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THEME ARTICLE (INVITED)

Enhancing Assertive Community Treatment With Cognitive Behavioral Social Skills Training for Schizophrenia: II. Ecological Momentary Assessment Outcomes in a Pragmatic Randomized-Controlled Trial

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Background and Hypothesis: **Individuals with schizophrenia experience severe impairments in everyday functioning. Cognitive behavioral social skills training (CBSST) has demonstrated moderate effects on functional outcomes in controlled trials. This study examined whether CBSST, when integrated into assertive community treatment (ACT), improves daily-life functioning as assessed by ecological momentary assessment (EMA).**

Study Design: **This was a secondary analysis of a pragmatic randomized controlled trial involving 155 participants diagnosed with schizophrenia or schizoaffective disorder. Participants were randomized to receive either ACT + CBSST ($n = 75$) or ACT alone ($n = 80$). Assessments occurred at baseline, 9 months ($n = 100$), and 18 months ($n = 67$) to capture real-time reports of "productive" and "non-productive" activities. The primary outcome was productive activity. Secondary outcomes included non-productive activity, the productive/non-productive activity ratio, anhedonia, and defeatist beliefs. Linear mixed models were used to test for differential changes over time between groups.**

Study Results: **Although the groups differed at baseline, the ACT + CBSST group showed significantly greater improvements over time relative to the ACT group in productive activities, the productive/non-productive activity ratio, and in reductions in anhedonia and defeatist beliefs. However, between-group differences at follow-up were not statistically significant.**

Conclusions: **Adding CBSST to ACT may yield greater improvements in daily-life functioning than ACT alone. While these results support the potential added value of integrating CBSST into routine care, further research is needed to confirm its superiority. Together with the companion report from this study, these findings suggest that EMA may offer a sensitive approach for detecting changes in real-world functioning in clinical trials.**

Trial Registration: ClinicalTrials.gov (NCT02254733; https://clinicaltrials.gov/)

Key words: schizophrenia; EMA; ESM; functioning; social skills; cognitive behavior therapy; assertive community treatment.

Introduction

Schizophrenia-spectrum disorders (SSD) are associated with profound functional impairment, including declining cognitive functions,[1] lower educational attainment, and high rates of unemployment.[2] In the social domain, many patients also face the loss of social relationships[3] and insecure housing.[4] These functional impairments are strongly related to defeatist beliefs[5-10] and motivational negative symptoms,[11-14] such as anhedonia.[15] Evidence-based psychosocial treatments that can alleviate defeatist beliefs, negative symptoms and improve functioning have been developed, tested,[16] and recommended in practice guidelines.[17-19] Nevertheless, these treatments are not available to most people with SSD.[20,21] This gap between research and service delivery must be closed by adapting evidence-based interventions for SSD to facilitate widespread implementation in routine care.

One promising approach that has the potential to bridge this gap is Cognitive Behavioral Social Skills

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Training (CBSST). Cognitive Behavioral Social Skills Training is a targeted psychological intervention that combines cognitive behavioral techniques with social skills training to address low functioning, motivational problems, and defeatist attitudes in people diagnosed with SSD.[22] Prior research has demonstrated that, compared to treatment as usual or goal-focused supportive contact, CBSST is effective in improving functioning and the amotivation and anhedonia domain of negative symptoms in SSD at post-treatment and at 1-year follow-up.[23-27] Studies investigating mechanisms of change in CBSST have found that significant reductions in defeatist performance beliefs predicted improvement in negative symptoms and functioning.[23,24,28] Although this suggests that CBSST is effective in improving psychosocial functioning as well as in alleviating negative symptoms and defeatist beliefs, it is limited by the fact that in prior research CBSST has been delivered by highly trained professionals in specialized research clinics. Consequently, the impact of CBSST when delivered by typical frontline clinicians to more representative clinical populations in routine care settings is yet to be determined. The companion article of the current study in this issue[29] reports on a randomized-controlled pragmatic trial testing the effectiveness of CBSST delivered on assertive community treatment (ACT) teams for psychosocial functioning and negative symptoms. Using well-established and validated interviewer-rated scales for their outcome assessments, this trial did not find a significant effect of CBSST delivered on ACT teams on these outcomes compared to ACT alone.

Despite the fact that the interview-based in-lab assessments of daily-life functioning in previous studies, eg, the study by Granholm et al. (2014),[24] are time- and cost-efficient measures with adequate psychometric properties,[30-32] it is not clear whether they provide the most accurate measure of daily-life functioning, particularly to capture small and slowly progressing changes (ie, over 18 months). These scales require participants to retrospectively report experiences and behaviors over the past days, weeks or even months, which might not adequately capture intrapersonal fluctuations in daily-life functioning and may be prone to bias, for example, due to memory impairment.[11] Some of these caveats can be bypassed with ecological momentary assessment (EMA),[33,34] which has been extensively used over the last 2 decades to capture momentary subjective experiences of functioning,[15,35] amotivation/anhedonia,[36-40] and defeatist beliefs.[41] The most notable benefits of using EMA as an adjunct measure to the conventional interviewer-rated scales are its high temporal resolution and high ecological validity.[42,43] Indeed, a recent study confirmed low convergence between in-lab and EMA measures of functioning, suggesting that in-lab measures might offer solid global impressions of functioning, whereas EMA is likely to provide a more nuanced reflection of everyday functioning.[44] Thus, it is highly appropriate to complement the current gold standard of outcome measurement (ie, interviewer-rated scales) in clinical trials with EMA. Given EMA's superior ecological validity and its high temporal resolution, it offers valuable insights and a deeper understanding of the effectiveness of CBSST, particularly in the context of the trial by Granholm et al.[29]

In this study, we examined the EMA outcomes of a pragmatic trial,[45] the primary results of which are reported in the companion article (see Granholm et al. in this issue). We tested whether CBSST delivered on ACT teams was more effective in improving daily-life functioning, anhedonia, and defeatist performance beliefs than ACT alone using EMA of outcomes. It was hypothesized that participants in ACT + CBSST would show significantly greater improvements on EMA-measured functioning (primary outcome), and anhedonia and defeatist beliefs (secondary outcomes).

