency). Theoretically, the function may be more important for long-term behavior change, helping individuals engage in health behaviors to move towards personal values, while reducing unhelpful away moves.

The current pilot feasibility study sought to conduct an initial test of an ACT matrix app over a 2-week timeframe and with supports to help maintain adherence (in-person orientation, follow up calls). Although the short timeframe and additional supports limit generalizability in testing the long term impact of the app when used in isolation, these features were important for a preliminary feasibility trial prior to conducting more intensive efficacy testing. The short timeframe was chosen so that post assessment data could be collected in relation to immediate and active use of the mobile app, while minimizing the effects of nonadherence or other sources of influence over time. Similarly, it is well known that providing orientation to technology and follow up calls significantly improve adherence (Andersson, 2016), which helped ensure adequate adherence rates for preliminary evaluation of the mobile app. This helped rule out

potential alternative explanations should the trial fail to find positive effects from the app (e.g., if participants did not adhere to or understand how to use the app).

Such initial pilot research is needed to test the feasibility of using the matrix in a mobile app format. For example, it is unclear if users will be willing and able to track toward and away behaviors multiple times each day, whether such a simple prompting app will be acceptable, what training may be required for users to benefit from the app, and what additional features or revisions to the app may be desired by users. Furthermore, it is unclear whether simply discriminating toward and away moves actually increases valued action over time, and if so, whether there are baseline characteristics that might moderate this (suggesting those for whom a relatively simple app intervention is sufficient for increasing valued action). Such preliminary research is critical for informing further development and testing as well as highlighting generalizable "lessons learned" for other apps.

The current pilot feasibility study tested the matrix app with a sample of adults interested in changing their diet/exercise behaviors. Although health behaviors include a broader range of activities (e.g., minimizing sedentary behavior and substance use), this study focused on diet and exercise behaviors to provide a more specific and well-defined set of outcomes for initial evaluation of the matrix app. A randomized trial method was used with a waitlist control group to test the hypotheses that a matrix app would be acceptable to users, improve processes of change (valued action, experiential avoidance), and improve diet/exercise behaviors. Study predictions included that a) participants would be satisfied using the app, b) participants would use the app on at least 75% of days, c) participants using the app would improve on health behaviors, valued action, and experiential avoidance relative to waitlist, and d) participants' rate of toward moves would increase and away moves would decrease the more they used the app.

An additional set of exploratory analyses were conducted to examine whether changes in the rate of toward moves reported in the app are moderated by baseline levels of values and experiential avoidance, which would help clarify what users may benefit more or less from the matrix app. Overall, testing these hypotheses would serve to determine the feasibility of the matrix app in improving diet/exercise behavior, providing guidance for a subsequent refined app and confirmatory efficacy trial.

Method

Participants

A sample of 23 adults interested in changing their diet and/or exercise behaviors and who owned a smartphone were recruited for the study. Participants were recruited through flyers posted around the community and local university. The sample was 57% Female with an average age of 26.91 (*SD* = 8.67). The sample was 83% non-Hispanic White, with 17% identifying as Hispanic or Latino. Approximately half (52%) of the sample was currently enrolled as an undergraduate or graduate student at the local university. In terms of education, 35% completed some college, 43% completed college or a technical degree, and 22% had a Masters or other specialist degree. In terms of gross annual income for primary household, 30% reported earning less than $20,000, 22% earning between $20,000 and $40,000, 26% between $40,000 and $80,000, and 9% earning over $100,000 (the remaining 13% were unsure of gross income). The average body mass index was slightly overweight at 27.30 (*SD* = 4.99), with 30% overweight and 30% in the obese range. On a scale from 1 (*strongly disagree*) to 7 (*strongly agree*), all participants reported wanting to change their eating habits (*M* = 6.26, *SD* = .54) and 87% reported wanting to change their level of exercise (*M* = 5.87, *SD* = 1.25).

Eligibility criteria consisted of being 18 years of age or older, a self-reported interest in changing diet and/or exercise behavior, and owning a smartphone. Inclusion criteria was purposefully broad as the goal was to evaluate whether the mobile app would be feasible with anyone interested in changing their diet and/or exercise (mirroring those who might actually use the app). All interested individuals who contacted the research team to participate met eligibility criteria (no potential participants were excluded based on eligibility criteria).

Procedures

Interested individuals first contacted the researchers to complete a phone screening, which assessed eligibility criteria (age, interest in changing diet/exercise behavior, smartphone ownership). Participants then attended an in-person meeting. During this meeting they completed informed consent followed by a computerized baseline assessment. Participants were then randomized to either the matrix app (n = 12) or to a waitlist (n = 11). To assign participants to condition the researcher randomly drew one slip of paper from an envelope with initially 24 slips of paper (12 for each condition). Each paper was removed after being selected to ensure randomization would lead to a balanced number of participants per group over time.

Participants randomized to the matrix app received an in-person orientation to the app and then used the app for 2 weeks (see Matrix App Condition Procedures). Participants randomized to waitlist were asked to simply wait 2 weeks before completing the next assessment. After 2 weeks, participants in both conditions received a link to complete the online post questionnaire. After completing the online post questionnaire, participants in the waitlist condition were offered the option to use the matrix app.

Matrix App Condition Procedures

The matrix app condition included an in-person orientation, use of the matrix app for two weeks, and follow up calls to support adherence. Each of these procedures is described in the following section.

In-Person Orientation. Participants randomized to the app were immediately provided a 15-20 minute orientation conducted by a trained graduate student following a structured protocol. This orientation involved having participants apply the ACT matrix perspective in relation to their own personal health goals, values, "toward moves," internal barriers, and "away moves." The researcher helped guide participants in "sorting" their experiences related to health behaviors into the four matrix quadrants: values (e.g., "adventure," "friendship"), toward moves (e.g., "exploring nature, hiking," "playing sports with friends"), internal barriers (e.g., "feeling anxious and overwhelmed," "body shame"), and away moves (e.g., "withdrawing from others," "'binging' on salty foods," "distracting with TV"). These steps were completed on a piece of paper, which participants could then take home as an ongoing reminder of their toward and away moves as well as internal barriers and values.

