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Mobile Enhancement of Motivation in Schizophrenia: A Pilot Randomized Controlled Trial of a Personalized Text Message Intervention for Motivation Deficits

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Objective: Motivation deficits remain an unmet treatment need in schizophrenia. Recent research has identified mechanisms underlying motivation deficits (i.e., impaired effort-cost computations, reduced future reward-value representation maintenance) that may be effective treatment targets to improve motivation. This study tested the feasibility and preliminary effectiveness of Mobile Enhancement of Motivation in Schizophrenia (MEMS), an intervention that leverages mobile technology to target these mechanisms with text messages. ***Method:*** Fifty-six participants with a schizophrenia-spectrum disorder were randomized to MEMS (n = 27) or a control condition (n = 29). All participants set recovery goals to complete over 8 weeks. Participants in the MEMS group additionally received personalized, interactive text messages on their personal cellphones each weekday. ***Results:*** Retention and engagement in MEMS were high: 92.6% completed 8 weeks of MEMS, with an 86.1% text message response rate, and 100% reported being satisfied with the text messages. Compared to participants in the control condition, the participants in the MEMS condition had significantly greater improvements in interviewer-rated motivation and anticipatory pleasure and attained significantly more recovery-oriented goals at 8 weeks. There were no significant group differences in purported mechanisms (performance-based effort-cost computations and future reward-value representations) or in self-reported motivation, quality of life, or functioning. ***Conclusion:*** Results demonstrate that MEMS is feasible as a brief, low-intensity mobile intervention that could effectively improve some aspects of motivation (i.e., initiation and maintenance of goal-directed behaviors) and recovery goal attainment for those with schizophrenia-spectrum disorders. More work is needed with larger samples and to understand the mechanisms of change in MEMS.

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The outcome results from the clinical trial have not been previously published. There is one paper that has been published from the baseline data from this trial; this paper looked at the relationship between self-reported and clinician-rated motivation and looked at moderators (e.g., metacognition and neurocognition) of this relationship.

Preliminary results from this work were presented at the 32nd annual meeting of the Society for Research in Psychopathology and the 2018 Translational Science Conference, and the 6th Biennial Schizophrenia International Research Society Conference. This trial was preregistered on ClinicalTrials.gov (NCT03059771). This work was supported by the William and Dorothy Bevan Scholarship from the American Psychological Foundation, the Indiana Clinical and Translational Sciences Institute (ICTSI) and the ICTSI Clinical Research Center (Grant UL1TR001108), and the National Institutes of Mental Health (Grant T32MH016259). The authors declare no conflicts of interest and are incredibly grateful to the participants who made this work possible.

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What is the public health significance of this article?
This study suggests that mobile text message interventions may improve motivation and help people with schizophrenia attain their personalized life goals. Further, this study suggests that text message interventions delivered via personal cell phones are feasible in those with schizophrenia.

Keywords: mhealth, negative symptoms, psychosis

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Schizophrenia is a severe mental illness (SMI) accounting for over 155 billion dollars in yearly treatment costs and lost wages in the United States alone (Cloutier et al., 2016). Research suggests that motivation deficits are a key factor affecting functional disability and quality of life (Fervaha, Agid, Takeuchi, Foussias, & Remington, 2013; Fervaha, Foussias, Agid, & Remington, 2014) and are barriers to attaining life goals that can facilitate recovery for people with schizophrenia (Clarke, Oades, Crowe, Caputi, & Deane, 2009). Yet motivation deficits remain an unmet clinical need, as most pharmacological and psychosocial interventions have demonstrated limited efficacy in ameliorating these symptoms (Fusar-Poli et al., 2015).