Methods

Design

This report provides a secondary analysis of EMA outcomes of a larger project investigating the effectiveness and implementation of CBSST (see Granholm et al. in this issue for the main report[29]). The study design was a parallel-group randomized-controlled pragmatic trial conducted in 7 ACT teams, recruiting patients from the community mental health system in San Diego County, California between December 2011 and January 2015. After providing informed consent and completing baseline assessments, eligible participants were randomly allocated (1:1) to receive either ACT + CBSST or ACT alone. The allocation sequence was generated by an independent statistician and stratified by ACT team and gender within ACT teams. Participants in both conditions received regular ACT services including psychopharmacological treatment. Ecological momentary assessment follow-up assessments were obtained at 9 months and 18 months, aligning with the study visit assessments of the main study. Because the EMA assessments were implemented after study inception, 23 randomized participants did not take part in the EMA of this report. The study protocol was prospectively registered (ClinicalTrials.gov NCT02254733), published,[45] and received approval from the Human Subjects Committees of the University of California, San Diego and the San Diego County Behavioral Health Services system.

Participants

Participants were eligible if they (1) provided voluntary informed consent, (2) were at least 18 years of age, (3) met diagnostic criteria for an SSD according to the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text revision DSM-IV-TR, American Psychiatric

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Association,[46] established with the Structured Clinical Interview for DSM-IV (SCID-IV)[47], and confirmed by a secondary consensus evaluation with an experienced diagnostician, (4) assigned to the specific ACT teams involved in the study for at least 3 months to ensure that they had an established relationship with the specific ACT team, (5) had not received SST or CBT in the past 3 years, and (6) were housed in the community for at least the past month. No exclusion criteria were applied.

Interventions

Assertive Community Treatment (ACT). Assertive community treatment is an evidence-based practice for serious mental illness that is widely implemented in community mental health programs across America. It is a comprehensive, team-delivered program with low, shared caseloads and community-based service delivery, generally reserved for individuals who are high utilizers of acute psychiatric care or who experience significant housing instability. The primary goals of ACT include reducing hospitalizations, maintaining housing, and improving daily functioning. Assertive community treatment was the standard treatment for participants in this study, meaning all individuals receiving care within the public mental health system who met eligibility criteria could be assigned to these ACT teams. The duration of ACT services is not fixed; rather, it varies based on each participant's specific needs and goals, with services typically continuing as long as clinically necessary. In the San Diego County Mental Health System, ACT teams typically consist of a mix of bachelor's-level staff, master's-level clinicians (approximately 40%, including substance use specialists), a nurse specialist, and a psychiatrist. This multidisciplinary team structure ensures comprehensive care, with CBSST integrated into standard ACT services by the same providers delivering routine clinical care. Assertive community treatment staff provided a broad range of services, including case management, 24/7 crisis intervention, and medication management. Treatment, including CBSST-enhanced ACT, was attempted on a weekly basis and provided in the community, typically outside of a clinic office.

Cognitive Behavioral Social Skills Training (CBSST). Cognitive Behavioral Social Skills Training is comprised of 3 six-session modules (ie, 18 sessions in total), targeted to improve (1) cognitive skills, by challenging defeatist beliefs, (2) social skills by training open and assertive social interactions, and (3) problem-solving skills, by training how to develop specific and feasible plans to solve real-world problems, including scheduling pleasant activities, improving living situations, handling finances, using public transportation, finding a volunteer or paid job, and enrolling in classes. Detailed descriptions of CBSST modules can be found elsewhere.[22,24,45]

Cognitive Behavioral Social Skills Training was delivered by the same providers in the context of standard ACT visits by staff, with sessions lasting approximately 30 min. Cognitive Behavioral Social Skills Training replaced supportive case management contact time rather than requiring additional clinical input. On average, visits in the ACT + CBSST group lasted 9 min longer than those in the ACT-only group, indicating a modest increase in session length (see Granholm et al. in this issue for further information). The study goal was to deliver at least 36 CBSST sessions within 18 months (ie, delivering each module twice). Cognitive Behavioral Social Skills Training was provided in community settings chosen by staff and patients to facilitate access to services, including residential settings, clubhouses, coffee shops, and parks. To ensure fidelity, ACT staff received an intensive 1-day workshop conducted by E.G., K.M., and J.H., providing structured training in CBSST delivery. Additional training and support were provided throughout the trial, including weekly face-to-face supervision, written feedback on fidelity ratings for individual therapists, and review of session audio recordings in supervision.

Measures

For the purpose of sample description at baseline, the following in-lab measures were used: Brief Psychiatric Rating Scale (BPRS)[48]; Scale for the Assessment of Negative Symptoms (SANS)[49]; the Independent Living Skills Survey (ILSS)[30]; and the Defeatist Performance Attitude Scale.[50] See Granholm et al. (2015)[45] for more details.

Ecological Momentary Assessment

At each assessment visit, participants were provided with a Samsung smartphone with an Android OS to deliver EMA surveys. The device was programmed using Samplex software to prompt participants with 10 surveys per day for 7 days. The signals occurred at stratified semi-random intervals with, on average, 1.5-h windows between 9:00 AM and 9:00 PM each day. Alarms could be silenced for 30-min intervals. All responses were time-stamped and were only allowed within a 15-min period following the signal. Based on functional behaviors assessed in the ILSS, EMA surveys presented a series of screens listing 36 check-box behaviors. Participants indicated whether they were currently engaged in certain behaviors and activities in- or outside of their homes. Activities related to different categories such as leisure activities, transportation, and social activities. Based on a previous study using an almost identical survey,[35] activities were categorized into productive (eg, shopping for groceries, showering, working, meeting with friends/family) or non-productive activities (eg, watching TV, resting), according to their level of goal directedness. The sum scores of productive (possible

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range: 0-32) and non-productive activities (possible range: 0-4) per survey and participant were used in subsequent analyses. To compute the ratio of productive to non-productive activities, sum scores of productive and non-productive activities were min-max-normalized and then divided by each other with positive ratios indicating a higher proportion of productive activities. Ecological momentary assessment questions also asked about current experiences of anhedonia (eg, "How much are you enjoying these activities") and defeatist beliefs (eg, "How well are you performing these activities?") with scales ranging from 1 "Not at all/Very poorly" to 7 "Very much/well." Anhedonia/defeatist beliefs mean scores of items referring to productive activities were inversed and used for analyses with higher scores indicating more pronounced anhedonia/defeatist beliefs (see Supplementary Material S1 for EMA protocol). Change in number of productive activities between baseline and 18-month follow-up was the primary endpoint. Secondary outcomes included change in number of non-productive activities, the ratio of productive to non-productive activities, and anhedonia and defeatist beliefs between baseline and 18-month follow-up.

