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An ecological momentary intervention study of emotional responses to smartphone-prompted CBT skills practice and the relationship to clinical outcomes

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RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Abstract

The practice of therapeutic skills outside of sessions in which they are learned is one presumed key component of cognitive behavioral therapy (CBT). Yet, our understanding of how skills practice relates to clinical outcomes remains limited. Here, we explored patients' emotional responses to CBT skills practices in a pilot study pairing smartphone app-delivered skills reminders and guided practice (ecological momentary intervention [EMI]) using ecological momentary assessment (EMA). Participants ($n = 25$) were adults recently hospitalized for a suicide attempt or severe suicidal thinking. They received brief inpatient CBT (1 to 3 sessions covering core CBT skills from the Unified Protocol), followed by one month of EMI and EMA after discharge. On average, participants reported modest reductions in negative affect after skills use (i.e., *immediate* responses; median time elapsed = 4.30 minutes). Additionally, participants tended to report less negative affect when the timepoint preceding the current assessment included EMI skills practice, rather than EMA alone (i.e., *delayed* responses; median time elapsed between prompts = 2.17 hours). Immediate effects were unrelated to longer-term clinical outcomes, whereas greater delayed effects were associated with lower symptom severity at follow-up. Future studies should further examine how CBT skills use in daily life may alleviate symptoms.

Key words: cognitive behavioral therapy; skills; ecological momentary assessment; ecological momentary intervention; mHealth

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Introduction

Cognitive behavioral therapy (CBT) is an effective treatment for a wide range of emotional disorders and concerns, such as depression, anxiety, and suicidal thoughts and behaviors (Butler, Chapman, Forman, & Beck, 2006; Karlin & Cross, 2014; National Institute for Health and Clinical Excellence, 2011; Rudd et al., 2015; Williams & Martinez, 2008). It is also arguably the most extensively researched, in-demand, and efficacious psychological treatment. Successful CBT is generally understood to require weeks of learning and regularly practicing new skills outside of the therapy session. The practice of therapeutic skills outside of sessions (e.g., reviewing psychoeducation, completing worksheets, repeating planned exposures) is one core and presumed key element of all CBTs (Bakker, Kazantzis, Rickwood, & Rickard, 2018; Helbig & Fehm, 2004; Dahne & Lejuez, 2015). Despite other efforts to pare down CBT to increase its potency or accessibility (e.g., Sauer-Zavala et al., 2017), assigning outside-of-session practice is rarely an excised element. Yet, outside-of-session skills practice has only been rigorously evaluated in a handful of studies (Kazantzis, Whittington, & Dattilio, 2010; Kazantzis et al., 2016).

It remains unclear exactly whether (and how) skills practice leads to better treatment outcomes. Prior work has shown that regular skills practice at least partially mediates in-person and mobile treatment effects (Hundt, Calleo, Williams, & Cully, 2016; Hundt, Mignogna, Underhill, & Cully, 2013; Terides et al., 2018). However, this work is limited in its static lens; skills practice is typically operationalized as a sum or average across a study period and treatment responses operationalized with measurements taken before and after an intervention period. It is thus uncertain what effects individual practices are having in real time and how such responses relate to treatment outcomes. In other words, we would expect CBT skills usage to

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

have both long-term effects (e.g., more frequent skills usage over time makes CBT more effective over the duration of treatment) and short-term effects (e.g., using or practicing a CBT skill now leads to reduced distress a few hours from now). However, research to date has only measured the long-term cumulative effects. More work on short-term effects is needed to understand skills practice as a therapeutic treatment component. Understanding the role and experience of independent skills use can help to guide treatment improvements, set clearer expectations and motivations for patients engaging in CBT, and monitor treatment progress.

Addressing this knowledge gap is increasingly pressing as the field rethinks the paradigm of traditional individual-based treatment, which relies on significant face-to-face time with a professional (Kazdin & Blase, 2011; Kazdin & Rabbitt, 2013). Critically, there is a shortage of mental healthcare providers and evidence-based options are ostensibly declining (Cunningham, 2009; Harvey & Gumport, 2015; Thomas, Ellis, Konrad, Holzer, & Morrissey, 2009). Furthermore, inconvenient office hours, transportation issues, time demands, stigma, and cost create barriers even for those given access to a qualified professional (Andrews, Cuijpers, Craske, McEvoy, & Titov, 2010; Singla, Raviola, & Patel, 2018). Such obstacles are thought to contribute to the increasing prevalence of mental health problems—including rates of suicide—in the United States and the world (Hedegaard, Curtin, & Warner, 2018). In this vein, there is widespread and growing enthusiasm for mobile health, or using mobile devices to deliver or supplement mental healthcare (Chandrashekar, 2018). There is particular optimism for mobile health enhancing skills-based therapies such as CBT (Lindhiem, Bennett, Rosen, & Silk, 2015). Practicing skills outside of therapy, without the help of a clinician, is often daunting or even deterring for potential patients. Assignments rely on patients independently overcoming the challenges of consistently remembering to practice and being able to recall skills during

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

emotional experiences. Mobile technology has been increasingly harnessed to enhance skills use through frequent contact, reminders to complete homework, and opportunities for guided practices (Lindhiem et al., 2015; Morgan, Mackinnon, & Jorm, 2013; Terides et al., 2018). That skills review and practice are at the heart of so many mobile health developments further underscores the need to better understand this treatment component.