The researcher summarized each participant's matrix and discussed how this matrix applied to using the app. This included how noticing toward and away moves with the app may make it easier to break "stuck loops" with away moves and choose to take toward moves, even when internal barriers are present. The researcher then guided participants through downloading the matrix app, provided clear instructions for how to use the mobile app, and helped the participant set a goal for using the app over the next two weeks. Participants' app usage goal generally followed the standard expectations to complete most random prompts that were received, and to use the app at least once a day. Although the researcher sought to elicit goals consistent with app adherence, it was important that participants were given the opportunity to

state personal goals for usage as a method of enhancing adherence by promoting personal choice (Mohr, Cuijpers, & Lehman, 2011).

Matrix App Features. The Matrix App was delivered through MetricWire, an online mobile assessment platform that provides the ability to deliver native applications with sophisticated prompting and interactive components as well as secure database integration. This approach allowed for the rapid development and evaluation of the Matrix App, with the ability to revise the app based on pilot findings from this trial. The Matrix App was made available to both Android and iOS phone users by downloading MetricWire through the app store.

The matrix app randomly prompted participants three times a day to check-in between 9am and 9pm for two weeks. A push notification would appear on participants' screen asking "Are you moving toward or away?" with the option to proceed to an app check-in. A reminder occurred 15 minutes later if a user did not check-in. Participants could also check-in any time through the app, and were instructed to do so in relation to personal goals (e.g., before eating, when deciding whether to work out).

The matrix app check-in would ask participants "Right now are you engaged more in an away move or a toward move? If unsure just guess" with the options to respond "away" or "toward." Those selecting "toward" were also asked "How difficult was it to get started on this toward move?" on a visual analogue scale from "easy" to "fairly hard" to "very difficult." This difficulty rating was added based on clinical experience that such questions help reinforce toward moves by prompting users to appreciate the effort they put into making challenging toward moves (Polk, Schoendorff, & Webster, 2016). However, participants did not receive any follow up questions/messages if they indicated an away move, in part based on clinical experience that such questions might enhance ineffective shame or aversive control (Polk et al.,

2016). No additional interactive features were provided to maintain a core focus on a simple self-monitoring app for toward and away moves.

Follow Up Calls. Participants received check-in calls twice during the two week testing period (on day 2 and day 7 of using the app). These calls were completed by the same, single researcher who conducted the app orientation, following up on experiences using the app and supporting continued adherence. The phone check-in calls were based on the supportive accountability model and associated protocols (Duffecy, Kinsinger, Ludman, & Mohr, 2011; Mohr et al., 2011), which involve commonly used principles and procedures for ensuring adherence to online mental health programs. Check-in calls were relatively brief (approximately 5-10 minutes) and focused on supporting adherence to the app. The first portion of the call focused on reinforcing use of the app and promoting motivation for ongoing adherence (asking about use of the app, how using the app has been helpful, and eliciting desire, self-efficacy and reasons to use the app). Calls then explored any technical issues that might impede adherence to the app. Finally, phone calls assessed potential barriers to using the app and collaboratively problem solved any potential barriers to adherence (e.g., exploring how to remember to use the app). These procedures are consistent with a *guided self-help* approach (Andersson, 2016), which can help ensure adequate adherence to the technology for preliminary evaluation of its effects.

Measures

Weight Control Strategies Scale (WCSS; Pinto, Fava, Raynor, LaRose, & Wing, 2013). The 30-item WCSS assessed health behaviors related to weight management with subscales assessing dietary choices (healthy/unhealthy eating habits), self-monitoring (of caloric intake, exercise, weight), physical activity (activity level and strategies to support exercise), and psychological coping (effective psychological strategies for managing weight). Items were rated

on a 5-point scale ranging from 1 (*never*) to 5 (*always*). The WCSS has been found to have good reliability and validity in past studies and to be sensitive to weight loss intervention effects (Pinto et al., 2013). The WCSS had adequate internal consistency in the current study, α = .90.

Valuing Questionnaire (VQ; Smout, Davies, Burns, & Christie, 2014). The 10-item VQ includes two subscales assessing progress in living one's values and values obstruction (i.e., the extent to which barriers get in the way of progressing on personal values). The VQ has been found to have adequate reliability and validity in past studies (Smout et al., 2014) and to be sensitive to the effects of technology-based ACT interventions (Levin et al., in press). The VQ had adequate reliability in the current study (VQ Obstruction α = .89, VQ Progress α = .85).

Food Craving Acceptance and Action Questionnaire (FAAQ; Juarascio et al., 2011). The 10-item FAAQ assessed experiential avoidance in relation to food cravings and eating patterns. Each item is rated on a 7-point scale from 1 (*never true*) to 7 (*always true*). The FAAQ has been found to be reliable and valid in past studies (Juarascio et al., 2011) and to be a mediator for ACT with weight-related issues (Forman et al., 2013, in press). The FAAQ had adequate reliability in the current study (α = .89).

System Usability Scale (SUS; Tullis & Albert, 2008). The 10-item SUS was used at post to assess perceived usability and acceptability of the Matrix App. The SUS is a widely used measure for determining program acceptability. Response options are provided on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Previous research supports its reliability and validity (Bangor, Kortum, & Miller, 2008; Tullis & Albert, 2008), including with determining the usability of online ACT programs (e.g., Levin, Hayes, Pistorello, & Seeley, 2016; Levin, Haeger, Pierce, & Twohig, In Press). A series of additional satisfaction questions were included to further assess participants' reactions to the app. These questions were based on previous ACT-

based technology trials (Levin et al., 2016, In Press), with items rated on a 6-point scale from 1 (*strongly disagree*) to 6 (*strongly agree*).

Program Usage. Participants' use of the Matrix App was automatically collected through the MetricWire platform. Collected data included the number and timing of prompts received and responses to each prompt, which can be used to determine program engagement. The frequency of reported toward moves (i.e., valued actions), away moves (i.e., experiential avoidance), and ease of toward moves each day were collected to further examine patterns of valued action over time using the app.

Data Analysis Plan

Mixed model repeated measure (MMRM) analyses examined whether those assigned to the matrix app demonstrated greater changes from pre to post on outcomes relative to the waitlist with the full intent-to-treat (ITT) sample as well as only those who adhered to the app (3 used the app fewer than 75% of assigned days). Two participants did not complete the post survey (one in each condition), but this missing data was modeled in MMRM to support an ITT approach. Cohen's d effect sizes were calculated for MMRM time by condition effects as well as post hoc comparisons of within group contrasts using recommended procedures (Rosenthal & Rosnow, 1991; Verbeke & Molenberghs, 2000; Wackerly, Mendenhall, & Scheaffer, 2008). Cohen's *d* effect sizes were interpreted based on recommended descriptors for small (.2), medium (.5), and large (.8) effects (Cohen, 1988).