Treatment Fidelity

Fidelity ratings were done using the Cognitive Therapy Scale for Psychosis (CTS-Psy).[51] Expert consultants collected audio recordings from providers on the ACT teams each week and rated fidelity of sessions from all 3 modules on an ongoing basis throughout the project. The consultants provided their ratings to the ACT teams on a weekly basis to facilitate learning and delivery of CBSST.

Statistical Analyses

This study has a hierarchical data structure in which EMA surveys at level 0 are nested in participants at level 1, nested in assessment visits at level 2, and nested in trial arms at level 3. Consistent with the disaggregation approach, EMA data were analyzed at the survey level rather than aggregated (eg, by day) to preserve within-person variability and avoid the "ecological fallacy" (ie, drawing conclusions about individuals based on aggregated data, which falsely assumes that average patterns apply uniformly to individuals across the EMA week).[52,53] Following a previous trial using EMA of outcomes,[54] data were not collapsed at the participant level which allows testing cross-level interactions (ie, group × time interaction).[53] This high-resolution approach enhances ecological validity and sensitivity to change, allowing us to capture meaningful fluctuations in functioning that would be eliminated in aggregated measures. In accordance with the intent-to-treat principle and the latest recommendations for analyzing EMA data,[55] all participants who responded to at least 1 EMA survey at one of the study visits were included, allowing participants with incomplete data contribute to estimation of within-between variance.[56] Mixed linear models were calculated using the "lme4"[57] and the "lmerTest"[58] packages and visualized using "sjPlot"[59] and "ggplot2"[60] implemented in RStudio (version 2023.06.0 + 421). Group (CBSST + ACT vs ACT), time (baseline vs 9-month visit vs. 18-month visit), and the group x time interaction were modeled as fixed effects. Time was entered as an "unstructured" effect to account for non-linear trends in the data due to varying delivery frequency of CBSST (eg, some patients received many sessions at the beginning but no sessions at the end of the study, others received only a few scattered sessions throughout the 18 months) and expected non-linear effects of CBSST on functioning (ie, steeper slopes with progressing number of sessions).[56] The models included a random intercept for participant, an unstructured covariance structure, and were fitted using restricted maximum likelihood estimation. The fixed effects coefficients are reported as effect size estimates with corresponding 2-sided 95% confidence intervals.

Linear mixed models inherently control for type I error rates by accounting for within-subject correlations and modeling hierarchical data structures appropriately.[61,62] Unlike single-level models analyzing aggregated data, which require multiple testing corrections due to treating repeated measures as independent, mixed models estimate effects while preserving the true variance structure, mitigating the risk of inflated false-positive rates. This statistical approach enhances the robustness of our findings without necessitating additional corrections for multiple comparisons.

Results

Sample Characteristics and Preliminary Analyses

Of the 178 participants randomized into the main trial, 23 participants did not participate in the EMA part of the study because the EMA component was not implemented at the onset of the trial, resulting in an intent-to-treat sample of $n = 155$ ($n_{ACT} = 80$, $n_{ACT+CBSST} = 75$). At baseline, 122 participants participated in the EMA, and at 9 and 18 months, there were 100 and 67 participants, respectively (Figure 1). Mean response rates for the EMA surveys were comparable across groups and study visits (Table 1). There were no significant associations between mean response rates and functioning on the ILSS ($b = 16.03$, $SE = 16.75$, $P = .34$), total BPRS score ($b = 0.43$, $SE = 0.28$, $P = .13$), positive symptoms on the BPRS ($b = 0.54$, $SE = 0.42$, $P = .20$), and diminished motivation ($b = -0.19$, $SE = 0.20$, $P = .35$) or diminished expression on the SANS ($b = -0.19$, $SE = 0.20$, $P = .35$). In the ACT + CBSST group, treatment exposure (ie, number of CBSST sessions delivered) was not significantly associated with mean

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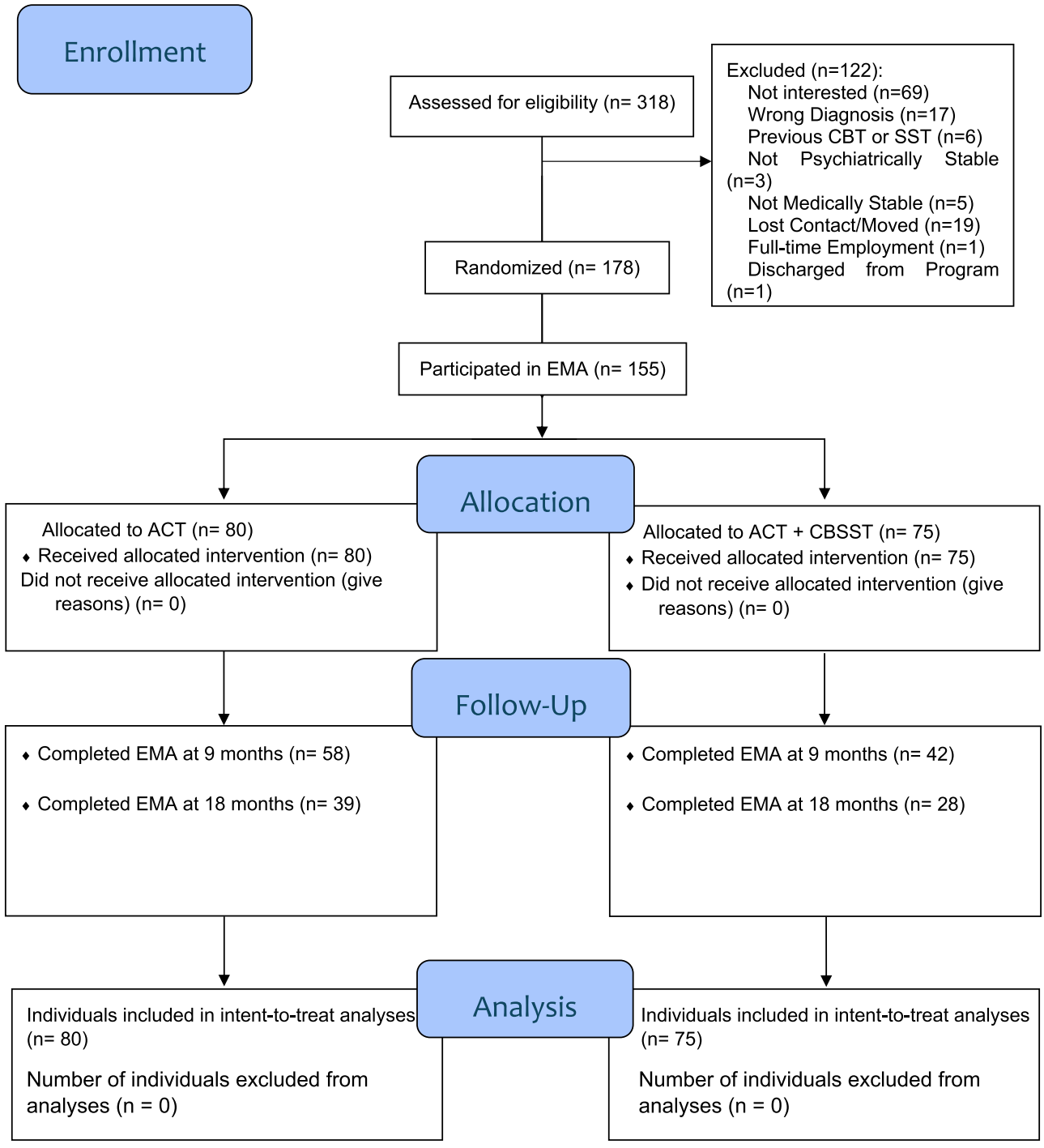