Fortunately, mobile technology presents a unique opportunity to improve access to CBT as well as explore mechanisms or mediators of treatment response in more ecologically valid ways. Here, we leveraged data from a recent pilot study pairing smartphone app-delivered skills reminders and guided practice (or ecological momentary intervention [EMI]) with ecological momentary assessment (EMA) to begin exploring these open questions. Patients received six smartphone-based prompts per day, some of which were guided skills practices plus emotion assessments (EMI) and some of which were emotion assessments only (EMA). It is frequently assumed that using a skill should lead to reduced negative or increased positive affect for a patient; for example, cognitive restructuring often moves individuals away from focusing on overly negative thoughts and behavioral activation encourages engagement in pleasant activities that boost mood. However, there has been little real-world testing of the effects of skills practice on negative and positive affect let alone the time course of this expected change. Although it is possible that patients tend to experience relief immediately or within minutes from implementing a skill, it is also possible that benefits are more likely to emerge on the scale of hours or days or vary by skill type. For example, challenging an automatic negative thought could help reduce anxiety in-the-moment, whereas being more mindfully aware of one's negative emotions could be less likely to offer immediate relief (as the individual comes into closer contact with their emotions), but result in reduced distress over longer periods of time. It is further unclear whether

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

the benefits of repeated practice over time are even related to how a given practice makes a person feel in the short-term.

In this study, we examined three core CBT skills (mindful emotional awareness, cognitive flexibility, and countering emotion-driven behaviors), drawn from the Unified Protocol for the Transdiagnostic Treatment of Emotional Disorders (UP) (Barlow et al., 2017; Barlow et al., 2011), an evidence-based transdiagnostic CBT intervention that aims to foster adaptive emotion management. The primary goal of the intervention was to reduce emotional distress in this high-risk, highly acute sample. Given the well-established association between suicidal thoughts and behaviors and emotion dysregulation (e.g., Turton et al., 2021), and that the vast majority of individuals who experience suicidal thoughts and behaviors meet criteria for at least one emotional disorder (e.g., depression, posttraumatic stress disorder, anxiety) (e.g., Bentley et al., 2016; Nock, Hwang et al., 2009; Nock et al., 2010; Nordentoft et al., 2011), participants were strong candidates for transdiagnostic, emotion-focused CBT strategies aimed to improve adaptive emotion management.

Moreover, CBT-based approaches have been shown to be effective interventions for suicidal and nonsuicidal self-injurious thoughts and behaviors (Tarrier, Taylor, & Gooding, 2008; D'Anci, Uhl, Giradi, & Martin, 2019) and are gaining increasing evidential support as brief interventions for inpatient units (e.g., Diefenbach et al., 2021; Rudd et al., 2015; Nawaz, Reen, Bloodworth, Maughan, & Vincent, 2021). The three transdiagnostic CBT skills included in this intervention—mindful emotional awareness, cognitive restructuring, and opposite action—also appear as key components of other evidence-based treatments for suicidal thoughts and behaviors (e.g., mindfulness and opposite action in Dialectical Behavior Therapy, cognitive restructuring in Cognitive Therapy for Suicide Prevention). Furthermore, the transdiagnostic UP

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

itself has been successfully applied to individuals with suicidal thoughts or behaviors (Lopez et al., 2015; Sauer-Zavala et al., 2020), including as a brief intervention for inpatient settings (Bentley et al., 2017; Bentley, Sauer-Zavala, Stevens, & Washburn, 2020). Importantly, the UP frames suicidal thoughts and behaviors as aversive reactions to and unhelpful coping strategies for negative emotions, serving similar functions to chronic avoidance or withdrawal behaviors, and instructs patients in cognitive and behavioral strategies they can flexibly apply across difficult emotional experiences.

In this initial exploration, our first aim was to examine whether patients experience improved affect (i.e., reduction in negative affect and increase in positive affect) immediately after practicing skills from CBT. Intensity of momentary negative and positive affect immediately before and after skills practices were compared. Our second aim was to examine whether individual skills practices impact participants beyond the immediate response. Specifically, we compared state affect at timepoints that were preceded by an earlier skills practice to timepoints that were preceded by only an assessment. Our third and final aim was to explore whether these responses relate to clinical outcomes. We predicted that participants would report less negative affect and more positive affect both immediately after practicing a skill (typically within 5 minutes) and after a delay (median time between prompts was approximately 2 hours), and that more consistent or stronger alleviative responses (immediate and delayed) to individual skills would predict less severe emotional symptoms at the end of the study period.

Material and Methods

Participants

Participants ($n = 25$) were recruited as part of a registered clinical trial (NCT03950765) from the Massachusetts General Hospital inpatient psychiatry service between July 2019 and

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

March 2020. Eligible participants were individuals whose primary reason for admission was severe suicidal ideation or suicidal behavior. Potential participants were excluded if they could not access a compatible smartphone or were unable to independently provide consent (e.g., psychosis, drug withdrawal). Demographic and clinical characteristics of the sample are summarized in Table 1. Average length of stay in the hospital was 7.88 days (SD = 4.51). In addition to the UP treatment described below, patients received routine inpatient care, including a combination of group and individual psychotherapy and medication and case management as determined by the clinical team.