Three-level hierarchical generalized linear models (HGLM) were run with Matrix App data to examine changes in the probability of making a "towards" move and making an "away" move over time while using the app. The three-level structure accounted for the nesting of observations within participants and within days, and to allow for random intercepts between

participants as well as across days within participants. Logit link functions were used to analyze the categorical outcomes of "towards" and of "away" in terms of a predicted probability at level 1 (the observation level), and the level-1 intercept of the logit was modeled as a continuous outcome at level-2 (the day level). HGLM was also conducted on the difficulty getting started with a toward moves, modeled as a continuous outcome. It was hypothesized that toward moves would get easier over time, such that the average difficulty score for a given day would decline across the study period.

Finally, HGLM examined whether baseline valued living and experiential avoidance moderated the relation between day using the app and probability of making a toward move. Significant moderation effects were examined by plotting the probability of toward moves over time among participants at 1 SD below the mean, at the mean, and 1 SD above the mean for the moderator.

Results

Program usage/satisfaction

For those in the app condition, the average number of completed check-ins was 35.33 (SD = 14.19, range = 5-56 check-ins). Users completed check-ins on 11.67 days on average (SD = 3.45, range = 3-14 days). Overall, 75% of participants used the app on at least 11 of 14 days.

Ratings on the SUS indicated high perceived usability/acceptability of the app (M = 82.50, SD = 10.25), consistent with a rating of "good" and approaching "excellent" (Bangor et al., 2008). As indicated in Table 1, the majority of participants reported satisfaction with the app on various factors including whether it was helpful, easy to use, something they would recommend to others or use again, and so on. Participants provided low ratings for the necessity of the in-person orientation to the matrix with only 36% indicating 4 (*slightly agree*) or higher.

Open feedback indicated participants particularly liked how simple and easy the app was to use as well as how it helped remind them of their goals and the function of their actions. In terms of what participants liked least about the app, 45% stated the app was too simple and needed more features in terms of types of prompts and follow up questions based on users' responses. Some participants (27%) also indicated difficulties with noticing the prompts on their phone when they occurred.

Questionnaire analyses

Intent-to-treat. Independent sample *t*-tests indicated no significant differences between conditions at baseline. MMRM time by condition interactions were tested on each outcome measure with the full ITT sample (see Table 2). Cohen's *d* effect sizes for time by condition interactions on health behaviors ranged from .38 to 1.06, favoring the matrix app condition in each case. Within condition effect sizes in the matrix app condition ranged from .41 to 1.04, indicating small to large effect sizes for improvements over time in health behaviors. However, in the waitlist condition, within condition effect sizes ranged from -.70 to .21, indicating a general worsening, or at best, a small improvement in health behavior over time. The only significant time by condition interaction was for the WCSS psychological coping subscale (d = 1.06), such that only those in the app condition significantly improved over time on health-related psychological coping (Cohen's d = 1.06). There was no significant time by condition interactions on other measures.

MMRM time by condition interactions were also tested on process measures with the full ITT sample (See Table 2). Cohen's *d* effect sizes for time by condition interactions on process measures ranged from .33 to -.12, none of which approached significance ($p > .10$).

Program Completers. Analyses were repeated among those participants who fully engaged in the mobile app (used the mobile app on at least 75% of days; excluding 3 participants). Among program completers (see Table 3), Cohen's *d* effect sizes for time by condition interactions on health behaviors ranged from .76 to 1.35, favoring the matrix app condition in each case. Within condition effect sizes in the matrix app condition ranged from .66 to 1.32, indicating medium to large effect sizes for improvements over time in health behaviors. Significant time by condition interactions were found for the WCSS total score ($d = 1.17$) and WCSS psychological coping ($d = 1.35$) as well as trends for WCSS physical activity ($p = .053$, $d = 1.00$) and WCSS dietary choice ($p = .106$, $d = .82$). In each case, there were significant pre to post improvements on health behaviors in the matrix app condition (within condition effect sizes between .71 and 1.32), but not waitlist.

MMRM time by condition interactions were also tested on process measures with the program completer sample (See Table 3). Cohen's *d* effect sizes for time by condition interactions on process measures ranged from .36 to -.39, none of which approached significance ($p > .10$). Of note, experiential avoidance with food (FAAQ) was found to significantly improve within the matrix app condition ($d = .75$), but not waitlist ($d = -.12$).

Mobile app analyses

Within the app condition only, HGLM analyses examined whether the probability of toward moves, away moves, and the ease of toward moves improved over days using the app, which might suggest a practice effect with greater gains from noticing toward and away moves over time. Intraclass correlation coefficients (ICC) were computed prior to running the models to examine the proportion of variance accounted for by the participant-level and day-level clustering of the data. The ICC analyses revealed that 7.78% of the variance in towards moves

was accounted for by between-participant variance, and that 14.74% of the variance in the difficulty of making toward moves was accounted for by between-participant variance. Similarly, 8.9% of the variance in toward moves and 23.69% of the variance in the difficulty of making a toward move was explained by variance between days nested within participants. These findings suggest the effects of participant-level and day-level clustering were important to address through a hierarchical approach. Thus, the HGLM approach was warranted.

Day of using the app significantly predicted the level-1 intercept for toward moves, indicating that the average probability of making a towards move increased by 2.7% for each day of participating in the study ($OR = 1.027$, $p = .012$). Similarly, days of using the app significantly predicted away moves, with the probability of making an away move decreasing by 2.4% for each day using the app ($OR = 0.976$, $p = 0.037$). However, the association between day and difficulty of making a toward move was non-significant ($OR = 1.006$, $p = 0.272$), suggesting toward moves did not get easier over time.

Additional HGLMs examined whether change in the probability of making towards moves over time was moderated by pre-intervention scores on values (VQ) and experiential avoidance (FAAQ). In separate models, the VQ-Progress, VQ-Obstruction, and FAAQ all significantly moderated the rate of change in the probability of making towards moves at the participant-level, VQ Progress $\Lambda = 0.008$, $SE = .004$, $p = .018$, VQ Obstruction $\Lambda = -0.008$, $SE = .002$, $p < .001$, and FAAQ $\Lambda = -0.005$, $SE = .001$, $p < .001$. Figures 1-3 plot the predicted probability of making a towards move by days elapsed in the study for participants at -1SD below the mean, the mean, and +1SD above the mean on each moderator. Participants with greater perceived progress on valued living, lower obstruction to valued living, and lower

experiential avoidance each showed a greater rate of improvement in the probability of making a toward move across the 14-day intervention period.

