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Single-Session Mobile-Augmented Intervention in Serious Mental Illness: A Three-Arm Randomized Controlled Trial

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Psychosocial interventions for serious mental illness are resource intensive and poorly accessible. Brief interventions (eg, single session) that are augmented by follow-on automated mobile health intervention may expand treatment access. This was a randomized single-blind controlled trial with 255 individuals diagnosed with schizophrenia or bipolar disorder. Participants were randomized to one of three conditions: CBT2go, which combined one individual session of cognitive behavioral therapy with automated thought challenging/adaptive behavior delivered through mobile devices; Self-Monitoring (SM), which combined single-session illness psychoeducation with self-monitoring of symptoms; and treatment-as-usual (TAU). Participants were assessed at baseline, 6 weeks (midpoint), 12 weeks (posttreatment), and 24 weeks (follow-up) with our primary outcome global psychopathology (Brief Psychiatric Rating Scale–expanded version [BPRS-24]), and secondary outcomes community functioning (Specific Level of Function; SLOF) and defeatist performance beliefs (DPBs). We also collected data on adverse events. Outcome analyses on the primary outcome, BPRS Total score, indicated a significant time (0–24 wk) by group interaction with significant but modest improvement comparing two active conditions (CBT2go and SM) relative to TAU. Effects of CBT2go were not different from SM. There was a significant time × group interaction with better SLOF scores in CBT2go across 24 weeks, but not in SM. There were no time-by-group effects on DPBs. DPBs decreased in the CBT2go condition but not in SM. These results indicated that single intervention augmented by mobile intervention was feasible and associated with small yet sustained effects on global psychopathology and, when inclusive of CBT, community function compared with usual care.

Key words: bipolar disorder/schizophrenia/psychotherapy/technology/Internet-based treatments/depression/ecological momentary assessment

Introduction

Limited access to evidence-based interventions for serious mental illnesses (SMI; schizophrenia, bipolar disorder) has resulted in efforts to create brief or low-intensity interventions to expand reach of treatments[1] including through mobile technology.[2,3] Rates of mobile device usage and ownership in SMI are increasing,[4] and mobile health interventions are of interest to the population.[5,6] Moreover, despite concerns raised over the quality of extant clinical trials, reviews have generally indicated positive impact on symptoms.[7,8] Although one meta-analysis suggested differential impact across design features,[8] a few studies have experimentally tested variations in mobile intervention content or whether treatment effects are sustained after acute phases of intervention. To address these gaps, we conducted a randomized controlled trial (RCT) contrasting two types of single-session interventions augmented by mobile health: cognitive behavioral therapy (CBT) vs illness education with self-monitoring.

In a previous trial in bipolar disorder, we found greater impact on depressive symptoms when a 4-session psychoeducation intervention was augmented by mobile intervention compared with psychoeducation alone, immediately posttreatment.[9] Although that trial supported mobile augmentation, there are a variety of design considerations for mobile health interventions[10,11] that can impact the user, time for personnel delivering the intervention, and the cost and complexity of deployment. Moreover, mounting evidence indicates mobile applications are associated with a steep decline in engagement following initiation.[12] Our prior trial found attenuation of effect of mobile augmentation 12 weeks after active encouragement of device use.[9] Finally, mechanism of change in mobile intervention is poorly understood, such as whether self-monitoring by itself may affect change (as in other behaviors[13]) or if therapeutic elements that draw from evidence-based

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interventions such as CBT are impactful beyond self-monitoring. A recent proof-of-concept trial evaluated CBT vs self-monitoring content in schizophrenia in early psychosis and found positive impact of CBT compared with self-monitoring on psychotic symptoms.[14] That trial, although highly promising, did not include a treatment-as-usual (TAU) condition and was sized to be focused on feasibility and acceptability rather than outcomes.

Few studies have evaluated the impact of design features on mechanisms. Defeatist beliefs are an intervention target for CBT in psychosis and may be useful in disentangling the impact of CBT vs self-monitoring.[15,16] A recent meta-analysis[13] of the relationship between defeatist attitudes found consistent associations with negative symptoms and functioning but with small effect sizes, because multiple factors contribute to poor functioning. The relationship, however, is sufficiently robust such that we found improvement in defeatist attitudes in cognitive-behavioral social skills training (CBSST) significantly mediated improvements in negative symptoms and functioning, and participants with more severe defeatist attitudes showed significantly greater improvement in functioning in CBSST.[17–19]

We developed a single-session in-person intervention called CBT2go augmented by mobile interactions for SMI. Building from prior work,[9,20] this intervention integrated in-person training with mobile frequent assessment of self-management targets (ie, current mood symptoms or voices, socialization, and medication adherence), related defeatist beliefs (eg, lack of perceived control of symptoms), and adaptive beliefs and behaviors. We developed a Self-Monitoring (SM) alternative, in which in-person content concerned psychoeducation and resources pertinent SMI, and mobile interaction only involved self-monitoring without CBT elements. CBT2go and SM were contrasted to a TAU condition. The primary outcome was change in global psychopathologic symptoms and the secondary outcomes were functioning and defeatist performance beliefs (DPBs). We hypothesized that the two mobile interventions would result in significant decreases in symptoms and improvements in functioning compared with TAU and that the CBT2go intervention would result in greater improvements than the SM condition.