Procedure

Informed consent was obtained from all individual participants included in the study. Participation encompassed three periods. During the first period, or recruitment phase, eligible participants were enrolled in the study within one to two days of admission. After signing the consent form, participants completed a battery of baseline questionnaires and received instructions for using the EMA software. The second period, or the remainder of a participant's inpatient stay (1-7 days), involved one to three sessions of individual cognitive behavioral therapy (CBT); exact number of sessions depended on a patient's availability and length of stay. Each session covered one of three core CBT skills drawn from the UP (Barlow et al., 2017; Barlow et al., 2011): mindful emotional awareness, cognitive flexibility, and countering emotion-driven behaviors. Additionally, participants began the EMA component of the study. Each day, participants received six short survey prompts delivered via a smartphone app. The third period encompassed the time between discharge from the hospital and the end of the study 28 days later. Participants completed two more batteries of questionnaires, one at discharge and one at the end of the study. Participants continued receiving EMA prompts throughout the third

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

period. Measures included in the present manuscript are summarized below. Participants were compensated \$0.50 for each prompt completed plus an additional \$2 for each day on which they completed more than four prompts (up to \$175 total). Participants received \$15 for completing the end of study assessment. Payments were distributed via electronic gift cards at discharge, halfway through the follow-up period, and at end of study.

Materials

Patient-Reported Outcomes Measurement Information System (PROMIS). We administered the three subscales of the PROMIS Emotional Distress measure (Cella et al., 2007)— PROMIS-Depression (4 items), PROMIS-Anger (5 items), and PROMIS-Anxiety (4 items)— and the PROMIS Self-efficacy for managing emotions measure (4 items) at baseline, discharge, and end of study. Each item asked participants to rate their emotional experiences over the past seven days (or since starting the study, if completing the measure at discharge) on a scale from 1 (never) to 5 (always). Higher scores reflect more severe symptoms of depression, anger, and anxiety, but greater self-efficacy. To facilitate comparison across studies, T-scores, rather than raw scores, are reported in this manuscript.

Emotion Reactivity Scale (ERS). The 21-item ERS, administered at baseline and end of study, captures emotional reactivity and yields an overall score and three subscale scores: emotional sensitivity (e.g., “I tend to get very emotional very easily”), intensity (e.g., “I experience emotions very strongly”, “When I’m emotionally upset, my whole body gets physically upset as well”), and persistence (e.g., “When something happens that upsets me, it’s all I can think about for a long time”) (Nock, Wedig, Holmberg, & Hooley, 2008). Items are rated on a 0 to 4 scale and with reference to experiences over the past week. Higher scores reflect greater reactivity.

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Brief Experiential Avoidance Questionnaire (BEAQ). Participants rate 15 types of experiential and emotional avoidance on a 1-6 scale (Gámez et al., 2014; Gámez, Chmielewski, Kotov, Ruggero, & Watson, 2011) is a 15-item self-report measure that assesses several types of experiential and emotional avoidance (e.g., “I’m quick to leave any situation that makes me feel uneasy,” “I work hard to keep out upsetting feelings”). Total scores can range from 15 to 90; higher scores indicate greater use of avoidance strategies.

EMA. Surveys were hosted by Qualtrics and prompted six times daily via the LifeData (<https://www.lifedatcorp.com/>) company’s RealLife Exp smartphone app (Runyan et al., 2013) to collect EMA data. Prompts were delivered at random times within a specified window based on individual participants’ sleep schedules. There were two types of prompts, chosen randomly: (1) assessment-only (EMA), and (2) skills practice (mindfulness emotional awareness, cognitive flexibility, and countering emotion driven behaviors) (EMA+ EMI). Participants received three assessment-only and three skills practice prompts (one of each type) each day in a randomized order.

Assessment-only prompts. Participants rated a series of affect labels on a 0 (not at all) to 10 (very much) scale to capture their experience in the moment. Labels were selected for their relevance to suicide risk and hypothesized treatment mechanisms. Negative labels were hopelessness (*things will never get better*) and burdensomeness (*you, the things you do or just your presence causes other people to suffer hardship*) as well as agitation (*you are crawling out of your skin and cannot sit still*) and anger (*you’ve been unfairly treated or wronged*). Positive labels included gratefulness (*thankful or appreciative for the positive things in life*) and connectedness (*how connected you feel to others*). Labels were presented in randomized order each time. To reduce the number of models to be computed, we use four affect variables moving

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

forward: agitation/anger (average of agitation and anger ratings), burdensomeness/hopelessness (average of burdensomeness and hopelessness ratings), gratefulness, and connectedness.¹

Skills practice prompts. Up to three times per day, participants were given the opportunity to practice one of the three skills learned in treatment. Through a series of pages delivered through the app, participants were walked through the steps of mindful emotion awareness (i.e., anchoring oneself in the present moment, away from ruminating on past events or worrying about future possibilities), cognitive flexibility (i.e., looking for alternative, more balanced interpretations of emotion-provoking situations), and countering emotion-driven behaviors (i.e., identifying and implementing more adaptive, alternative actions). Each step was interactive (e.g., typing a negative automatic thought, selecting which challenging questions to use, entering responses, generating an alternative thought) to promote in-the-moment engagement (rather than simply reviewing the concepts). Participants were encouraged to practice skills using any current distressing emotions; in the absence of any present emotions, patients were instructed to think of a time recently when they felt distressing emotions. Immediately before and after this practice, participants completed the above affect ratings.