Discussion

This pilot study sought to evaluate the feasibility and potential efficacy of an ACT-based mobile app for improving health behaviors using the matrix approach (Polk & Schoendorff, 2014). As hypothesized, the matrix app was rated as highly satisfying and demonstrated acceptable engagement rates among adults seeking to change their diet and exercise behavior. Improvements in health behaviors were relatively small when including the full ITT sample, with only psychological coping related to weight control being significant. However, when analyses were limited to those who adhered to the app, the matrix app produced medium to large improvements in health behavior change efforts relative to the waitlist condition, with several effects being significant or trending towards significance. Surprisingly, the matrix app did not lead to self-reported, global improvements in values or experiential avoidance. However, analyses with the app data indicated a practice effect such that the rate of towards moves (i.e., valued actions) increased and rate of away moves (i.e., experiential avoidance) decreased over days using the app. It may be that the app was more effective for those who were more psychologically flexible, given these changes in toward move were moderated by baseline values and experiential avoidance. Overall, the matrix app appears to be a promising approach for enhancing health behaviors, although there were some mixed findings, particularly in terms of targeting process of change measures.

Mobile phones are an ideal format for health behavior change interventions due to their ease of dissemination, convenience, and ability to provide high frequency, low intensity interventions across a range of relevant contexts (Heron & Smyth, 2010). Self-monitoring is one

of the most common and popular features provided in mobile health behavior change apps (Azar et al., 2013; West et al., 2012). Furthermore, research suggests that technology-based self-monitoring may be more effective than "paper-and-pencil" versions (Ross & Wing, 2016). This study adds to this literature by piloting an alternate approach for self-monitoring apps focused on noticing the function of one's actions rather than their form/topography (e.g., frequency of exercise, caloric intake). Although there have been at least four published clinical trials evaluating ACT-based mobile apps (Torous, Levin, Ahern, & Oser, 2017), no studies have been published evaluating a matrix-based ACT app or specifically focused on self-monitoring valued actions and experiential avoidance.

Theoretically, the more individuals notice the function of their actions, the more their behavior will shift towards values rather than experiential avoidance (Polk & Schoendorff, 2014). The finding that toward moves increased and away moves decreased with more days using the app supports this theory. It may be that simply noticing the function of one's actions in terms of "toward" and "away" is sufficient for increasing valued action. If so, it's worth considering how to further augment this effect such as by having individuals track "toward" and "away" more frequently, for more days, or with other features (e.g., providing a chart to review tracking data, allowing users to share data with others, determining how to fade out or otherwise implement tracking over time to support long-term benefits and generalization). That said, there are numerous alternative explanations for the increases in reported toward moves over time within the app condition (e.g., placebo, demand characteristics), which may have been enhanced by the app only asking a follow up question when participants reported a "toward move."

It is noteworthy that the key survey questionnaires assessing ACT processes of change (VQ, FAAQ) did not improve from the matrix app. The failure to move this process of change

suggests the matrix may not target what it is designed to target, increasing the potential that positive findings are spurious, due to methodological factors in a waitlist design (e.g., placebo, demand characteristics), or otherwise not functioning as intended. That said, these lack of effects may just be due to a mismatch between the process measures and design of this intervention. While the FAAQ has been found to mediate ACT interventions, these are in the context of intensive ACT interventions that include an emphasis on food cravings (e.g., Forman et al., in press). Thus these process measures may not be particularly sensitive to detecting the effects of a low intensity ACT intervention that did not explicitly focus on accepting food cravings and with a short, 2-week assessment window. Future research may address this by testing adaptations such as a longer intervention/assessment window, a more targeted application (e.g., specifically with individuals struggling with food cravings and targeting food choice contexts), a more intensive intervention (e.g., booster sessions, additional features to augment noticing towards/away moves), and/or use of process measures more targeted to the matrix.

Participants generally liked the simplicity and ease of use with the app, but there was a general sense that the app was too simple. The matrix has a specific, refined focus that supports a simple approach of just noticing toward and away moves (Polk & Schoendorff, 2014). However, participants wanted the app to follow up on what they monitored or have other features to help build out toward moves. For example, the app purposefully left out any follow up prompts when participants reported an away move, but it may be beneficial to add a follow up feature (e.g., exploring workability, alternative toward moves). Additional app features may further improve outcomes (e.g., goal setting, ability to review app use over time, tailored feedback based on responses) or at least support user engagement. Alternatively, this might highlight a framing

problem – that the app needs to be more clearly introduced as a very simple program, while highlighting the potential powerful effect of this simple intervention over time.

The moderation results with rates of toward moves over time suggest the matrix app was especially helpful for those who were already relatively psychologically flexible (high in values and low in experiential avoidance). Individuals who have already identified their values and who are relatively accepting may be able to alter their actions to be more in line with values with a relatively simple self-monitoring intervention. However, individuals who struggle more with valued actions and experiential avoidance may require additional ACT interventions. Future research would benefit from testing the additive effects of additional ACT interventions for these subgroups. This highlights the importance of an iterative, theory driven testing approach with mobile apps given the number of questions regarding who would benefit, from what interventions, and in what format and timing relative to the app.

Given the pilot nature of the study there were several limitations. The most notable limitation was that this study compared a multifaceted intervention (including an in-person orientation to the matrix and follow up calls) to a waitlist control. Thus, the observed between group effects may be due to a wide range of alternative nonspecific or methodological variables. It is unclear the degree to which improvements are attributable to the matrix app relative to these other factors. Given the app might be delivered in the future through app stores without any such human contact and that participants generally thought the orientation was not necessary for using the app, future research is needed evaluating the app without human contact. However, the current design is justifiable in that these additional components helped address alternate explanations should the app have been found to be inert (e.g., low adherence, lack of understanding regarding the matrix). It is fairly common to include such features in early

feasibility testing (Torous et al., 2017), prior to conducting more carefully controlled confirmatory efficacy trials that evaluate the effects of the app alone. Furthermore, research has clearly found online mental health interventions are more effective when they include personal contact (Andersson, 2016) and clinicians tend to prefer using such technologies as an adjunct to treatment (Pierce, Twohig, & Levin, 2016). Thus, it may be reasonable to continue to evaluate and implement the matrix mobile app in such a guided self-help or adjunctive treatment format.