Methods

Participants and Recruitment

Participants were outpatients diagnosed with schizophrenia, schizoaffective disorder, or bipolar I disorder. The target accrual was 255 and participants were recruited between December 2013 and February 2017. Recruitment was through residential facilities and clinics affiliated with the San Diego County Mental Health System, self-help support groups, and online advertisements. The frequency of referral source for the entire sample, in descending order, was residential facility or congregate living (60.5%), referral from other study (21.5%), outpatient clinic (14.9%), referral from friends (2.6%), and advertisement (0.4%). This referral source distribution did not significantly differ by group assignment (CBT2go, SM, TAU; $\chi^2(8) = 7.3$, $P = .533$). To be eligible, participants needed to be (1) aged 18 years and older; (2) outpatients prescribed stable psychotropic medication regimens for the prior 3 months; (3) rated greater than 3 (1 = not present to 7 = extremely) on at least one of the Brief Psychiatric Rating Scale (BPRS) items 3 (Depression), 7 (Elevated Mood), 10 (Hallucinations), or 17 (Emotional Withdrawal). Note, these items were selected due to their relevance to the targeted domains in the Ecological Momentary Assessment protocol and positive, negative and mood symptom clusters in the target population. (4) Free of visual or manual dexterity disabilities that would preclude operation of a touch screen device. We excluded participants who (1) were intoxicated at the time of interview; (2) were psychiatrically hospitalized in the prior month; (3) had participated in CBT within the past 5 years; (4) had a diagnosis of dementia, seizure disorder, intellectual disability, or experienced a past head injury with a loss of consciousness greater than 20 minutes; or (5) were actively participating in another clinical trial.

This study was approved by the University of California, San Diego (UCSD) Human Subjects Protections Program. All participants provided written informed consent confirmed by passing the UCSD Brief Assessment of Decisional Capacity.[21] Diagnosis was determined with the Mini International Neuropsychiatric Interview for *Diagnostic and Statistical Manual, Fourth Edition*[22], chart review, and consensus meetings with the principal investigator. Participants were compensated $50 for time spent in each assessment (they were not compensated for intervention). The Clinicaltrials.gov number was NCT02035202. Prior publication with these data have concerned baseline characteristics.[23]

Randomization. Randomization with three-group 1:1:1 ratio was completed by an independent statistician via computerized random number generator. Participants were assigned to one of the following: (1) CBT2go, (2) SM, or (3) TAU. Raters were masked to study assignment. Masking was preserved by (a) separating case discussions with therapist from raters, (b) counseling participants not to reveal randomization status, and (c) replacing raters for all subsequent assessments in cases of breaking blind.

Intervention Conditions

Treatment-as-Usual (TAU). Participants only completed assessments. As per eligibility criteria, all participants were participating in outpatient psychiatric follow-up and required to be prescribed medications for their mental health diagnosis at the time of study entry.

Participants were linked with care in case of crisis during research assessments.

CBT2go In-Person Session. Participants met with a therapist in the community for a single 90-minute session. The treatment manual contained an introduction to the program and to the cognitive behavioral model, and then modules on mood symptoms, voices, socialization, and medications. We provided participants the option of completing the mood (depression) or voices sections (or both on alternating days) based on the symptom domain that participants believed most impacted their functioning. Each module provided psychoeducation about the topic and queried participants about their experience and current strategies for self-management. Participants then were presented with common defeatist beliefs that corresponded to the topic (eg, for depression, "I have no control over my symptoms;" for socialization, "Others won't like me"). The therapist and participant then collaboratively selected more balanced beliefs (eg, "Joe likes to hang out with me at the clubhouse") and a behavioral strategy linked to the belief (eg, ask to Joe to do someone fun). Participants were encouraged to personalize the cognitive and behavioral strategies to increase relevance. As such, a variety of "if–then" scripts were created linking maladaptive beliefs to sets of corresponding adaptive beliefs and behaviors. Participants were also asked about strategies for wellness, and personalized encouraging statements were presented linked to endorsement of low levels of symptoms or positive adherence.

Self-Monitoring (SM) In-Person Session. As with CBT2go, SM was a single 90-minute session that included psychoeducation about the diagnosis, causes, symptoms, and treatments for mental illness, and the importance of self-monitoring symptoms; unique manuals were developed for bipolar disorder and schizophrenia that provided content specific to that diagnosis. Participants were encouraged to ask questions about their diagnosis and treatment, and were provided a list of resources (eg, support groups). The manual was designed not to include any content regarding maladaptive beliefs or the cognitive-behavioral model.