Mobile interventions are a promising way to more effectively treat these deficits. In particular, text message interventions may be uniquely promising and feasible among people with schizophrenia since text messages are already commonly used among many with schizophrenia (Ben-Zeev, Davis, Kaiser, Krzsos, & Drake, 2013; Naslund, Aschbrenner, & Bartels, 2016), may be less technologically and cognitively challenging to use than some mobile application-based interventions, and may be more accessible than mobile application-based interventions as they do not require a specific type of phone (e.g., smart phone), mobile phone operating system, or costly cellular data. Further, extant studies have found that mobile text message interventions are feasible, acceptable, and clinically promising tools to support a range of outcomes in schizophrenia. Participants receiving daily text messages generally report high levels of satisfaction and usability with text messages (Ben-Zeev, Kaiser, & Krzos, 2014; Granholm, Ben-Zeev, Link, Bradshaw, & Holden, 2012; Kannisto, Adams, Koivunen, Katajisto, & Välimäki, 2015). Participant retention and text message response rates in mobile intervention studies have been high (Ben-Zeev, Kaiser, et al., 2014; Granholm et al., 2012; Pijnenborg et al., 2010), supporting the feasibility of this approach. Moreover, initial studies have demonstrated that text-messaging interventions are potentially effective in improving a range of targeted domains, including medication adherence, positive symptoms, and social functioning in schizophrenia (Granholm et al., 2012; Montes, Medina, Gomez-Beneyto, & Maurino, 2012; Pijnenborg et al., 2010; Španiel et al., 2008).

Despite these promising results, few mobile interventions have specifically targeted negative symptoms such as reduced motivation. Mobile text-messaging interventions may be particularly useful for improving motivation, given that they can help to cue, sequence, and reinforce goal-directed behavior in real time in a person's daily environment. For example, in contrast to office-based treatment where steps and barriers toward achieving a goal are discussed outside of the context where they will be implemented, mobile text message interventions can provide personalized in the moment interventions in the actual environments where participants are trying to implement strategies or perform steps that facilitate goal achievement. Given these possibilities, this study used mobile technology to deliver a motivation intervention via text messages in real-time, real-world settings. Further, since prior work has found that technology-based interventions targeting potential underlying mechanisms may yield greater effects (Webb, Joseph, Yardley, & Michie, 2010), we aimed to improve motivation by targeting two impaired reward-processing mechanisms posited to underlie motivation deficits in schizophrenia: (a) effort-cost computations, and (b) maintenance of reward-value representations (Gold, Waltz, Prentice, Morris, & Heerey, 2008; Strauss, Waltz, & Gold, 2014). Broadly, effort-cost computations involve generating representations of the perceived effort (or cost such as energy, time) and rewards linked to completing a task/goal, including the magnitude of the reward and probability of reward receipt (Green, Horan, Barch, & Gold, 2015), and then integrating this information to evaluate whether the reward is worth the effort (Strauss et al., 2014). Drawing from tasks initially used in preclinical animal models (Salamone, Cousins, McCullough, Carriero, & Berkowitz, 1994), researchers have primarily assessed effort-cost computations using the effort expenditure for rewards task (EEfRT; Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009) wherein participants choose between completing an easy effort task that provides low monetary rewards or a relatively harder effort task that provides greater monetary rewards. In addition, the probability of receiving the monetary rewards if the chosen task is successfully completed varies across trials. On this task, compared to controls, schizophrenia participants are less likely to choose the hard effort option when the rewards and probability of reward receipt are the highest (Barch, Treadway, & Schoen, 2014; Fervaha et al., 2013; McCarthy, Treadway, Bennett, & Blanchard, 2016; Reddy et al., 2015; Treadway, Peterman, Zald, & Park, 2015) but select about the same amount (Barch et al., 2014; Reddy et al., 2015) or even more (Fervaha et al., 2013; McCarthy et al., 2016) hard effort options than controls on trials with lower reward receipt probability and magnitude. In other words, people with schizophrenia allocate less effort on maximally rewarding tasks than controls. Several studies have found that greater motivation deficits or negative symptoms are associated with choosing fewer hard EEfRT tasks, particularly in the high reward, high probability conditions (Barch et al., 2014; Fervaha et al., 2013; Horan et al., 2015). Taken together, motivational deficits may reflect difficulty integrating information about the cost (i.e., effort) and reward (e.g., magnitude, probability) of a task to identify when it is most advantageous to allocate effort (McCarthy et al., 2016; Treadway et al., 2015).