Data Analysis

Descriptive statistics. Counts and proportions were calculated for categorical demographic variables (gender, ethnicity, race). Means and standard deviations were calculated for baseline continuous demographic (age) and clinical (PROMIS, ERS, BEAQ, UP Skills Use) measures. Summary statistics for clinical variables at discharge and end of study were also computed. Repeated measures ANOVAs and post hoc comparisons with Tukey contrasts were

¹ A multilevel confirmatory factor analysis supported organizing the negative affect labels into these two factors was a better fit than collapsing them into one. Specifically, the two factor solution yielded adequate and superior fit (CFI = .99, RMSEA = .07, SRMR = .02) compared to the one factor solution (CFI = .92, RMSEA = .13, SRMR = .05) (Hu & Bentler, 1999).

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

used to assess for differences in clinical measures across time points. Six participants did not provide end of study data and were excluded. Thus, subsequent analyses of EMI and outcomes data include 19 individuals.²

Prompted skills practice and immediate affect change. We first examined possible immediate changes in affective state following prompted skills practice. Specifically, we compared affect ratings immediately before the practice to ratings immediately after using mixed effects regressions (i.e., multi-level modeling), in which affect ratings were dependent variables, time (before vs. after skills practice) was a fixed effect, and subject was a random effect. Models including random intercepts and random intercepts and slopes were tested. Models were then repeated including an interaction term between time and type of skills practice (mindfulness, cognitive restructuring, or countering emotion-driven behaviors) as well as time in the study.

Prompted skills practice and later affect. We then examined whether prompted skills practice was related to participants' emotional experiences beyond their initial response. Using mixed effects regression models, we tested whether affect ratings at time t varied depending on whether a participant had received a skills practice versus an assessment-only prompt at time $t-1$. The first affect ratings of a given day were excluded as the previous prompt would have been the previous day. Affect ratings were dependent variables, type of prompt at previous timepoint was a fixed effect, and subject was a random effect. Models including random intercepts and slopes were tested. Models were then repeated including an interaction term between type of prompt and type of skills practice (mindfulness, cognitive restructuring, or countering emotion-driven behaviors) as well as time in the study.

² Chi-square tests showed that included and excluded participants did not significantly differ on any demographic or clinical variables at baseline, $ps > .05$.

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Association between responses to skills and clinical outcomes. Finally, we examined whether affect responses (immediate and deferred) to exercise prompts were associated with clinical outcomes at the end of the study period. Specifically, we looked at correlations between responses and symptom measures (PROMIS-Anger, PROMIS-Anxiety, PROMIS-Depression) and process measures (PROMIS Self-efficacy, ERS, BEAQ). We also examined partial correlations, adjusting for baseline scores of each clinical measure. Additionally, we examined whether simply engaging more with the app, operationalized as total number of prompts and number of skills practice prompts an individual responded to during the study period, was related to patterns of response. For these analyses, a new “immediate response” variable was operationalized for each emotion rating as the difference between an individual’s emotion rating immediately *after* a prompted skills practice and immediately *before* the practice (i.e., pre to post EMI). Positive values indicate that the affect rating *increased* following the skills practice. And, a new “deferred response” variable was operationalized for each emotion rating as the difference between an individual’s average emotion ratings when the previous EMA prompt was assessment-only and when the previous EMA prompt contained a skills practice (i.e., EMI at time t to EMA at time $t+1$). Positive values indicate that affect ratings were *higher* following assessment-only prompts compared to skills prompts.

Results

Descriptive statistics

At baseline, participants reported on average moderate to severe levels of anxiety and depression and moderate levels of anger (PROMIS measures). Although such scores numerically declined at discharge, declines were only statistically significant at the end of the study. At the end of the study, participants on average reported normal to mild levels of anger and mild to

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

moderate levels of anxiety and depression. Similar patterns of improvement emerged for PROMIS Self-efficacy, ERS, and BEAQ scores. See Table 1 for a summary of clinical measures across the study period. Participants responded to an average of 120.44 prompts ($SD = 60.06$). Response rates were not significantly different between assessment only prompts ($M = 69.83$, $SD = 36.99$) and skills prompts ($M = 50.61$, $SD = 39.53$), $t = 1.72$, $p > .05$. Response rates were not correlated with any baseline clinical measures, $ps > .05$.

Prompted skills practice and immediate affect change

Median time that elapsed between the time points (pre- to post-practice) was 4.30 minutes. Across all criteria, random intercept models provided the best fit; more complex models (random intercept and slope) were either overfitted or did not provide a significant improvement (i.e., larger BIC values). Thus, random intercept models are reported. Mixed effects models revealed declines in negative affect, and increases in gratefulness, following prompted skills practice. The model examining connectedness yielded non-significant results, $ps > .05$. See Table 2 for a summary of models. Additionally, time by type of skill or time in the study interaction terms were non-significant, $ps > .05$.

Prompted skills practice and later affect

Median time that elapsed between the completion of a prompt and delivery of the next prompt was 2.17 hours. Across all criteria, random intercept models provided the best fit; more complex models (random intercept and slope) were either overfitted or did not provide a significant improvement. Thus, random intercept models are reported. Mixed effects models revealed that participants reported *less* negative affect when the previous prompt involved skills practice compared to if it was assessment-only. Participants also reported *greater* connectedness following skills practice compared to assessment-only prompts. The effect for gratefulness was

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

non-significant, $ps > .05$, but trended in the same direction. See Table 2 for a summary of models. Differences by type of skill and time in the study were also non-significant, $ps > .05$, with one exception: an interaction between type of prompt and time in the study predicting burdensomeness/hopelessness, $F(1, 1597.4) = 6.09, p = .01$, revealing modest declines in the effect over time.