Therapist and Fidelity. The same therapist (JD), a master's-level clinician, conducted all in-person appointments for both active conditions and was not masked to condition. Sessions were audiotaped and the therapist completed a fidelity rating each session. Audiotapes of sessions were reviewed by two independent fidelity raters who were masked to condition; they were also asked to guess which condition was delivered in order to monitor potential crossover effects. An 8-item fidelity rating form was adapted from the Cognitive Therapy Rating Scale for Psychosis[24] with a score range of 0–16, with a parallel version for SM content. The therapist also provided a report of the proportion of CBT2go or SM material covered in the session, with a percentage between 0% and 100%. Supervision occurred in weekly meetings.

Mobile Interactions

Mobile Device Technical Description. Participants assigned to either CBT2go or SM were provided with an Internet-enabled smartphone or could elect to use their own phones. The rate of use of participant own phones during the course of the study was approximately 10% in both CBT2go and SM conditions. A web-based program called Mobile Online Behavioral Intervention Technology (MOBIT) delivered interactive surveys to the device that contained elements personalized from the individual session. At each survey epoch, users received an invitation to complete a "survey" at a randomly scheduled time within 3 daily blocks of time (morning, afternoon, and evenings). Interactions were triggered via SMS that automatically opened a web application. Responses were recorded by use of a touch screen interface with categorical responses, and all data resided on a server housed at UCSD. At the conclusion of the in-person session, participants were trained on how to operate the device and responding to alarms. Participants also received a written manual describing the operation of the device.

CBT2go Interactive Content. CBT2go algorithms contained assessment and intervention content. The goal for the mobile component was not meant to be a stand-alone intervention, but to augment in-person content by providing real-time thought challenging intervention outside of the clinic setting individualized to the specific symptoms or defeatist beliefs they endorsed at the time. Different from homework in traditional in-person therapy, which is self-initiated, the mobile device prompted participants to engage in cognitive restructuring. Mood or Voices algorithms were delivered during the morning survey, Socialization in the afternoon, and Medication Adherence in the evening. The first question pertained to symptom severity/frequency, socialization, and medication adherence and the second to presence of one of 3–4 current maladaptive beliefs corresponding to that domain (eg, "I have little control over my voices"). Participants could also select "none of these" in relation to the maladaptive beliefs. The intervention content branched from each of the maladaptive beliefs to offer a potential alternative or adaptive belief, personalized by the individual in the in-person session, accompanied by adaptive behaviors. Participants then rated their intention to engage in the activity on one of three levels (eg, "I probably/might/will do it") and received feedback based on this statement (eg, if "I might do it," then "Go ahead and give it a try"). These algorithms were developed to be completed in 1–2 minutes.

Self-Monitoring Content. The SM intervention contained the same questions about the frequency/severity of symptoms, socialization, and medication adherence, without any of the intervention content. In both SM and CBT2go participants could on demand review symptoms through a graphical application.

Follow-Up Telephone Contacts. In both the CBT2go and SM conditions, the study therapist contacted participants by phone 4 times (wk 1, 4, 7, and 10) to provide reminders of upcoming assessment appointments, encourage adherence to the surveys, and troubleshoot. CBT2go participants could also elect to change elements of the personalized responses at that time. At the end of 12 weeks, participants returned study devices and could elect to re-route surveys to their own devices if desired.

Measures

Assessment Schedule and Rater Training. Participants were assessed at baseline and 6-, 12-, and 24-week follow-up. Raters were trained to administer the BPRS via videotaped gold standard cases and attained at least 0.80 interrater reliability.

Demographics and Diagnosis. All participants were assessed at baseline for basic sociodemographic information, diagnosis and treatment history, and current participation in treatment, including medications.

MATRICS Consensus Cognitive Battery (MCCB). The MCCB used to assess global cognitive performance for sample characterization at the baseline visit.[25] We administered tests only in the domains of Verbal Learning, Reasoning/Problem Solving, Working Memory, and Processing Speed; domain scores were normed for age and education and then combined for a composite T-score.

Primary Outcome

Symptoms. The Brief Psychiatric Rating Scale–expanded version (BPRS-24) was used to measure psychopathologic symptoms[26] including anxiety, depression, mania, delusions/hallucinations, unusual behavior, and negative symptoms.

Secondary Outcomes

Functioning. The Specific Level of Functioning Scale (SLOF)[27] measures 4 domains: Interpersonal Functioning (eg, social participation); Everyday Activities (eg, instrumental activities of daily living); Work Skills (eg, ability to complete tasks), and Social Acceptability (eg, managing conflict). Consistent the Validation of Everyday Real-World Outcomes (VALERO) study,[28] a best-estimate approach was used, in which interviewers combined information from interview, participant self-report, and informants. Informants were professionals with high levels of contact (eg residential facility managers). We did not include the Personal Care or Physical Functioning subscales given that they are frequently at ceiling in community-dwelling outpatients.[29] We did not administer the SLOF at the 6-week assessment to minimize burden on informants.