This study was underpowered for detecting between group effects which increased the potential for Type II error, unstable effect size estimates, and spurious results due to sample size. To address this limitation, an emphasis was placed on observing the overall pattern of effect sizes. Although this pattern suggests at least some effect on health behaviors with the matrix intervention, further research is now needed with larger samples and adequate power to replicate these findings. The use of a short testing period (2 weeks) may have further reduced the effect sizes observed from the app, presuming the matrix app may have produced larger effects over time. This design decision was made in line with an emphasis on preliminary feasibility testing, and thus focusing on a relatively short assessment window closely linked to a period of time that users might continue to actively use the app. However, given the observed increased rate of reported toward moves over time using the app, it would be important for future research to extend the testing period and assess efficacy over time.

There were limitations with the demographics of the sample including the lack of racial diversity, which limits generalizability to the broader population of potential app users. The sample was also heterogeneous with regards to adults who want to change their diet and/or exercise behaviors. Although this might support external validity, a more targeted, homogeneous clinical sample would have enhanced statistical power.

There were also limitations with measurement. The study did not include objective health assessment measures and relied on self-report, which further introduced the potential for biases in reporting, and might be addressed with the use of passive self-monitoring devices in the future (Ross & Wing, 2016). Although this study purposefully focused on diet and exercise behaviors, there are a variety of other relevant health behaviors that might be examined in future studies (e.g., sedentary behavior, smoking). Finally, the satisfaction item assessing the in-person orientation used a double negative wording, which might have impacted the validity of this item.

Although these limitations introduce some questions regarding the validity and replicability of these findings, they are common challenges with pilot feasibility trials. Such pilot research is critical for identifying, early in development, potential feasibility and areas for future revisions. This ensures that further development and research is maximally efficient and directed by participant feedback, prior to conducting more resource and time intensive studies that may take multiple additional years to complete. This initial pilot research can also fairly rapidly produce generalizable knowledge for other developers and professionals using app technologies for health behavior change. Thus, although these limitations raise questions regarding the generalizability and replicability of findings, future research can address this by evaluating the matrix mobile app, possibly with some revisions based on study findings, in larger and more controlled confirmatory efficacy trials.

Thus although this was a small, limited pilot trial, it was successful in achieving its stated aims. Preliminary results indicate a “signal” for the potential efficacy of the matrix app in improving health behaviors and increasing valued action. Although the app appeared acceptable with participants being satisfied with and engaging in using the app, areas for future revision were identified. These include considering increasing the number of prompts per day, the length

of time using the app, or adding other features (e.g., booster sessions, additional types of prompts like goal setting, follow up questions based on user responses). In addition, the moderation findings suggest the matrix app might be more effective for individuals who are already psychologically flexible, suggesting additional ACT intervention may be beneficial for those struggling more with valued action and experiential avoidance. Overall, apps focused on noticing the function of one's actions from an ACT perspective appear promising for health behavior change and warrant further research and development.

References

Andersson, G. (2016). Internet-delivered psychological treatments. *Annual Review of Clinical Psychology, 12,* 157-179.

Azar, K. M. J., Lesser, L. I., Laing, B. Y., Stephens, J., Aurora, M. S., Burke, L. E., & Palaniappan, L. P. (2013). Mobile applications for weight management: Theory-based content analysis. *American Journal of Preventive Medicine, 45*, 583-589.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the System Usability Scale. *International Journal of Human-Computer Interaction, 24*, 574-594.

Bricker, J. B., Mull, K. E., Kientz, J. A., Vilardaga, R., Mercer, L. D., Akioka, K. J., & Heffner, J. L. (2014). Randomized, controlled pilot trial of a smartphone app for smoking cessation using acceptance and commitment therapy. *Drug and Alcohol Dependence, 143*, 87–94.

Butryn, M. L., Forman, E., Hoffman, K., Shaw, J., & Juarascio, A. (2011). A pilot study of acceptance and commitment therapy for promotion of physical activity. *Journal of Physical Activity and Health, 8*, 516–522. doi: 10.1123/jpah.8.4.516

Butryn, M. L., Webb, V., & Wadden, T. A. (2011). Behavioral treatment of obesity. *Psychiatr Clin North Am*, *34*, 841-859.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York: Academic Press.

Dombrowski, S. U., Sniehotta, F. F., Avenell, A., Johnston, M., MacLennan, G., & Araujo-Soares, V. (2012). Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: A systematic review. *Health Psychology Review, 6*, 7-32

Duffecy, J., Kinsinger, S., Ludman, E., & Mohr, D. C. (2011). *Telephone coaching to support adherence to internet interventions (TeleCoach): Coach Manual.*

Forman, E. M., & Butryn, M. L. (2015). A new look at the science of weight control: How acceptance and commitment strategies can address the challenge of self-regulation. *Appetite, 84*, 171-180.

Forman, E. M., Butryn, M., Juarascio, A. S., Bradley, L., Lowe, M., Herbert, J. D., & Shaw, J. (2013). The Mind Your Health Project: Evaluating an innovative behavioral treatment for obesity. Obesity. 21(6), 1119-1126. doi:10.1002/oby.20169

Forman, E. M., Butryn, M. L., Manasse, S. M., Crosby, R. D., Goldstein, S. P., Wyckoff, E. P., & Thomas, J. G. (in press). Acceptance-based versus standard behavioral treatment for obesity: Results from the mind your health randomized controlled trial. *Obesity.*

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (2011). *Acceptance and Commitment Therapy: The process and practice of mindful change.* New York: The Guilford Press.

Heron, K. E., & Smyth, J. M. (2010). Ecological Momentary Interventions: Incorporating mobile technology into psychosocial and health behavior treatments. *British Journal of Health Psychology, 15*, 1-39.

Juarascio, A. S., Forman, E. M., Timko, C. A., Butryn, M., & Goodwin, C. L. (2011). The development and validation of the food craving acceptance and action questionnaire (FAAQ). *Eating Behaviors,* 182-187.

Katterman, S. N., Goldstein, S. P., Butryn, M. L., Forman, E., & Lowe, M. R. (2014). Efficacy of an acceptance-based behavioral intervention for weight gain prevention in young adult women. *Journal of Contextual Behavioral Sciences, 3*, 45-50.

Levin, M. E., Haeger, J., Pierce, B., & Twohig, M. (In Press). Web-based acceptance and commitment therapy for mental health problems in college students: A randomized controlled trial. *Behavior Modification.*

Levin, M. E., Hayes, S. C., Pistorello, J., & Seeley, J. (2016). Web-based self-help for preventing mental health problems in universities: Comparing acceptance and commitment training to mental health education. *Journal of Clinical Psychology, 72*, 207-225.