Figure 1. The CONSORT Flow Chart.

EMA response rates ($b = 0.60$, $SE = 0.32$, $P = .08$). These findings indicate that mean EMA response rates and completeness of data were neither confounded by functioning, symptomatology, nor treatment exposure, underscoring the validity of these EMA data. No differences in demographic or clinical characteristics were observed between the 2 groups at baseline. However, participants in the ACT + CBSST group at baseline reported a lower number of productive activities and a lower ratio of productive to non-productive activities in EMA. Across groups and study visits, we found significant associations between the number of productive activities reported in EMA and functioning on the ILSS ($b = 1.31$, $SE = 0.28$, $P < .001$), between experiences of anhedonia reported in EMA and negative symptoms on the SANS ($b = 0.004$, $SE = 0.001$, $P < .001$), and between defeatist

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Table 1. Baseline Demographic and Clinical Characteristics

	Group				
	ACT ($n = 80$)		ACT + CBSST ($n = 75$)		Test statistic
Demographic characteristics	n (%)		n (%)		
Gender f (%)	29 (36.3)		29 (38.7)		$Z = 0.31$, $P = .756$
Ethnicity	31 (38.8)		29 (38.7)		$Z = -0.05$, $P = .482$
White	24 (30)		19 (25.3)		
Black American	13 (16.3)		18 (24)		
Asian American	4 (5)		2 (2.7)		
Native American	3 (3.8)		5 (6.7)		
Native Hawaiian/Other Pacific Islander	4 (5)		1 (1.3)		
Bi/Multiracial	1 (1.3)		1 (1.3)		
Diagnoses					$Z = -1.04$, $P = .300$
Schizophrenia	74 (92.5)		62 (82.7)		
Schizoaffective disorder	6 (7.5)		13 (17.3)		
	M	***SD***	***M***	***SD***	
Age	44.82	9.39	45.12	11.82	$F(1,153) = 0.03$, $P = .859$
Education	12.31	2.10	12.00	1.76	$F(1,153) = 1.00$, $P = .318$
Medication (CPZe)	441.43	426.15	390.35	375.26	$F(1,153) = 0.62$, $P = .431$
In-lab baseline measures					
BRPS (total)	55.28	13.20	55.09	13.29	$F(1,153) = 0.01$, $P = .932$
Positive symptoms	9.51	3.96	10.43	3.71	$F(1,153) = 2.19$, $P = .141$
SANS (total)	9.86	3.86	9.83	3.43	$F(1,153) = 0.00$, $P = .952$
Diminished motivation	13.23	5.62	13.01	5.71	$F(1,153) = 0.05$, $P = .817$
Diminished expression	10.65	9.01	8.43	9.01	$F(1,153) = 0.25$, $P = .118$
ILSS	0.70	0.10	0.71	0.10	$F(1,151) = 0.47$, $P = .496$
Ecological momentary assessment					
Response rates (mean %)					
Baseline	48.6%	0.30	49.4%	0.31	
9-month follow-up	54.5%	0.29	53.9%	0.35	
18-month follow-up	52.3%	0.32	52.4%	0.33	
Daily-life functioning[a]					
Productive activities	1.38	0.12	0.99	0.13	$F(1,101) = 4.94$, $P = .029$
Non-productive activities	1.32	0.09	1.23	0.10	$F(1,116) = 0.48$, $P = .491$
Ratio productive/non-productive activities	10.41	1.07	6.93	1.14	$F(1,95) = 4.97$, $P = .028$
Secondary outcomes[a]					
Anhedonia	3.19	0.16	3.28	0.17	$F(1,115) = 0.16$, $P = .686$
Defeatist Performance Beliefs	3.02	0.15	3.07	0.16	$F(1,118) = 0.04$, $P = .842$

Abbreviations: BRPS = Brief Psychiatric Rating Scale, CPZe = daily antipsychotic dose in chlorpromazine equivalents, ILSS = Independent Living Skills Survey, SANS = Scale for the Assessment of Negative Symptoms, [a]Estimated marginal means and standard errors at baseline.

performance beliefs reported in EMA and the Defeatist Performance Beliefs Scale ($b = 0.001$, $SE = 0.002$, $P < .01$). This indicates validity of the EMA survey in capturing these constructs.