Additional work in schizophrenia demonstrates that motivational deficits are linked to difficulties maintaining (i.e., "hold[ing] in mind"; Gard et al., 2011) mental representations of the value of future rewards (Gold et al., 2008; Strauss et al., 2014). Thus, temporally distant rewards may be poorly represented and undervalued, especially compared to more immediate rewards (Heerey, Matveeva, & Gold, 2011). Indeed, many with schizophrenia have difficulty sustaining effort for long-term goals or vocational or educational programs (Harding et al., 2008; Kurtz, Rose, & Wexler, 2011), especially when the rewards are temporally distant (e.g., paycheck, degree). Using a delay discounting task, several studies have found that schizophrenia participants discount the value of future rewards more steeply than controls (Ahn et al., 2011; Heerey et al., 2011; Heerey, Robinson, McMahon, & Gold, 2007; L. Q. Yu et al., 2017), suggesting they have greater difficulty representing and thus devalue future rewards. Notably, Heerey et al. (2011) found that greater difficulty representing future rewards was related to reduced motivation. Others have found that value maintenance even over a brief time is impaired and associated with reduced motivation in schizophrenia (Gard et al., 2011). Thus, motivational impairments in schizophrenia may also stem from difficulties identifying and maintaining reward-value representations needed to guide long-term goal-directed behavior.

Although these results provide converging evidence that impaired effort-cost computations and future reward-value representations are mechanisms underlying reduced motivated behavior in schizophrenia, little work has been done to translate these findings into novel motivation targets and treatments. This study tested an intervention that leverages mobile technology to target these two mechanisms in real-world settings. Mobile text-messaging interventions may be particularly apt at targeting these mechanisms for several reasons. First, effort-cost computations are made throughout a person's daily life (e.g., making favorite meal from scratch vs. making a less flavorful frozen meal version), and mobile text message interventions can provide real-time services to support adaptative effort-cost computations. Mobile text message interventions can guide effective effort allocation by cueing and reinforcing engagement in high-effort, high-reward tasks (e.g., looking/applying for jobs involving animals) that are important to long term-goals (e.g., becoming a veterinary technician). Mobile text message interventions can also deliver frequent reminders to promote and maintain reward-value maintenance to guide behavior to support long-term goal attainment (Strauss et al., 2014).

To date, we are aware of only one mobile intervention that has targeted motivation. Schlosser et al. (2018) used a mobile app-based intervention for people with early psychosis and found that the 12-week intervention led to significant improvements in social motivation components (i.e., anticipated pleasure and effort for social tasks); trend improvements in self-reported motivation/pleasure symptoms; and no significant changes in clinician-rated negative symptoms, functioning, or quality of life. However, compared to mobile app-based interventions, mobile text message interventions may be more effective at targeting motivation for those across the schizophrenia-spectrum given that text message interventions may have fewer barriers to treatment initiation and engagement (i.e., does not require a smart phone or cellular data) and may be more accessible and impactful for those with a range of mobile phone experience and cognitive abilities. Yet, to date, mobile interventions targeting other symptoms/domains have found limited effectiveness for improving motivation or other negative symptoms (Ben-Zeev, Brenner, et al., 2014; Granholm et al., 2012). Further, mobile intervention, particularly text message studies, generally have yet to move beyond feasibility studies, resulting in calls for more rigorous randomized designs (Naslund, Marsch, McHugo, & Bartels, 2015; Payne, Lister, West, & Bernhardt, 2015). An additional limitation is that many extant studies provide participants cellphones only for the study period, reducing the results' ecological validity and clinical utility.