Defeatist Performance Beliefs. The Defeatist Performance Attitude Scale (DPAS) is a 15-item self-report subscale using items from the Dysfunctional Attitude Scale.[30] The DPAS indexes endorsement of defeatist attitudes about one's ability to perform goal-directed tasks (eg, "People will probably think less of me if I make mistakes").

Adverse Events. The study was monitored by a Data and Safety Monitoring Board (DSMB) annually. The timing, duration, and aftermath of psychiatric and nonpsychiatric hospitalizations were collected.

Statistical Analyses. We evaluated the association between attrition and baseline characteristics. Generalized linear mixed models were performed with subject as a random effect and fixed effects for condition (CBT2go, SM, and TAU), time (0, 6, 12, and 24 wk), and for the primary outcome (BPRS) baseline score due to a significant difference between randomized and participants who completed the intervention. Time was entered as a continuous variable and an autoregressive (AR1) covariance structure was used. Planned contrasts were performed in contrasting the combined and independent comparisons of the active conditions to TAU (CBT2go, SM vs TAU) and between the two active conditions (CBT2go vs SM). Effect sizes comparing treatment arms were calculated at 6, 12, and 24 weeks as Cohen's d,[31] dividing differences between estimated means by the pooled baseline raw standard deviation,[32] as well as estimated change from baseline to 24 week follow-up in the same manner. We calculated number needed to treat (NNT) by comparing 25% response rates on the primary outcome at 24 weeks. Finally, we explored moderation by diagnosis status (bipolar disorder vs schizophrenia/schizoaffective disorder) on our primary outcome. We evaluated the global association between survey completion and follow-up phone call completion by Pearson correlation between these adherence indicators and estimated 24-week BPRS Total change scores. The α level was set to .05.

Results

Sample Ascertainment and Characteristics. The Consolidated Standards of Reporting Trials (CONSORT) figure displays flow through the trial (figure 1). The recruitment target was met and retention in the trial was reasonable, with an overall retention rate at 24 weeks of

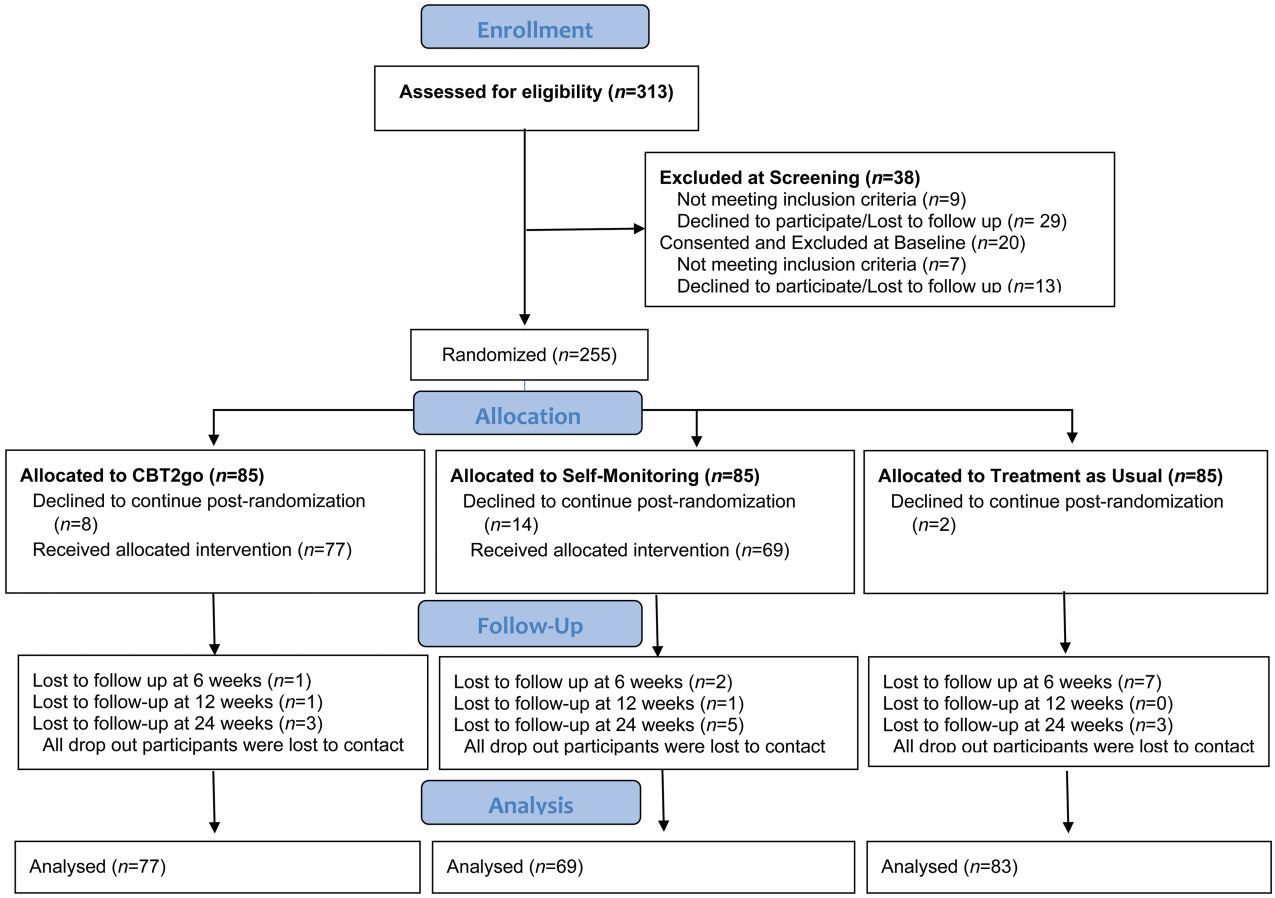

Figure 1. Consort diagram.