Lillis, J., Hayes, S. C., Bunting, K., Masuda, A. (2009). Teaching acceptance and mindfulness to improve the lives of the obese: A preliminary test of a theoretical model. *Annals of Behavioral Medicine, 37*, 58-69.

Lillis, J., & Kendra, D. E. (2014). Acceptance and commitment therapy for weight control: Model, evidence and future directions. *Journal of Contextual Behavioral Science, 3*, 1-7. dx.doi.org/10.1016/j.jcbs.2013.11.005

Loef, M., & Walach, H. (2012). The combined effects of healthy lifestyle behaviors on all cause mortality: a systematic review and meta-analysis. *Prev Med, 55*(3), 163-170. doi:10.1016/j.ypmed.2012.06.017

Mohr, D. C., Cuijpers, P., & Lehman, K. (2011). Supportive accountability: A model for providing support to enhance adherence to eHealth interventions. *Journal of Medical Internet Research, 13,* e30. doi: 10.2196/jmir.1602

Moffitt, R., & Mohr, P. (2015). The efficacy of a self-managed acceptance and commitment therapy intervention DVD for physical activity initiation. *British Journal of Health Psychology, 20*, 115-129.

Mozaffarian, D., Wilson, P. W., & Kannel, W. B. (2008). Beyond established and novel risk factors: lifestyle risk factors for cardiovascular disease. *Circulation, 117*(23), 3031-3038.

Pierce, B. G., Twohig, M. P., & Levin, M. E. (2016). Perspectives on the use of acceptance and commitment therapy related mobile apps: Results from a survey of students and professionals. *Journal of Contextual Behavioral Science, 5,* 215-224.

Pinto, A. M., Fava, J. L., Raynor, H. A., LaRose, J. G., & Wing, R. R. (2013). Development and validation of the weight control strategies scale. *Obesity, 21,* 2429-2436.

Polk, K. L., & Schoendorff, B. (2014). *The act matrix: A new approach to building psychological flexibility across settings and populations*. Context Press.

Polk, K. L., Schoendorff, B., & Webster, M. (2016). *The essential guide to the ACT matrix: A step-by-step approach to using the ACT matrix model in clinical practice*. Context Press.

Rosenthal, R., & Rosnow, R. L. (1991). *Essentials of behavioral research: Methods and data analysis* (2nd ed.). New York: McGraw-Hill.

Ross, K. M., & Wing, R. R. (2016). Impact of newer self-monitoring technology and brief phone-based intervention on weight loss: A randomized pilot study. *Obesity, 24*, 1653-1659.

Schaumberg, K., Schumacher, L. M., Rosenbaum, D. L., Kase, C. A., Piers, A. D., Lowe, M. R., … & Butryn, M. L. (2016). The role of negative reinforcement eating expectancies in the relation between experiential avoidance and disinhibition. *Eating Behaviors, 21*, 129-134.

Smout, M., Davies, M., Burns, N., & Christie, A. (2014). Development of the valuing questionnaire (VQ). *Journal of Contextual Behavioral Science*, *3*, 164-172. dx.doi.org/10.1016/j.jcbs.2014.06.001

Tapper, K., Shaw, C., Ilsley, J., Hill, A. J., Bond, F. W., & Moore, L. (2009). Exploratory randomised controlled trial of a mindfulness-based weight loss intervention for women. *Appetite, 52*(2), 396–404. [PubMed: 19101598]

Torous, J. B., Levin, M. E., Ahern, D., & Oser, M. (2017). Cognitive behavioral mobile applications: Research literature, marketplace data, and evaluation guidelines. *Cognitive and Behavioral Practice, 24*, 215-225.

Tullis, T., & Albert, W. (2008). *Measuring the user experience*. San Francisco, CA: Morgan Kaufmann.

Vartanian, L. R., & Shaprow, J. G. (2008). Effects of weight stigma on exercise motivation and behavior: A preliminary investigation among college-aged females. *Journal of Health Psychology, 13*, 131-138.

Verbeke, G., & Molenberghs, G. (2000). *Linear mixed models for longitudinal data*. New York: Springer-Verlag.

Wackerly, D. D., Mendenhall, W., & Scheaffer, R. L. (2008). *Mathematical statistics with applications*. Belmont, CA: Thomson Brooks/Cole.

Weineland, S., Arvidsson, D., Kakoulidis, T. P., & Dahl, J. (2012). Acceptance and commitment therapy for bariatric surgery patients, a pilot RCT. *Obesity Research & Clinical Practice, 6*, e21-e30. dx.doi.org/10.1016/j.orcp.2011.04.004

Wang, D. D., Li, Y., Chiuve, S. E., Hu, F. B., & Willett, W. C. (2015). Improvements In US Diet Helped Reduce Disease Burden And Lower Premature Deaths, 1999-2012; Overall Diet Remains Poor. *Health Aff (Millwood), 34*(11), 1916-1922. doi:10.1377/hlthaff.2015.0640

West, J. H., Hall, P. C., Hanson, C. L., Barnes, M. D., Giraud-Carrier, C., & Barrett, J. (2012). There's an app for that: Content analysis of paid health and fitness apps. *Journal of Medical Internet Research, 14*.

Table 1. *Satisfaction ratings for the matrix app at post.*

Satisfaction Question	*M* (*SD*)	≥ 4 "slightly agree"
Overall I was satisfied with the matrix app	4.18 (1.60)	64%
The matrix app helped me to increase my progress towards diet and/or exercise goals	3.55 (1.57)	73%
The matrix app helped me in other areas of my life	3.73 (1.90)	64%
The matrix app was easy to use	5.64 (.51)	100%
The matrix app was made for someone like me	3.64 (1.96)	54%
I would use the matrix app again in the future	3.82 (1.89)	64%
I feel the program would be helpful for others working on fitness-related goals	4.45 (1.70)	73%
I would recommend this program to others	4.27 (1.95)	73%
The matrix app was a helpful tool	4.00 (1.79)	64%
The matrix app helped me to better understand myself	3.73 (1.49)	64%
I wouldn't have been able to use the app without the orientation I completed with the researcher	2.91 (1.92)	36%

Note: Responses were provided on a 6-point scale from 1 (strongly disagree) to 6 (strongly agree).