Treatment Exposure and Therapist Fidelity

Treatment exposure in the ACT + CBSST group ranged from 0 to 52 sessions. The median number of CBSST sessions delivered was 13 with $M = 14.24$ ($SD = 10.66$) sessions indicating relatively low overall treatment exposure (2.4% reached the target of 36 sessions). Therapists' fidelity ratings (mean across recorded sessions) on the CTS-Psy ranged from 29.77 to 44.32 with a median of 37.35, indicating satisfactory therapist fidelity with $n = 3$ scoring below and $n = 72$ (99%) scoring above the cutoff (>30).

Improvement in Daily-Life Functioning, Anhedonia, and Defeatist Beliefs

The group × time interaction was significant for productive activities ($F_{(2,9266.2)} = 3.07$, $P = .046$), the ratio of productive to non-productive activities ($F_{(2,7071.4)} = 4.31$, $P = .013$), anhedonia ($F_{(2,9106)} = 24.86$, $P < .001$), and defeatist beliefs ($F_{(2,9102)} = 36.31$, $P < .001$), indicating that the ACT + CBSST group improved more than the ACT group in these outcomes, but not in non-productive activities ($F_{(2,7039.3)} = 1.47$, $P = .229$) (Table 2). Figure 2 depicts the estimated marginal means of all primary and secondary outcomes across study visits by group. While variability in change across activity types was considerable, the largest descriptive improvements were observed in budgeting/paying bills, internet/computer, exercising, listening to music, and reading/writing/journaling. Please

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Table 2. Linear Mixed Models for Primary and Secondary Outcomes

	Number of productive activities	Number of non-productive activities	Ratio of productive to non-productive activities	Anhedonia	Defeatist performance beliefs
Predictors	**Estimate (95% CI)**	**Estimate (95% CI)**	**Estimate (95% CI)**	**Estimate (95% CI)**	**Estimate (95% CI)**
Intercept	1.29*** (1.07–1.51)	1.31*** (1.15–1.47)	9.34*** (7.62–11.06)	3.14*** (2.83–3.44)	2.92*** (2.63–3.22)
Group (CBSST)	−0.15 (−0.47–0.17)	0.00 (−0.23–0.24)	−1.91 (−4.41–0.59)	0.04 (−0.40–0.48)	0.18 (−0.25–0.60)
Visit (9 months)	0.08 (−0.00–0.17)	−0.10** (−0.17–−0.03)	0.25 (−0.49–1.00)	0.46*** (0.36–0.57)	0.44*** (0.34–0.54)
Visit (18 months)	0.03 (−0.07–0.12)	−0.08* (−0.16 to −0.00)	0.09 (−0.74–0.91)	0.35*** (0.23–0.47)	0.37*** (0.25–0.48)
CBSST × 9 months	0.02 (−0.12–0.14)	0.09 (−0.01–0.20)	0.39 (−0.74–1.53)	−0.08 (−0.24–0.07)	−0.21** (−0.36–−0.05)
CBSST × 18 months	0.17* (0.02–0.32)	0.07 (−0.05–0.19)	1.85** (0.55–3.15)	−0.42*** (−0.61–−0.24)	−0.55*** (−0.73–−0.37)
Random effects					
σ^2	1.34	0.66	76.05	1.31	1.19
τ_{00}	0.89_{id}	0.46_{id}	51.48_{id}	1.77_{id}	1.64_{id}
ICC	0.40	0.41	0.40	0.57	0.58
N	155_{id}	149_{id}	149_{id}	154_{id}	154_{id}
Observations	9,298	7,100	7,100	6,384	6,375
Marginal R^2/Conditional R^2	0.003/0.402	0.002/0.413	0.005/0.407	0.014/0.581	0.012/0.584

σ^2 = amount of variability of the random effects; τ_{00} = variance of the random intercept; $^*P < .05$ $^{**}P < .01$ $^{***}P < .001$.

see Supplementary Material S2 for a figure depicting changes in productive activities by type of activity and study visit in the ACT + CBSST group. Within-group contrasts revealed that productive activities increased significantly from baseline to 9 months ($b = 0.10$, $SE = 0.05$, $P < .05$) and from baseline to 18 months in the ACT + CBSST group ($b = 0.19$, $SE = 0.06$, $P < .001$), but not in the ACT only group (all P's > .05). Furthermore, the ratio of productive to non-productive activities increased significantly in favor of productive activities from baseline to 18 months in the ACT + CBSST group ($b = 1.91$, $SE = 0.52$, $P < .001$), but not in the ACT only group (all P's > .05). Non-productive activities did not change significantly in the ACT + CBSST group (all P's > .05) but significantly decreased in the ACT only group from baseline to 9 months ($b = -0.10$, $SE = 0.04$, $P < .01$) and 18 months ($b = -0.08$, $SE = 0.52$, $P < .001$). Anhedonia and defeatist beliefs increased significantly in both groups between baseline and 9 months (anhedonia: ACT + CBSST: $b = 0.38$, $SE = 0.07$, $P < .001$; ACT: $b = 0.46$, $SE = 0.09$, $P < .001$; defeatist beliefs: ACT + CBSST: $b = 0.23$, $SE = 0.06$, $P < .001$; ACT: $b = 0.37$, $SE = 0.06$, $P < .001$). Between baseline and 18 months, there was a significant increase in anhedonia in the ACT only group ($b = 0.35$, $SE = 0.09$, $P < .001$), but no change in ACT + CBSST ($b = -0.07$, $SE = 0.04$, $P > .05$). Defeatist beliefs decreased significantly between baseline and 18 months in the ACT + CBSST group ($b = -0.19$, $SE = 0.07$, $P < .01$), whereas ACT only showed a significant increase in defeatist beliefs between baseline and 18 months ($b = 0.37$, $SE = 0.06$, $P < .001$). See Supplementary Materials S3-S6 for full model parameters of within-group contrasts.

Between-group comparisons were non-significant for all outcomes at both follow-ups (Supplementary Materials S7 and S8). Estimated marginal means by group and study visit with their standard deviations and 95% confidence intervals can be found in Supplementary Material S9.

Sensitivity and Exploratory Analyses

Per-protocol analyses excluding participants from the ACT + CBSST group ($n = 37$) who received less than the recommended minimal dose of 12 sessions of CBSST[22] or with therapist fidelity ratings below the cutoff yielded a similar pattern of findings. When compared to intent-to-treat analyses, the model estimates predicting productive activities and the ratio between productive to non-productive activities at 18 months increased by one-third in magnitude with similar confidence intervals. Significant within-group effects on productive activities and the ratio of productive to non-productive activities were found in the ACT + CBSST group, but no significant between-group effects were found at any study visit (Supplementary Materials S10-S13).