Association between responses to skills and clinical outcomes

Summary statistics for participants' immediate and deferred responses to skills prompts are reported in Table 3; average changes in emotion ratings were small given variability in whether skills practices tended to yield improvements for individual participants. Pairwise correlations are included in Table 4. PROMIS-Anger scores at the end of the study showed large positive correlations with deferred effects for negative affect response scores (both agitation/anger and burdensomeness/hopelessness), and a large negative correlation with deferred gratefulness response scores, $ps < .05$. In other words, individuals who experienced less severe anger symptoms at the end of the study tended to be those whose negative emotions were less severe and feelings of gratefulness were greater following skills practices than assessment-only prompts. Similar patterns were found for PROMIS-Anxiety scores with deferred gratefulness responses. Correlations remained significant for burdensomeness/hopelessness and gratefulness when adjusting for baseline levels. Additionally, participants who reported lower ERS-sensitivity scores at the end of the study were also more likely to report less burdensomeness/hopelessness when they had previously seen a skills practice prompt versus an assessment-only prompt, reflected in large positive correlations between ERS scores and deferred negative responses, $ps < .05$. This held when adjusting for baseline values. To be conservative, we re-ran correlations using the Benjamini-Hochberg method of adjusting for

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

multiple comparisons. Associations of delayed responses with anger and anxiety symptoms were reduced to trends ($ps = .10-.17$) and with ERS-sensitivity to $p = .31$. When examining partial correlations, additional negative associations emerged between delayed effects for connectedness and ERS sensitivity, $r = -.45, p = .03, 95\% \text{ CI } [-.72, -.05]$, and persistence subscales, $r = -.61, p < .01, \text{ CI } [-.81, -.27]$. Significant partial correlations also emerged for delayed agitation/anger with ERS total score, $r = -.55, p = .01, 95\% \text{ CI } [-.78, -.18]$, and the persistence subscale, $r = -.86, p < .01, 95\% \text{ CI } [-.94, -.69]$.

Interestingly, however, ERS scores were also negatively correlated with immediate burdensomeness/hopelessness and agitation/anger responses, $ps < .05$, such that individuals who reported being less emotionally reactive at the end of the study were *less* likely to have reported improved negative affect after a prompted skills practice. This effect for the total ERS score was largely driven by the arousal subscale. These associations survived correction for multiple comparisons and held when adjusting for baseline scores. Partial correlations revealed additional negative associations between the ERS persistence subscale and immediate agitation/anger responses, $r = -.47, p = .02, 95\% \text{ CI } [-.74, -.09]$, as well as positive associations between immediate gratefulness responses and ERS total scores, $r = .41, p = .04, 95\% \text{ CI } [.01, .81]$, and the arousal subscale, $r = .64, p < .01, 95\% \text{ CI } [.32, .96]$. Again, less emotional reactivity at the end of the study was associated with lesser acute changes in affect with skills practices.

Additionally, PROMIS self-efficacy scores were positively associated with agitation/anger responses, meaning that participants who were more confident in their ability to manage strong emotions at the end of the study were those who experienced greater reductions in negative affect following skills practices. This association, however, did not survive correction ($p = .62$) and was not significant when adjusting for baseline levels of self-efficacy. There were

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

no significant correlations among emotional responses and total number of prompts answered or number of skills prompts answered, $ps > .05$. Total number of prompts and number of skills prompts were also unrelated to clinical outcomes, $ps > .05$, except for ERS scores. Total number of prompts showed large correlations with the total ERS score and all subscales ($rs < -.60$), $ps < .05$, such that participants who engaged more frequently with the app reported less emotional reactivity at the end of the study.

Discussion

To our knowledge, this is the first study to explore evidence of short-term effects of real-time skills use, expanding our understanding of independent skills use as a therapeutic element of CBT (Hundt et al., 2013; Kazantzis et al., 2010; Terides et al., 2018). Participants initially received face-to-face sessions to teach CBT skills, but most of the intervention period was spent engaging in daily independent, structured, prompted skills practice. Encouragingly, participants reported improvements across outcome measures from baseline to end of study. Consistent with hypotheses, on average, participants experienced modest reductions in negative affect after engaging in a prompted CBT skills practice. Perhaps surprisingly, however, clinical outcomes were unrelated to these immediate reductions in reported negative affect. In other words, end-of-study anxiety, anger, and depressive symptom severity were connected neither to how frequently a participant reported feeling relief after skills practices nor to how large that relief tended to be. What instead was associated with lesser symptoms were the delayed effects of skills practices. Participants tended to report less negative and more positive affect after a delay (i.e., next assessment timepoint) following an earlier skills practice than no practice. And individuals who reported larger or more consistent deferred effects reported less anger, anxiety, and emotional

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

reactivity at the end of the study period. Associations did not emerge for depression, self-efficacy, or emotional avoidance.