84.7%. The 24-week retention rate was lower in the SM condition (77%) compared to CBT2go (91%) and TAU (88%), $\chi^2(2) = 6.5$, $P = .037$). Participants who dropped out had higher BPRS scores at baseline than those who completed all 4 assessments (dropout = 46.3 (12.2) vs 42.0 (10.4), $F(1,250) = 5.5$, $P = .020$), but were not different on any other sample characteristic. Sensitivity analyses indicated that the association between baseline BPRS score and dropout was only significant in the SM condition ($F(1,82) = 7.3$, $P = .009$). On average (table 1), the sample was middle-aged, exhibiting cognitive ability 1 standard deviation below average and experiencing a mild level of severity of psychopathology.[33]

In-Person Session and Follow-Up Contact Fidelity and Adherence. Fidelity rating scales indicated a high level of fidelity to both the SM and CBT2go, and scores were not different between conditions (CBT2go: 16.0, $SD = 0.0$, SM: 15.9, $SD = 0.22$; $t(144) = 0.9$, $P = .346$). Similarly, participant comprehension did not differ between conditions (CBT2go: 15.0, $SD = 0.3$, SM: 14.9, $SD = 0.3$, $t(144) = 0.2$, $P = .822$). Masked raters were able to differentiate 100% of tapes into the correct condition and audio review fidelity ratings were high and consistent with therapist ratings ($M = 15.7$ of 16, $SD = 1.0$). Therapist ratings of proportion of manualized content covered within the session averaged 94.5% ($SD = 15.9$) for the SM condition and 93.6% ($SD = 16.8$) in the CBT2go condition, which was not significantly different (Mann–Whitney U-test $z = 0.2$, $P = .813$). Of the 4 scheduled follow-up phone calls, the average proportion completed was 56% ($SD = 0.32$). The average duration was 8.7 minutes in the CBT2go condition ($SD = 7.0$) and 8.0 minutes in SM ($SD = 5.8$); the rate of call completion or duration did not differ between conditions ($P = .912$ and .612 for CBT2go and TAU, respectively).

In terms of adherence to the mobile device interactions, mean adherence (% of surveys responded during the monitoring period) aggregated across modules was similar between the CBT2go and SM conditions (CBT2go: $M = 68.7\%$, $SD = 27.4$; SM: $M = 66.2\%$, $SD = 29.9$, $t(358) = 3.0$, $P = .413$). Within the individual modules, rates of adherence were higher for the evening survey on medication adherence in the CBT2go condition ($t(117) = 2.2$, $P = .025$), but there were no other differences. Neither the rate of survey completion ($r = .073$, $P = .616$) nor phone call completion ($r = -.079$, $P = .560$) were associated with estimated change in BPRS Total scores. Similarly, rates of survey completion ($r = .089$, $P = .527$) and follow-up phone calls ($r = -.061$, $P = .685$)

Table 1. Baseline Characteristics (n = 229)

	CBT2go (n = 77)	SM (n = 69)	TAU (n = 83)
	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %
Age	51.2 (11.5)	49.4 (11.1)	48.1 (11.7)
Sex (% female)	45.8	53.3	49.2
Ethnicity			
White/non-Hispanic	46.5%	41.0%	43.2%
African American	16.3%	24.1%	17.3%
Asian	5.8%	9.6%	6.2%
Latino/Hispanic	27.9%	24.1%	33.3%
More than one ethnicity	4%	0%	0%
Education (y)	12.9 (2.1)	12.2 (2.3)	12.1 (2.2)
Marital status (% married)	9.8	14.6	4.9
Living situation			
Independent living, in community	47.7%	59.2%	49.8%
Residential facility	50.0%	39.8%	46.3%
Homeless	2.3%	1.0%	4.9%
Diagnosis			
Schizophrenia/Schizoaffective	71.4%	78.3%	75.9%
Bipolar disorder	28.6%	21.7%	24.1%
Age of first onset	23.2 (9.1)	23.2 (9.1)	21.3 (8.1)
MATRICS total (T-score)	38.6 (8.8)	38.1 (10.3)	38.3 (9.2)
Medications prescribed			
Antipsychotic	84.4%	87.0%	82.1%
Mood stabilizer	26.0%	17.4%	19.3%
Antidepressant	58.3%	46.4%	61.4%

Note: SM, Self-Monitoring; TAU, Treatment-as-usual.

were not significantly associated with BPRS change in the SM condition.