While randomization was successful for the primary outcome (ILSS functioning) in the main study, baseline differences emerged in the EMA outcome of productive activities, with higher scores in the ACT-only group. To assess whether this imbalance may have led to a ceiling effect driving the observed group × time interactions, we first conducted a sensitivity analysis excluding participants from both groups who fell into the upper quartile of baseline productive activities ($n = 27$). In this reduced sample, groups no longer differed significantly at baseline on any outcome (all P's > .09). The group × time interaction remained significant for productive activities at 9 months ($b = 0.25$, $SE = 0.08$, $P < .01$) and 18 months ($b = 0.43$, SE = 0.09, $P < .001$), as well as for the ratio of productive to non-productive activities at 18 months ($b = 3.81$, $SE = 0.75$, $P < .001$). Effect estimates in this model were approximately double

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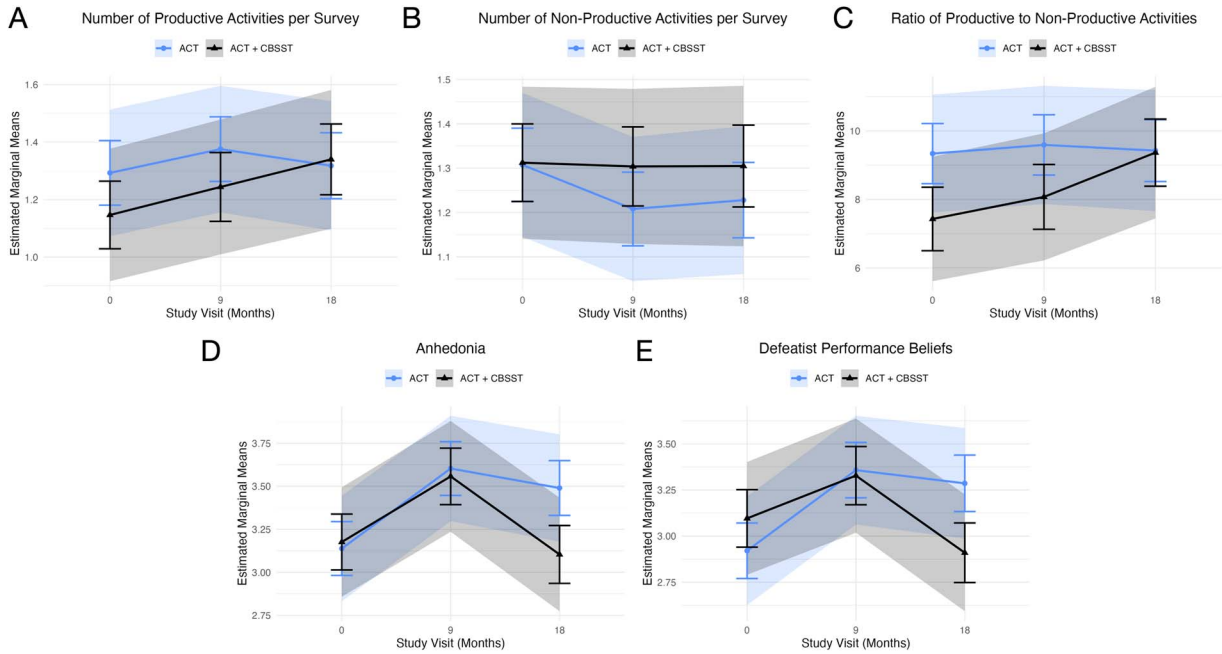


Figure 2. Panel A Shows the Estimated Marginal Means of the Number of Productive Activities Per Survey by Group and Study Visit. Panel B Shows the Estimated Marginal Means of the Number of Non-productive Activities Per Survey by Group and Study Visit. Panel C Shows the Estimated Marginal Means of the Ratio of Productive and Non-productive Activities by Group and Study Visit. Scores Have Been Min-Max Normalized for the Computation of the Ratio Score. Panel D shows the Estimated Marginal Means of anhedonia assessed in EMA by group and study visit. Panel E shows the Estimated Marginal Means of defeatist performance beliefs assessed in EMA by group and study visit. All Error Bars Represent Standard Errors.

those in the intent-to-treat analyses, with overlapping confidence intervals, suggesting that baseline differences did not account for the treatment effects. Within-group contrasts indicated significant improvements in the ACT + CBSST group from baseline to 9 months ($b = 0.32$, SE = 0.06, $P < .001$) and to 18 months ($b = 0.48$, $SE = 0.07$, $P < .001$), whereas no significant change was observed in the ACT-only group. However, between-group differences remained non-significant at all study visits (see Supplementary Materials S14-S17 for full model parameters).

To address the possibility of a "catch-up" effect in participants with particularly low baseline activity, we conducted an additional sensitivity analysis excluding those in the lower quartile of baseline productive activity. In this model, the group × time interaction again favored the ACT + CBSST group, but the effect was not statistically significant ($b = 0.06$, SE = 0.09, $P = .47$).

To address the dropout between baseline and the 18-months follow-up, which was relatively higher in ACT + CBSST (63%) than in ACT (51%), productive activities and clinical characteristics at baseline were examined as a function of dropout vs. completer and the interaction with group. However, the main effect of dropout, and the dropout x group interaction were not significant (Supplementary Materials S18 and S19).

To address the unexpected increase in secondary outcomes from baseline to the 9-month visit, we reanalyzed changes in anhedonia by examining the group × visit interaction while excluding EMA survey responses in which participants reported engaging in potentially less pleasurable activities (eg, cleaning, paying bills, work, or school-related tasks). This analysis revealed that the ACT + CBSST group exhibited a greater reduction in anhedonia compared to the ACT-only group, from baseline to 9 months ($b = -0.23$, $SE = 0.10$, $P < .05$) and from baseline to 18 months ($b = -0.73$, $SE = 0.12$, $P < .001$). Anhedonia decreased significantly from baseline to 18 months in ACT + CBSST but increased in ACT. At 18 months, the ACT + CBSST group showed significantly lower levels of anhedonia than the ACT group. See Supplementary Material S20 for full model parameters and estimated marginal means.