Immediate relief from practicing a skill may be desired by patients and potentially reinforce regular practice. Indeed, there was a signal that greater reductions in high arousal negative affect (e.g., anxiety, agitation) after using a skill may be related to one's confidence in ability to self-regulate. Yet, we did not actually find that immediate emotional benefits were associated with responding to more prompts. This finding could inform psychoeducation for CBT. For example, it could be helpful to advise patients not to worry if they do not experience treatment effects right away; instead, providers should emphasize broader shifts in emotional responding and functioning over time. This could be particularly important in the context of treating individuals with suicidal thoughts and behaviors, who may be distinctly sensitive to perceiving failures or feelings of hopelessness. As it appears that this acute response may grow with repeated practice, such messaging could be most potent early in treatment. Notably, however, we were unable to measure (and thus account for) frequency of independent skills practice outside of app-based prompts, including skills that patients may have learned in other inpatient or outpatient therapies. It is possible that immediate relief from intense negative affect or rise in positive affect reinforces skills use and promotes more self-initiated practice. How responses to or appraisals of individuals skills practices contribute to individuals' motivation and learning to use skills effectively and habitually merits further exploration. Still, results suggest that an accumulation of immediate mood boosts is unlikely to be a mechanism of treatment effects.

A more compelling therapeutic process is how skills practice impacts subsequent emotional shifts. Critically, it cannot be determined from present data exactly what that impact

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

is. Less negative and more positive affect following skills practice relative to assessment-only prompts could reflect sustained elevation, which in turn could reflect the potency of a given skills practice. This pattern of results could also reflect less inert negative emotions; in other words, even if a person was still feeling distressed immediately after practicing a skill, they might return to baseline more quickly with time than had they not attempted to regulate their emotions with a CBT strategy. Results may also reflect resilience to emotional stressors; prior skills use could help patients better cope with subsequent emotional challenges and not be pulled as far down as they otherwise would. In this way, formal practices might promote greater use of “informal practice” (Hundt et al., 2013), or using skills more automatically as needed. In fact, the finding that deferred emotional effects of skills use were associated with less emotional reactivity was driven by the sensitivity subscale, which generally reflects one’s ability to weather perturbations. A future study designed to evaluate these possibilities is merited.

Overall, we posit that using CBT skills meaningfully does not necessarily equate to immediately feeling better after a skill. In many ways, this aligns with core elements of CBT, and especially the emotion-focused UP treatment, which focuses on approaching negative emotions or avoided thoughts and situations (Ellard, Fairholme, Boisseau, Farchione, & Barlow, 2010; Hofmann, 2012). Mindful emotional awareness encourages individuals to observe and accept thoughts, feelings, and behavioral urges, even when these experiences are distressing. The goal of cognitive flexibility is to develop alternative thoughts that are balanced and realistic, not necessarily positive. Countering emotion-driven behaviors inherently asks individuals to approach instead of avoid, or take valued actions with the understanding that doing so may initially trigger negative emotions. To be sure, particularly early on in treatment, these important changes may not always be comfortable for patients. Yet, prior research shows how reducing

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

emotional avoidance predicts reductions in suicidal thoughts and behaviors, even in acute psychiatric settings (e.g. Ellis & Rufino, 2016; Luoma & Villatte, 2012). This also aligns with some newer developments in CBT, such as inhibitory learning approaches to exposures, which emphasize that acute reductions in negative emotions are not necessary for learning and that past data show them to be unrelated to treatment gains (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Results may provide support for reframing the rationale and goals of skills practice and setting clearer expectations for participants. Psychoeducation emphasizing that immediate relief is not an apt indicator of whether a skill is being used “correctly” could help patients not be discouraged (or feel hopeless) when skills feel difficult or do not lead to quick declines in negative affect. This perspective could lead to more sustained engagement and better outcomes. In the present sample of high-risk individuals navigating the challenging, often chaotic post-discharge period, this expectation setting may be heartening and even critical or life-saving for some.

Interestingly, participants in the present study who reported the largest improvements in negative affect immediately after using a skill actually reported the highest levels of emotional reactivity at the end of the study, specifically in terms of emotional arousal or how intensely emotions are experienced (e.g., physical sensations, overreacting). Hence, immediate reactions to using a skill may be more a function of how amenable a person is to changes in their environment—whether that be a happy occurrence, emotional stressor, or smartphone prompt to shift one’s attention to practicing a skill described as helpful—than a function of how well the skill was implemented. In fact, larger acute declines in negative affect in response to positive events is characteristic of individuals suffering from depression relative to healthy controls (Bylsma, Taylor-Clift, & Rottenberg, 2011; Thompson et al., 2012). Such immediate effects may

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

be transient and reflect larger patterns of high emotional variability and instability, typically associated with poor emotional health (Houben et al., 2015). More gradual shifts in thinking and behavior, and consequently emotional reactions, may be more beneficial and critical in the long term. This arc could be more likely to engender learning and meaningful changes in how a person interacts with stressors moving forward. This may be especially relevant for individuals who, after being discharged, frequently return to the same stressors that could have contributed to their suicidal crisis initially as well as novel stressors (e.g., returning to work, strained relationships).