Primary Outcome. Planned comparisons for BPRS Total were the following: (1) two active conditions and TAU (CBT2go/SM vs TAU), (2) the two active conditions (CBT2go vs SM), and (3) each active conditions and TAU (table 2). There was a significant time × visit interaction in comparing the two active conditions to TAU. There were no significant time × group interactions when contrasting the CBT2go vs SM conditions, or each of the individual conditions to TAU. Treatment effects were small (d = 0.23 at 2 wk for CBT2go and d = 0.22 for SM). The average estimated improvement was significant in the CBT2go condition (estimated BPRS improvement =3.53 points, SE = 1.02, t = 3.4, P < .001, pre-post change Cohen's d = 0.36) and in the SM condition (estimated BPRS improvement = 3.10 points, SE = 1.01, t = 2.8, P = .005, d = 0.26). Finally, in regard to treatment response (25% improvement in BPRS Total scores), compared to TAU (9.6%), response rates were 21.1% in the CBT2go condition (NNT = 8.7) and 15.6% in the SM condition (NNT = 15.6).

Secondary Outcomes. There was a significant group × time effect for community functioning (SLOF) favoring CBT2go vs TAU (table 3). Treatment effects were small–medium at 24 weeks for CBT2go (d = 0.36). Scores in TAU condition were in the direction of worsening over time, whereas the active conditions were greater by week 24. The estimated average change was not significant in the CBT2go condition (estimated SLOF improvement = 2.1 points, SE = 1.8, t = 1.1 P = .254, pre-post d = 0.14), SM condition (estimated SLOF improvement = 0.3 points, SE = 1.9, t = 0.2, P = .864, pre-post d < 0.01), or TAU condition (estimated SLOF worsening = −3.0 points, SE = 1.7, t = 1.7, P = .087, pre-post d = 0.19).

There were no time × group interactions for DPBs (table 4). However, estimated change indicated significant improvement in the CBT2go condition (estimated DPB improvement = 4.73 points, SE = 1.7, t = 2.8, P = .005, d = 0.25) but not in the SM condition (estimated DPB improvement = 1.82, SE = 1.8, t = 1.0, P = .311, pre-post d = 0.10).

Adverse Events. There were 31 adverse events, experienced by 21 different participants in the study (12 in SM, 10 in CBT2go, and 9 in TAU). These events were all hospitalizations (12 medical and 19 psychiatric). Two participants were dropped from the study as a result of being placed in long-term care facilities due to medical conditions; the remainder returned to their residence and resumed participation. These events were reported to the DSMB and were determined unlikely to be related to the study interventions and consistent population risk.

Exploratory Outcome Analysis by Diagnosis. In an exploratory analysis, we evaluated whether diagnosis (schizophrenia/schizoaffective disorder vs bipolar

Table 2. Brief Psychiatric Rating Scale Total Score Across the Study Period by Condition

	CBT2go		SM		TAU		Active Conditions vs TAU	CBT2go vs SM	CBT2go vs TAU	SM vs TAU
BPRS Total	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value
Baseline	43.2 (9.7)	76	41.6 (11.5)	69	42.0 (10.9)	83	N/A	N/A	N/A	N/A
6 Wk	41.0 (11.1)	75	39.5 (7.7)	67	41.0 (11.3)	76	0.10, *P* = 03.51	0.02, *P* = .803	0.08, *P* = .385	0.10, *P* = .357
12 Wk	39.7 (11.5)	74	38.6 (9.1)	66	41.0 (11.4)	76	0.18, *P* = .111	<0.01, *P* = .685	0.11, *P* = .113	0.13, *P* = .259
24 Wk	39.7 (11.9)	71	37.6 (10.1)	61	41.1 (11.4)	73	0.22, *P* = .028	<0.01, *P* = .972	0.23, *P* = .053	0.21, *P* = .068
					Significance tests for difference in slopes		*Time* × *Grp: F* (1,862) = 3.9, *P* = .048	*Time* × *Grp*: *F*(1,405) = 1.3, *P* = .262	*Time* × *Grp*: *F*(1,599) = 3.9, *P* = .071	*Time* × *Grp:* *F*(1,566) = 3.9, *P* = .129

Table 3. Specific Level of Function (SLOF) Scores Across the Study Period by Condition

	CBT2go		SM		TAU		Active Conditions vs TAU	CBT2go vs SM	CBT2go vs TAU	SM vs TAU
SLOF Total	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value
Baseline	126.9 (15.2)	73	128.4 (15.5)	69	126.9 (16.1)	79	N/A	N/A	N/A	N/A
12 Wk	129.1 (15.8)	74	127.8 (16.1)	66	123.4 (15.8)	75	0.18, *P* = .106	0.12, *P* = .353	0.30, *P* = .063	0.24, *P* = .383
24 Wk	130.0 (16.9)	71	128.7 (16.3)	61	123.3 (18.0)	72	0.27*P* = .015	0.11, *P* = .402	0.36, *P* = .011	0.33, *P* = .107
					Significance tests for difference in slopes		*Time* × *Grp: F* (1,630) = 3.3, *P* = .068	*Time* × *Grp: F* (1,554) = 0.1, *P* = .705	*Time* × *Grp*: *F* (1,437) = 4.0 *P* = .046	*Time* × *Grp:* *F*(1,414) = 1.0, *P* = .325