To account for study site-level variability, we conducted additional models including a random intercept for provider agency (ie, study site). However, these models exhibited singular fit issues, indicating that the variance for provider agency was effectively zero and did not contribute meaningful variation. Importantly, adding provider agency as a random effect did not alter the pattern of results or the magnitude of the fixed effects. See Supplementary Material S21 for full model parameters.

Discussion

This study found that integrating CBSST into ACT services led to greater improvements on EMA measures of daily-life functioning than ACT alone. This advances

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the evidence from prior efficacy trials[23-28] by showing effectiveness of CBSST delivered by typical community mental health providers in a routine care setting and with low functioning patients. Unlike the EMA measures in this report, in-lab measures of functioning and negative symptoms in the companion report in this issue[29] did not show significantly greater improvement in ACT + CBSST relative to ACT alone. Thus, although the current EMA analyses suggest real-world effectiveness of CBSST, the discrepancy between the preregistered primary outcomes (ie, in-lab measures) and the current EMA analyses warrants caution when drawing definitive conclusions about the effectiveness of CBSST.

Effectiveness of CBSST in Enhancing Real-World Functioning

The average increase by 0.2 productive activities per survey equals an average increase in functioning by 2 productive activities per day in participants who received ACT+CBSST. Although the clinical significance of this statistically significant change remains to be determined, the current study suggests that these functional improvements were accompanied by significant reductions in momentary daily-life experiences of anhedonia and defeatist beliefs. While the initial increase in these secondary outcomes was somewhat unexpected, it is important to note that, according to the estimated marginal means from the main analyses, anhedonia and defeatist beliefs in the ACT + CBSST group only returned to baseline levels by the 18-month study visit. However, the exploratory anhedonia model, which focused solely on positive activities, revealed a significant reduction in anhedonia from baseline to the 18-month follow-up in the ACT + CBSST group. In contrast, the ACT group showed a significant increase in anhedonia and significantly higher anhedonia than ACT + CBSST at 18 months. This suggests that CBSST was associated with significant and greater reductions in anhedonia than ACT alone. Anhedonia and defeatist beliefs have been found to mediate the effect of CBSST on functioning in previous studies using in-lab measures.[23,24,28] Future studies should replicate previous mediator studies based on retrospective self-reports and interviews testing the putative mechanisms of change in CBSST using EMA measures of functioning, defeatist beliefs and anhedonia.

Follow-up analyses of the significant group × time interaction suggest that the effect was primarily driven by more favorable trajectories in the ACT + CBSST group. Although no significant between-group differences emerged at individual follow-up visits, participants in the ACT + CBSST group showed significant improvements in productive activities over time, whereas the ACT-only group did not. This suggests that CBSST may have contributed to greater gains in productive activities beyond what was achieved with ACT alone. The absence of significant group differences at follow-up, despite divergent trajectories, indicates that ACT + CBSST did not achieve superior end-point outcomes in productive activity. Therefore, while the findings support the added value of CBSST in enhancing trajectories of productive activity, the superiority of ACT + CBSST in terms of final outcomes remains uncertain. The presence of significant group differences in productive activity at baseline in this study underscores the importance of future trials that use EMA of productive activities as a primary outcome and ensure balanced randomization to avoid baseline group differences that may confound longitudinal effects.

Sensitivity analyses excluding participants in the upper quartile of baseline productive activities demonstrated that the group × time interaction remained significant, with effect estimates approximately doubling in magnitude. This finding strengthens the interpretation that the observed improvements in the ACT + CBSST group reflect meaningful gains rather than a ceiling effect in the ACT-only group. In contrast, the complementary analysis excluding participants in the lower quartile of baseline productive activity yielded a non-significant interaction. This suggests that the group difference in improvement may be partially driven by greater room for improvement among lower-functioning participants. Although the lack of effect in this model might also highlight the heterogeneity of change trajectories. Importantly, in both sensitivity analyses, between-group differences at individual follow-up time points remained non-significant. Thus, while the trajectory data suggest that CBSST may enhance functional outcomes when added to ACT, these results should be interpreted with caution. The overall pattern of marked improvement in the ACT + CBSST group and stability in the ACT-only group nonetheless points to the potential of CBSST as a valuable augmentation to standard ACT services.

Notably, improvements in outcomes were evident despite relatively low exposure to CBSST in the intervention group. Specifically, effect sizes tripled in participants who received a higher dose, suggesting a dose–response effect of CBSST on functioning. This provides further support for the conclusion of Granholm et al. in this issue[29] that the small and non-significant effect sizes observed in intent-to-treat analyses for CBSST were likely attributable to inadequate implementation within the ACT services, rather than the limited effectiveness of CBSST itself. Even the most efficacious interventions can only achieve the intended benefits if they are offered to patients and implemented appropriately. Our findings highlight the necessity for appropriate implementation of evidence-based interventions for the treatment of individuals with SSD. However, there might be issues of resources and scalability of interventions to consider when addressing functioning difficulties in this population. While previous research has begun to investigate the implementation of CBSST into ACT services within this project,[63,64] further research is required to identify the barriers and facilitators to the implementation

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of evidence-based psychotherapy for individuals with SSD as well as its cost-effectiveness, particularly for implementing CBSST into ACT services. Such knowledge could contribute to the improvement of, and increased access to, care for this otherwise underserved population.

Unexpectedly, the ACT + CBSST group did not show a decrease in non-productive activities, suggesting that improvements in the productive/non-productive activity ratio were driven by the increase in productive activities. Thus, further CBSST adaptations could put stronger emphasis on the differentiation of productive and non-productive activity. However, it is also important to point out that, all but one non-productive activity (ie, smoking) items assessed behaviors that—from a clinician's perspective—should not be reduced per se (eg, resting, eating/-drinking). Rather, these should be actively encouraged by clinicians to initiate recovery periods in balance to increasing productive activity. The current study supports this by showing that improvements in daily-life functioning are possible, even without a reduction of "non-productive activities."