Still, we must be careful not to overinterpret results given a few additional limitations of this study. Most notably, it included a small sample, a limited number of emotion and outcome variables, only pre-post measures of symptoms, and no control group. Additionally, affect ratings were only repeated in short succession surrounding a skills practice; there was no control condition featuring repeat assessment without a skills reminder. Consequently, observed effects could have been the result of individual skills practices, the cumulative effect of practicing a skill repeatedly, or the cumulative effect of practicing multiple skills; however, effects could also have been influenced by a number of intervening factors such as regression to the mean, self-monitoring, or demand characteristics, as well as the unique stressors or other supports patients may or may not be experiencing during the study period. A larger, randomized control trial with more intensive data collection would allow for replication and extension of results to tease apart these possibilities and rigorously explore more dynamic effects (e.g., changes in these relationships over longer periods of time), as would studies including more heterogeneous samples, different clinical populations, or other CBT-based skills with evidence base for addressing suicidal thoughts and behaviors. The present study was conducted during the month

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

after hospitalization, which is a high-risk and often chaotic time for patients, where interventions are most needed. But, given that this time period is so different from other periods, results may not generalize to time periods or less acute populations more characteristic of typical outpatient CBT. For example, this sample may exhibit greater than average emotional reactivity, which could modulate patterns of response to CBT skills. Additionally, optimal response to skills may vary dynamically with time in treatment or symptom severity; perhaps with greater mastery of skills or less acute symptoms, patients may more frequently experience positive changes in affect with skills use and this may in turn portend stronger treatment response or relapse prevention. Moreover, we could not account for the effects of concurrent psychiatric and other professional supports on these data. Larger samples would also provide the power necessary to effectively compare individual skills, rather than grouping them together.

Similarly, we cannot deduce the context in which skills were practiced. Research increasingly suggests that the success of many emotion regulation skills depends on context; for example, cognitive reappraisal is most beneficial when used for stressors that are uncontrollable (Bonanno & Burton, 2013; Haines et al., 2016; Troy, Shallcross, & Mauss, 2013). With the present design, we cannot account for situation-strategy fit. Encouragingly, by sending practice prompts at random times, participants may have been more likely to practice skills in a wider range of situations and emotional contexts than they otherwise would. There is evidence that patients tend to initiate assigned skills practices at times when they are not feeling strong emotions, such as setting aside time in the evening away from the stressors of the day. Although this practice can still lead to learning, it can also make it less likely or more challenging for patients to access those skills when they are needed most (Hundt et al., 2013). Accordingly, future iterations should consider context. It will also be important compare prompted and patient-

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

initiated skills use, particularly because the ultimate goal of CBT practice assignments is for patients to recognize when a skill would be helpful and to then implement it independently. Relatedly, next steps should also delve deeper into the *quality* of skills practices. Further differences may emerge when we consider additional dimensions such as time spent practicing, content (e.g., type of unhelpful thought identified), or success (e.g., ability to generate a more balanced thought).

Conclusions

An estimated half of Americans will meet diagnostic threshold for a mental disorder at some point in their lives and many more will suffer from subthreshold symptoms (Kessler, Chiu, Demler, Merikangas, & Walters, 2005; Schaefer et al., 2017). The corresponding and continued prevalence of suicidal thoughts and behaviors and suicide as a leading cause of death underscores this public health issue (Borges, Angst, Nock, Ruscio, & Kessler, 2008; Centers for Disease Control and Prevention, 2018; Crosby, Han, Ortega, Parks, & Gfroerer, 2011; Kessler, Berglund, Borges, Nock, & Wang, 2005). The present study contributes to growing body of work demonstrating the promise of brief, scalable interventions and the utility of mobile health platforms (Chandrashekar, 2018; Melhem & Brent, 2020), as well as calls for mobile mental health options that are evidence-informed and scientifically tested (Neary & Schueller, 2018; Torous et al., 2019). Results shines light on the central role of independent skills practice in response to CBT and potential mechanisms by which such practice could improve outcomes.

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Glossary

Cognitive behavioral therapy (CBT) is an evidence based treatment used to treat a wide range of mental health problems. In CBT, individuals learn skills for identifying and changing unhelpful patterns of thinking and behaving to reduce symptoms and improve daily functioning.

Ecological momentary interventions (EMI) are treatments (or treatment components) that are delivered to patients in their daily lives, for example via text message or smartphone app.

Ecological momentary assessment (EMA) captures repeated sampling of individuals' experiences, such as their emotional state or recent behaviors, in their daily lives and in real time.

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

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Table 1. Demographic and clinical characteristics of the sample

Measure	<i>n</i> (%)			
Gender				
Female	14 (56.0)			
Male	11 (44.0)			
Ethnicity				
Hispanic/Latino	4 (16.0)			
Not Hispanic/Latino	20 (80.0)			
Did not answer	1 (4.0)			
Race				
African America/Black	2 (8.0)			
Caucasian/White	15 (60.0)			
Asian American/Asian	4 (16.0)			
Mixed Race	1 (4.0)			
Other	3 (12.0)			
Measure	Baseline <i>M</i> (<i>SD</i>)	Discharge <i>M</i> (<i>SD</i>)	End of Study <i>M</i> (<i>SD</i>)	Difference
Age (years)	33.48 (13.84)			
PROMIS Self-efficacy (T-score)	35.83 (4.66)*	35.33 (3.78) ⁺	42.84 (8.34)* ⁺	$F(2,30)=14.19, p=.001$
PROMIS-Anger (T-score)	63.34 (8.34)*	46.49 (9.32)*	54.36 (7.76)*	$F(2,31)=33.92, p=.001$
PROMIS-Anxiety (T-score)	69.84 (7.08)*	56.12 (8.34)*	60.82 (9.16)*	$F(2,33)=28.55, p<.001$
PROMIS-Depression (T-score)	69.37 (4.81)*	55.96 (6.62)*	59.73 (7.17)*	$F(2,36)=47.37, p<.001$
ERS				
Total score	50.65 (14.32)*		35.00 (20.77)*	$F(1,14)=18.47, p<.001$
Sensitivity	22.25 (7.53)*		16.17 (10.68)*	$F(1,16)=8.33, p=.011$
Arousal	19.46 (5.86)*		12.94 (6.93)*	$F(1,16)=21.99, p<.001$
Persistence	9.91 (2.76)*		7.06 (4.36)*	$F(1,15)=13.24, p=.002$
BEAQ	60.84 (9.69)*	57.80 (10.95)	54.37 (11.90)*	$F(2,37)=3.70, p=.034$