Table 4. Dysfunctional Performance Belief Scores Across the Study Period by Condition

	CBT2go		SM		TAU		Active Conditions vs TAU	CBT2go vs SM	CBT2go vs TAU	SM vs TAU
DPB Total	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value	Adj. Effect Size (*d*), *P* value
Baseline	49.9 (18.8)	76	49.9 (18.2)	69	49.3 (17.8)	83	N/A	N/A	N/A	N/A
6 Wk	47.8 (19.0)	75	49.9 (18.0)	68	49.6 (15.4)	75	0.02, *P* = .894	0.10, *P* = .554	0.06, *P* = .684	−0.03, *P* = .357
12 Wk	47.0 (18.3)	75	46.0 (17.4)	66	51.3 (18.9)	76	0.10, = .122	−0.05, *P* = 0.735	0.19, *P* = .239	0.25, *P* = .259
24 Wk	45.2 (19.0)	721	48.0 (19.0)	62	48.6 (16.4)	74	0.08, *P* = .596	0.16, *P* = .336	0.15, *P* = .354	−0.01, *P* = .680
					Significance tests for difference in slopes		*Time* × *Grp*: *F* (1,647) = 1.4, *P* = .213	*Time* × *Grp*: *F* (1,417) = 0.9, *P* = .346	*Time* × *Grp*: *F* (1,447) = 2.1, *P* = .140	*Time* × *Grp*: *F* (1,423) = 0.3, *P* = .613

disorder) moderated primary outcome. This analysis should be interpreted with caution due to the imbalance in sample sizes between diagnostic groups. The bipolar disorder and schizophrenia subgroups did not differ on age ($t(227) = 1.8$, $P = .067$), gender ($\chi^2(1) = 1.5$, $P = .206$), or ethnicity ($\chi^2(5) = 9.5$, $P = .108$). Patients with bipolar disorder had significantly lower (less severe) scores on the BPRS Total compared to patients with schizophrenia (39.3 [*SD* = 6.8] vs 43.2 [*SD* = 11.2], t(1) = 2.4, $P = .017$], and baseline BPRS Total was incorporated into the model. We found a 3-way interaction between group × time × and diagnosis (F(6,226) = 2.7, $P = .011$). Inspection of the effect sizes compared to TAU indicated that 12-week visit effects were large for CBT2go in the bipolar group ($d = 1.24$; SM vs TAU: $d = 0.20$), and negligible for the schizophrenia (CBT2go vs TAU: $d = 0.01$; SM vs TAU: $d = 0.11$). However, at 24 weeks, these effects were small–moderate for CBT2go in the schizophrenia/schizoaffective group ($d = 0.33$; SM condition vs TAU: $d = 0.26$), whereas they were minimal in the bipolar group (CBT2go vs TAU: $d = -0.21$; SM vs TAU: $d = 0.07$).

Conclusions

This was among the largest RCTs of mobile health in SMI to date, and it was unique in that two different single-session mobile-augmented interventions were compared. Participants who received interventions experienced greater improvement in global psychopathology than TAU. On balance, the magnitude of this impact was small. in addition, community functioning improved more in the CBT2go vs TAU condition, and the effect size was small–medium. DPBs also significantly improved in the CBT2go condition but not in the SM or TAU conditions. Each intervention was generally well tolerated, although pretreatment dropout was higher in the SM condition, and participants with more severe BPRS scores at baseline were more likely to drop out of that condition. It is unclear why the SM intervention was associated with greater dropout, but because this occurred prior to intervention, it is possible that SM may be less appealing to patients experiencing more severe symptoms. Finally, the pattern of results indicated sustainment of improvement at 24-week follow-up. Overall, single-session interventions augmented by mobile health intervention resulted in modest yet sustained positive impact on global psychopathology, with more selective positive impact on attitudes and community functioning when incorporating elements of CBT.