EMA as a Sensitive Measure of Change: Convergence, Divergence, and Implications

This study, along with the companion report (Granholm et al. in this issue), found relatively low convergence between EMA and in-lab findings, despite significant associations between EMA and in-lab measures. The significant associations between our EMA and the in-lab measures supports the convergent validity of our EMA findings, given the well-established validity of the in-lab assessments such as the ILSS. Consistent with prior research, these findings suggest that EMA may serve as a more sensitive and complementary tool to traditional in-lab assessments in clinical research.[44] While the findings suggest that EMA measures may be more sensitive to detecting changes in these outcomes within clinical trials, they also highlight a potential limitation of relying on interviewer-rated measures as primary outcomes. Specifically, the meaningful within-person variance in outcomes—that was reflected in significant random effects on the person-level—may have been obscured by participants providing retrospective averages of their experiences and behaviors, potentially masking the true effects of CBSST observed in the main trial. However, alternative explanations should also be considered. For instance, participants engaged more with CBSST may have completed more EMA assessments. In addition, higher engagement in EMA may have increased self-monitoring and awareness of daily behaviors, aligning with prior research showing that repeated self-assessment can influence behavior.[65] On the other hand, the association between treatment exposure and mean EMA response rates was non-significant in the current study. Moreover, while EMA captures real-time fluctuations in daily behavior, in-lab measures rely on retrospective recall, which is susceptible to cognitive biases and social desirability effects. Therefore, the observed divergence in findings may not solely reflect differences in sensitivity but rather fundamental differences in the constructs these measures assess.

It should be noted that the samples from the EMA study and the main study were not identical. Due to the incomplete implementation of EMA at the outset of the recruitment process, 23 participants (13%) could not be included in the intent-to-treat population of this study. This introduced a slight discrepancy in the mean CBSST exposure between the 2 samples, with slightly greater exposure in the current EMA sample (2 additional sessions on average). Greater exposure to CBSST was associated with greater CBSST skill learning and functional outcome in Granholm et al. in this issue.[29] Thus, in addition to the putatively greater sensitivity to change in EMA, this slightly higher exposure to CBSST in the EMA sample may have contributed to these significant effects.

The response patterns in the EMA component were complex. While overall participation in any EMA assessments varied by study visit and group (Figure 1), average response rates among those who engaged with EMA were comparable across groups and visits (Table 1). This suggests that lower participation rates primarily reflect trial dropouts rather than poor compliance among continuing participants. Still, average response rates of 49%-55% per visit raise valid concerns about the reliability of EMA outcomes in longitudinal RCTs. However, EMA has clear strengths. With 70 prompts per visit in the current study, even a 50% response rate yields roughly 35 data points per participant—far exceeding the data density of traditional in-lab measures. This enhances statistical power and enables detailed tracking of real-world functioning over time.[43] Although lower response rates may introduce some limitations, their consistency across groups reduces the risk of systematic bias. In sum, despite these challenges, EMA adds unique and valuable insights that complement retrospective and cross-sectional assessments.

Together with another study investigating EMA outcomes from a clinical trial on AVATAR therapy (see Edwards et al. in this issue), these findings may inform future trials assessing functional outcomes in psychological and psychiatric research. Specifically, the conditional and marginal R^2 values from our models indicate that only a small proportion of the variance in outcomes was attributable to fixed effects (ie, the group × time interaction) when ignoring the random effect structure. Conversely, up to 58% of the variance in outcomes was explained by the combination of fixed and random effects, indicating that the effect of CBSST across study visits was highly individual. This may be due to the relatively limited overall exposure to the CBSST intervention and variability in amount of exposure across individuals. However, it also highlights the limitation of relying solely on

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interviewer-rated in-lab measures, which may obscure this meaningful within-person variance. The current study, in conjunction with the companion article, provides a framework for a combined outcome assessment approach that integrates interviewer-rated in-lab measures with EMA of outcomes in future trials assessing psychological and behavioral outcomes. Importantly, despite all potential reservations against the utility of EMA in mental health research,[66] previous research suggests generally good feasibility and tolerability of EMA in clinical samples,[34,67] including people diagnosed with schizophrenia.[68]

Limitations

Study limitations include the relatively high dropout rate. However, dropouts from treatment are common in community-based care, and were not associated with any measure at baseline. Moreover, the study groups showed unexpectedly large differences in productive activity at baseline. Although we observed significantly more favorable trajectories in the ACT + CBSST group compared to ACT alone, the follow-up data suggest similar levels of functioning across groups. While this questions the absolute superiority of ACT + CBSST, caution is warranted in interpreting these follow-up analyses, because these comparisons could not be adjusted for baseline values. Adjusting for baseline values was not feasible with this long format data, as this would have required complete data across all visits for each participant, which would have excluded a substantial portion of the sample and introduced additional bias. Our interpretation that EMA provides a more sensitive measure is limited by baseline differences observed in EMA of productive activities but not in ILSS measures from the main report. This suggests that EMA and ILSS may capture different aspects of functioning. However, this study included only a subset of the original sample described in Granholm et al., which may constrain across the 2 studies and about EMA's sensitivity when compared to the ILSS. Nevertheless, it is possible that EMA detected baseline differences obscured by the ILSS's reliance on retrospective averages of functioning. Lastly, despite the strengths of EMA, the current study refers only to self-report data and lacks an objective assessment of activity such as actigraphy[69] or digital phenotyping, eg, by capturing GPS profiles,[70] which could be combined with EMA in future trials.

Conclusion

This study provides initial evidence for significant improvement on EMA measures of daily-life functioning, anhedonia, and defeatist beliefs with CBSST delivered by ACT teams. However, given the baseline imbalance in productive activity levels and the lack of significant between-group differences at follow-up, these findings must be interpreted as preliminary. Together, our findings argue for the potential utility of implementing CBSST into routine care for patients with schizophrenia and add to a growing array of clinical trials[54,71-75] demonstrating the benefits of using EMA to capture clinical outcomes directly in daily life.

Supplementary Material

Supplementary material is available at https://academic.oup.com/schizophreniabulletin.

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Conflicts of Interest

Dr. Granholm has an equity interest in Granholm Consulting, Inc., a company that may potentially benefit from the research results as he receives income from the company for CBSST workshops and consulting. The terms of this arrangement have been reviewed and approved by the University of California, San Diego, in accordance with its conflict of interest policies.

Data Availability

The data that support the findings of this study are available from the corresponding author, [M.P.], upon reasonable request.

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