Table 2. *Descriptive statistics by condition and MMRM results with full ITT sample.*

	Matrix App Condition				Waitlist Condition				Time * Condition	
Measure	Pre *M* (*SD*)	Post *M* (*SD*)	Pre-Post *t*	*d*	Pre *M* (*SD*)	Post *M* (*SD*)	Pre-Post *t*	*d*	*F*	*d*
WCSS – Total Behaviors	69.83 (16.48)	81.36 (17.71)	2.19*	.65	68.36 (21.47)	66.10 (19.48)	-.18	.06	2.70	.74
WCSS – Dietary Choice	30.58 (9.27)	33.91 (8.10)	1.38	.41	27.09 (10.00)	27.00 (9.80)	.15	.05	.72	.38
WCSS – Self Monitoring	9.50 (2.11)	11.27 (3.44)	1.80†	.54	11.09 (4.39)	10.80 (3.29)	-.24	.08	2.01	.63
WCSS – Physical Activity	16.50 (6.54)	19.36 (5.80)	1.65	.49	15.73 (5.50)	14.10 (6.61)	-.70	.22	2.71	.74
WCSS – Psych. Coping	13.25 (4.88)	16.82 (5.13)	3.49**	1.04	14.45 (5.59)	14.20 (4.39)	.21	.07	5.11*	1.06
VQ Progress	24.42 (5.42)	25.36 (3.78)	.74	.22	21.55 (5.68)	21.10 (6.69)	-.31	.09	.28	.33
VQ Obstruction	15.92 (6.96)	13.72 (5.02)	1.07	.32	19.55 (7.63)	15.70 (8.47)	1.75†	.55	.54	-.23
FAAQ	42.67 (7.58)	40.27 (9.39)	1.61	.48	45.73 (12.79)	41.60 (11.99)	1.90†	.60	.07	-.12

†$p < .10$, *$p < .05$; **$p < .01$; ***$p < .001$. WCSS = Weight Control Strategies Scale, VQ = Valuing Questionnaire, FAAQ = Food Craving Acceptance and Action Questionnaire. Time by condition interactions are comparing the waitlist condition to the matrix app condition with the full ITT sample from pre to post.

Table 3. *Descriptive statistics by condition and MMRM results with program completer sample.*

	Matrix App Program Completers				Time * Condition	
Measure	Pre *M* (*SD*)	Post *M* (*SD*)	Pre-Post *t*	*d*	*F*	*d*
WCSS – Total Behaviors	67.00 (16.07)	85.22 (12.95)	3.11**	1.04	5.81*	1.17
WCSS – Dietary Choice	29.22 (9.77)	36.00 (6.40)	2.49*	.83	2.91	.82
WCSS – Self Monitoring	9.44 (2.35)	11.56 (3.64)	1.97†	.66	2.56	.76
WCSS – Physical Activity	16.11 (7.01)	20.22 (3.87)	2.15*	.71	4.31†	1.00
WCSS – Psych. Coping	12.22 (4.18)	17.44 (5.15)	3.97**	1.32	7.61*	1.35
VQ Progress	24.33 (5.07)	25.89 (3.72)	.77	.26	.58	.36
VQ Obstruction	15.22 (7.69)	14.00 (5.29)	.51	.17	.69	-.39
FAAQ	41.78 (7.87)	37.56 (7.55)	-2.25*	.75	.07	.13

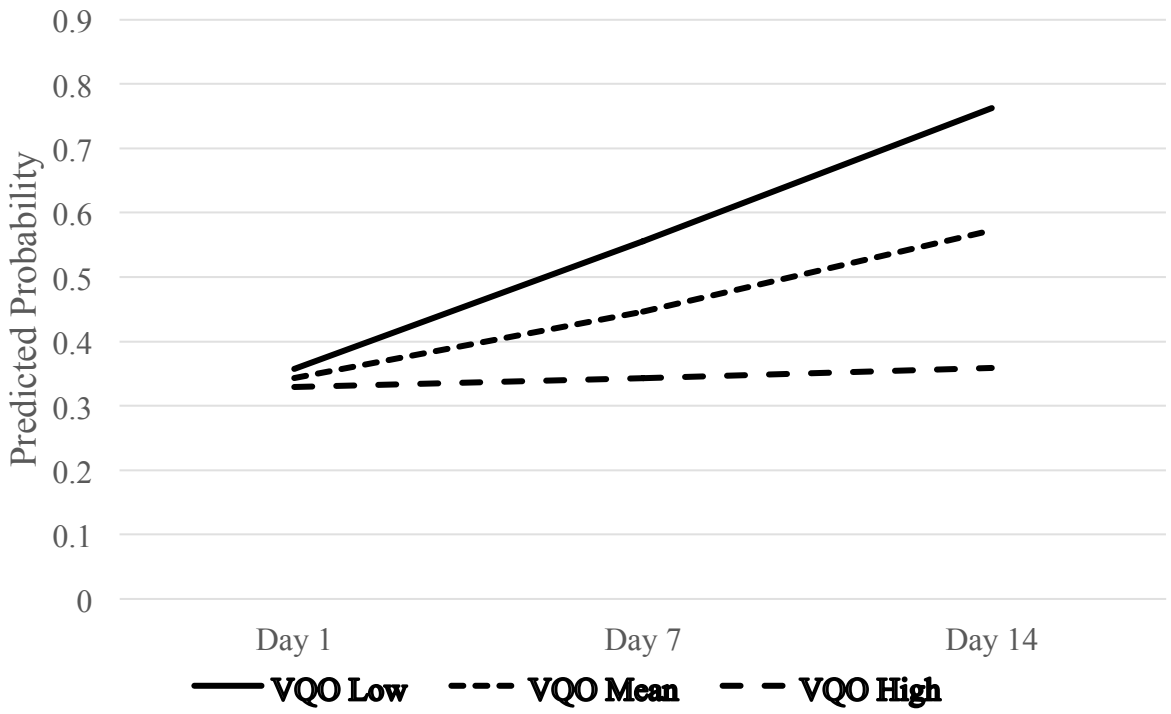
†$p < .10$, *$p < .05$; **$p < .01$; ***$p < .001$. WCSS = Weight Control Strategies Scale, VQ = Valuing Questionnaire, FAAQ = Food Craving Acceptance and Action Questionnaire. Time by condition interactions are comparing the waitlist condition to program completers (n = 9) in the app condition from pre to post.