Study strengths included the relatively large sample size, 3-group design, and systematic collection of fidelity and adverse event data noted to be lacking in some prior RCTs of mobile interventions. However, there were several limitations. The sample was primarily middle-aged with an average duration of illness of approximately 20 years, and so these results may not generalize to first

onset populations. The sample was treated and had on average a mild level of symptoms and so the results may not generalize to untreated or more acutely ill populations. The low level of symptoms also restricted range of possible improvement. Adaptations may be needed to reach more severely ill populations. Our study design did not enable us to disentangle which of the in-person session or mobile health augmentation was associated with observed improvements, and we cannot rule out that primary driver of impact was the in-person session and/or follow-up calls. We did evaluate whether the rate of participation in survey completion or follow-up calls was associated with global change in our primary outcome, which may have provided some indication which aspects of the intervention were associated with the changes observed. However, we did not find global associations in either the CBT2go or SM conditions, and so the "active ingredients" of the interventions described here are still unclear. Nonetheless, it may be that a deeper investigation of trajectories or patterns of adherence to the components of the interventions could shed light on how participant engagement throughout the trial impacted outcomes. Furthermore, both of our interventions involved active clinician delivery and follow-up telephone calls, which is a model that is less scalable than completely automated interventions. Moreover, the same therapist delivered study intervention in both conditions, and whereas masked ratings of fidelity were nearly identical across conditions, we fully cannot rule out potential bias; moreover, the use of a single therapist may limit generalizability as therapist training and competence was standardized across patients. The rate of follow-up call completion (56%) was lower than expected, which was due to difficulty scheduling remote calls with participants.

There was mixed evidence for the incremental benefit of CBT content over and above self-monitoring, psychoeducation, and novelty of using a mobile device.[34] None of the head-to-head comparisons between CBT2go and SM were significant, yet CBT2go was superior to TAU on community functioning, whereas SM was not. Our trial results were consistent with a recent proof-of-concept study indicating relative benefit of CBT vs self-monitoring.[14] That trial was somewhat different in that app use was incentivized and the population focus on early psychosis; therefore, in addition to the distinction between CBT and self-monitoring content, future research should examine the extent to which sampling and implementation strategies such as incentivization impact outcome.

Much more needs to be learned about the active ingredients of smartphone-delivered interventions. The limited understanding about which specific mechanisms of mobile interventions produce impact is evident as well in other disorders such as depression[8] and is derivative of the long-standing debate regarding the active ingredients of evidence-based psychotherapies in general. Active ingredients may vary within an illness application depending on which outcome is being targeted and the sustainability of these effects beyond supervised participation in the mobile intervention. For example, our study suggests that the incorporation of CBT elements may be more necessary, relative to self-monitoring alone, for addressing community function than for symptom management. Therefore, future work should evaluate active ingredients across a range of outcomes and durability of changes after cessation of active periods of coaching. CBT2go was associated with significant within-group improvement on the defeatist attitudes, consistent with the general model for CBT in psychosis, whereas SM was not. Given that DPBs have been linked to asociality, amotivation, and poor functioning in schizophrenia,[15] it is possible that the greater impact of CBT2go on functioning was due to the impact of CBT elements on defeatist beliefs. Because frequent data can be collected on hypothesized treatment mechanisms and outcomes, mobile interventions could be particularly useful in delineating which intervention mechanisms impact outcomes by evaluating mediation at the day-to-day level. Future design improvements could strengthen the impact of CBT-based mobile interventions, which could include user-driven and on-demand interaction, adaptive and scaffolded interaction based on an individual's prior responses over time, and device-triggered (rather than scheduled and frequently missed in this study) interactions with providers. In a traditional RCT, isolating the impact of these features is implausible given the large number of potential features. Emerging adaptive research designs[35] could be used to evaluate the impact of these design elements, perhaps on their immediate impact on mechanisms like defeatist beliefs.

Finally, there was preliminary evidence of differences between diagnoses (schizophrenia vs bipolar disorder) in the pattern of treatment response; this variation by diagnosis should be interpreted with caution due to unequal sample sizes and diagnostic variation at baseline in severity which was adjusted for statistically. In bipolar disorder, CBT2go effects were large at the conclusion of the active phase of treatment but dissipated at follow-up, consistent with our prior study[8]; however, participants with schizophrenia experienced improvements relative to TAU at follow-up that were undetectable at the end of active monitoring. Pending replication, interventions may need to be further tailored in content or perhaps duration of contact to different diagnoses.

In terms of clinical implications, an important consideration is where CBT2go and similar other mobile-augmented interventions might fit in the care continuum. The magnitude of effects we observed was attenuated compared to brief (~10 session)[1] or intensive[36] (20+ session) interventions, yet this is weighed against the total clinician time of 2 hours per participant. Moreover, the NNT for reduction in overall symptomology was 8.7 for CBT2go, which compares favorably to outcomes of brief 6-session CBT delivered by nurses.[37] Rather than

a replacement for standard evidence-based therapies for serious mental illness, the potential clinical application of CBT2go (and other single-session interventions) may likely be in settings in which there is little or no access to evidence-based psychotherapies for SMI, given that the intervention maybe easier to scale than more prolonged treatments that have to date been poorly disseminated. In addition, within settings that do offer more intensive interventions, CBT2go may be a potential solution to enhance operational efficiency, such as a first stage in stepped care, or as a treatment alternative among patients with low levels of symptoms to conserve access to higher intensity care for more severely ill people. Further enhancements, such as by delivering in-person sessions through videoconferencing or online, may further enhance scalability such as to patients with limited geographic access.

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Conflict of Interests

The authors have declared that there are no conflicts of interest in relation to the subject of this study.

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