Note. * and ⁺ denote significant post-hoc contrasts. PROMIS = Patient-Reported Outcomes Measurement Information System, BEAQ = Brief Experiential Avoidance Questionnaire, ERS = Emotion Reactivity Scale.

Table 2. Summary of multi-level models

Criterion	Estimate (Time)	95% CI	Statistic	<i>p</i>
Immediate Response				
Burdensomeness/hopelessness	-0.12	[0.02, 0.21]	6.17	.01
Agitation/anger	-0.10	[0.03, 0.18]	6.90	.01
Grateful	0.11	[0.001, 0.22]	3.76	.05
Connected	0.10	[-0.02, 0.21]	2.60	.11
Criterion	Estimate (Type)	95% CI	Statistic	<i>p</i>
Delayed Response				
Burdensomeness/hopelessness	-0.16	[-0.29, -0.04]	6.58	.01
Agitation/anger	-0.13	[-0.23, -0.03]	6.55	.01
Grateful	0.11	[-0.03, 0.62]	2.35	.13
Connected	0.19	[0.04, 0.34]	6.19	.01

Note. Time = binary variable (immediately before versus after skills practice); negative values indicate that level of a given emotion decreases from pre- to post-practice. Type = type of prompt, binary variable (timepoint preceded by an assessment versus exercise prompt); negative values indicate that participants reported lower levels of a given emotion following exercise prompts than assessment prompts (e.g., less negative affect); positive values indicate that participants reported higher levels of a given emotion following exercise prompts than assessment prompts (e.g., more connectedness).

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Table 3. Summary of immediate and deferred emotional responses to prompted skills practice

Measure	<i>M</i> (<i>SD</i>)
Immediate Response	
Burdensomeness/hopelessness	-0.12 (0.30)
Agitation/anger	-0.11 (0.21)
Grateful	0.10 (0.30)
Connected	0.10 (0.16)
Deferred Response	
Burdensomeness/hopelessness	0.17 (0.29)
Agitation/anger	0.13 (0.30)
Grateful	-0.12 (0.39)
Connected	-0.19 (0.45)

Note. Immediate Response = Difference between an individual's emotion rating *after* a prompted skills practice and *before* the practice. Deferred Response = Difference between an individual's average emotion ratings when the previous EMA prompt was assessment-only and when the previous EMA prompt included a skills practice.

Table 4. Associations between clinical measures at end of study and emotional effects of skills practice.

	End of Study										
	PROMIS				ERS				BEAQ	# Total Prompts	# Skills Prompts
	Self-efficacy	Anger	Anxiety	Depression	Total	Sensitivity	Arousal	Persistence			
<u>Immediate Response</u>											
Burdensomeness/hopelessness	.350	-.045	-.156	-.288	-.534*	-.230	-.551*	-.242	.347	.210	.197
Agitation/anger	.475*	-.225	-.357	-.375	-.705*	-.427	-.644*	-.410	.370	.252	.133
Grateful	-.290	.005	.231	.171	.346	.255	.437	.274	-.112	-.385	-.214
Connected	-.129	-.183	-.051	.045	.171	-.051	.187	-.063	-.434	.049	-.040
<u>Deferred Response</u>											
Burdensomeness/hopelessness	-.132	.496*	.297	.150	.467	.576*	.286	.417	.131	-.495	-.335
Agitation/anger	-.247	.539*	.255	.327	.135	.280	.017	.003	.084	.017	.311
Grateful	.389	-.579*	-.610*	-.425	-.244	-.399	-.045	-.382	-.154	.170	-.190
Connected	.210	-.272	-.469	-.246	.076	-.259	.198	-.418	-.420	.264	.199

Note. Table shows Pearson correlation coefficients. * $p < .05$, ** $p < .001$. PROMIS = Patient-Reported Outcomes Measurement Information System (T-scores), BEAQ = Brief Experiential Avoidance Questionnaire, ERS = Emotion Reactivity Scale. Immediate Response = Difference between an individual's emotion rating *after* a prompted skills practice and *before* the practice. Deferred Response = Difference between an individual's average emotion ratings when the previous EMA prompt was assessment-only and when the previous EMA prompt included a skills practice.

RESPONSES TO PROMPTED CBT SKILLS PRACTICE

Highlights

- Independent practice of cognitive behavioral therapy skills improves outcomes.
- Patients reported modest reductions in negative affect after skills practice.
- Immediate reductions were largely unrelated to clinical outcomes.
- Outcomes were predicted by skills-related improvements in affect after a delay.

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