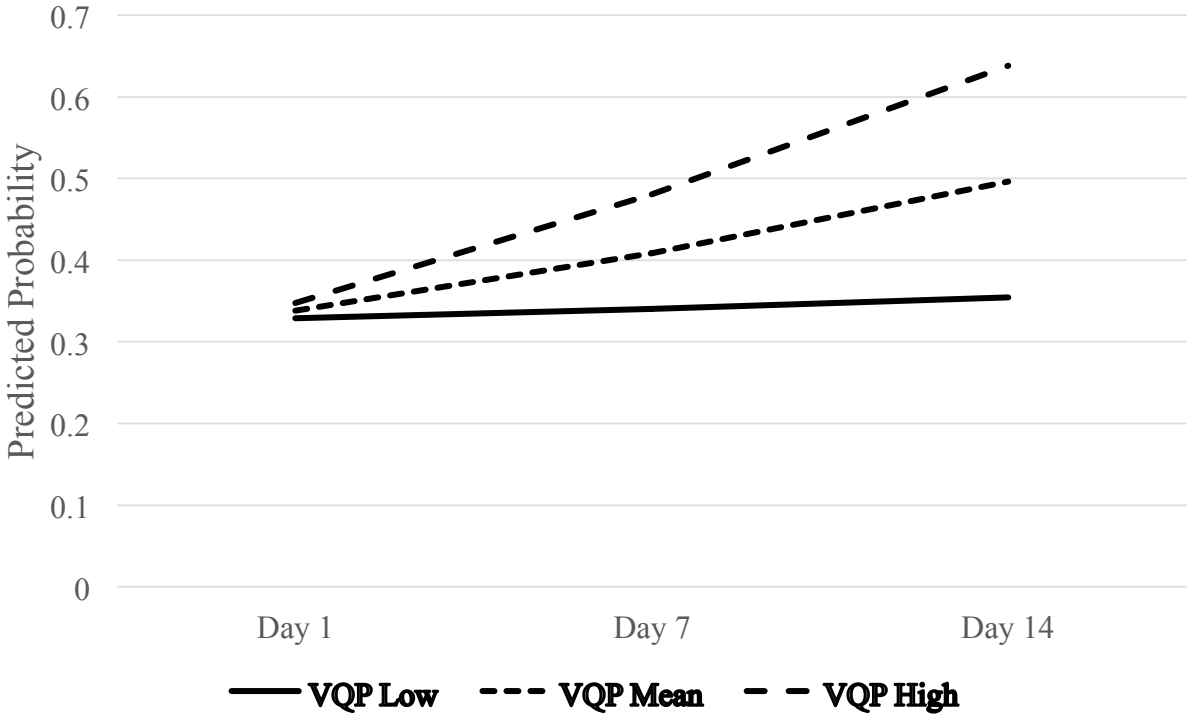
Figure caption

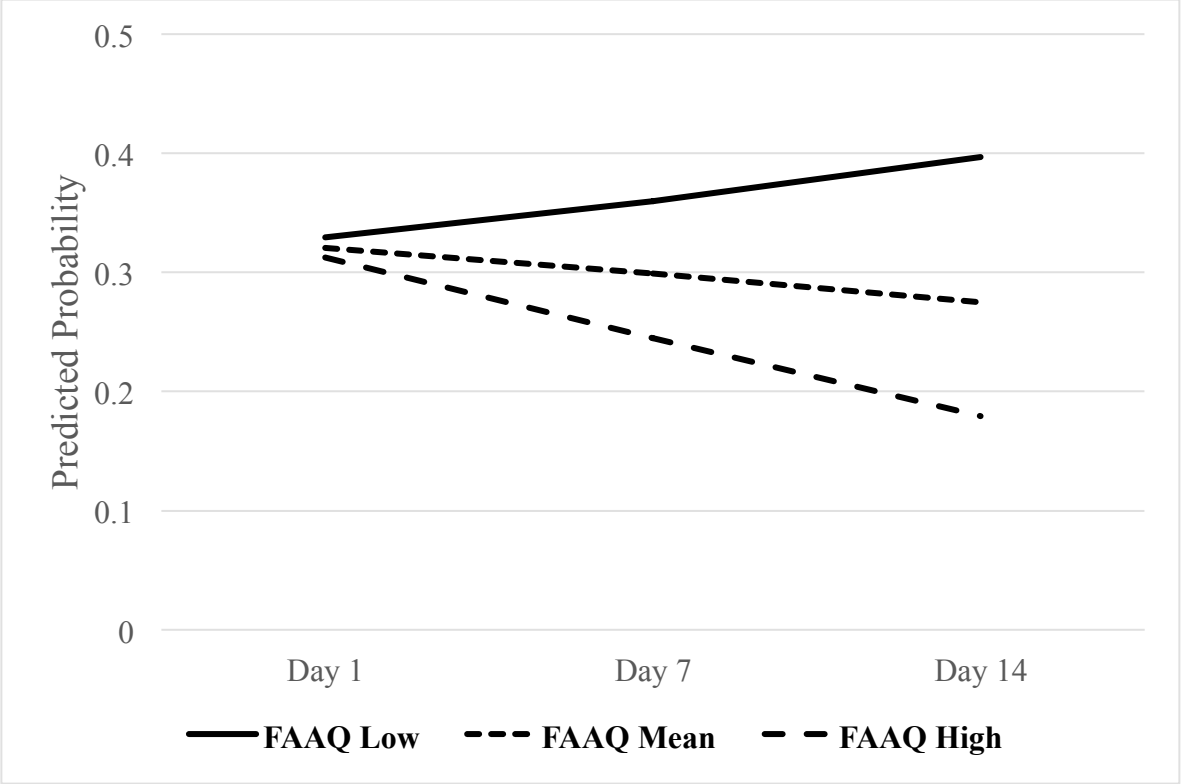
Figure 1. Changes in the predicted probability of making a "towards" move, by VQ Obstruction scores (higher VQO scores mean more difficulty engaging in valued actions).

Figure 2. Changes in the predicted probability of making a "towards" move, by VQ Progress scores (higher VQP scores means more progress in engaging in values actions.

Figure 3. Changes in the predicted probability of making a "towards" move, by FAAQ scores (higher FAAQ scores means greater experiential avoidance).


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Predicted Probability
Day 1
Day 7
Day 14
VQO Low
VQO Mean
VQO High


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Predicted Probability
Day 1
Day 7
Day 14
VQP Low
VQP Mean
VQP High


0.5
0.4
0.3
0.2
0.1
0
Predicted Probability
Day 1
Day 7
Day 14
FAAQ Low
FAAQ Mean
FAAQ High