To address these gaps, this pilot study tests the feasibility and preliminary effectiveness of a mobile text-messaging intervention, Mobile Enhancement of Motivation in Schizophrenia (MEMS), which targets effort-cost computations and future reward-value representation maintenance to improve motivation. We used a randomized design to identify whether MEMS would lead to improvements in outcomes above the effects of a group who only engaged in a goal-setting session—a common method to target motivation (Clarke, Oades, Crowe, & Deane, 2006). We hypothesized that MEMS would lead to greater improvements in our main therapeutic targets (i.e., primary outcomes) of effort-cost computations, future reward-value representations, interviewer-rated and self-reported motivation, and overall goal attainment compared to goal-setting alone. We also explored whether there were group differences in the more distal outcomes (i.e., secondary outcomes) of quality of life, functioning, neurocognition, and additional symptoms. Finally, we tested the feasibility of using personal mobile phones to deliver MEMS, including examining MEMS engagement, usability, and satisfaction.

Method

Participants

Participants were recruited from a community mental health center serving outpatients with SMI. Participants were eligible if they: (a) were $\geq$18 years old, (b) had a Structured Clinical Interview for *DSM–5* (First, Williams, Karg, & Spitzer, 2015) confirmed schizophrenia-spectrum diagnosis, (c) owned a mobile phone that could send/receive text messages, (d) would permit study text messages be sent to their phone, (e) demonstrated at least a fourth grade reading level on the Graded Word List (La Pray & Ross, 1969), (f) were in a postacute illness phase (i.e., no past month inpatient hospitalizations or medication changes), and (g) had at least moderate motivation moderate motivation deficits on the Clinical Assessment Interview for Negative Symptoms (CAINS; Kring, Gur, Blanchard, Horan, & Reise, 2013) in a minimum of one domain: motivation for family, close friends and romantic relationships, work and school, and/or recreational activities.

Recruitment occurred over a span of eight months, and our recruitment targets were based on a number of factors. First, given that this was a feasibility and pilot study, we examined sample sizes in prior text-message intervention studies and pilot intervention work (Ben-Zeev, Kaiser, et al., 2014; Freeman et al., 2015; Granholm et al., 2012; Yanos, Roe, West, Smith, & Lysaker, 2012), whose enrolled samples ranged from 19 to 55. Based on our internal resources, we targeted 50 for the final sample. We also conducted a preliminary a priori power analysis that suggested this sample size would be sufficient to detect medium-large to large effect sizes, and other research has recommended 25 per condition for pilot randomized trials (Whitehead, Julious, Cooper, & Campbell, 2016). Finally, we allowed for some attrition. Specifically, we planned to enroll approximately 55 participants in the study and assumed a 10% attrition rate, resulting in approximately 50 participants completing the trial.

Procedure

After completing informed consent and baseline measures, each participant completed a goal-setting session with the study therapist, a doctoral student in clinical psychology, where they set recovery-oriented goals to complete over 8 weeks. Participants were then randomized to receive either (a) MEMS, or (b) no additional intervention (referred to hereafter as the control group). Randomization was conducted using a random number generator in blocks of 10; each block had an equal number of both conditions. Randomization codes were generated by an independent researcher and sealed in envelopes with consecutive numbers; these were opened in ascending order after participants completed baseline assessments and the goal-setting session. After randomization, study assessors only contacted (i.e., called) participants in the control condition during the 8 weeks to schedule the follow-up assessment. For participants in the MEMS group, we tried to limit additional contact over the 8 weeks outside of the text messages (detailed below) as much as possible to help ensure any identified effects were due to the text-messaging. Thus, following prior procedures (Ben-Zeev et al., 2014), the study therapist would only call participants in the MEMS group if they did not reply to study text messages for three consecutive days. Study assessors also called MEMS participants to schedule the follow-up assessment. Follow-up assessments were completed after 8 weeks for both groups. Participants completed all primary and secondary outcome measures at baseline and follow-up assessments with trained raters blinded to condition; the questionnaire assessing MEMS feasibility at the follow-up assessment was only provided to assessors and completed with participants after all other study measures and ratings had been completed. Participants were compensated $40 and could win an additional $2.00–$8.24 on a study task (see below) at each assessment. Text message costs were reimbursed ($30/month); to ensure this additional compensation was not differentially influencing outcomes, both groups received it. Study procedures were approved by the local institutional review board.

Goal-setting session. Prior to randomization, all participants set recovery goals to complete over eight weeks during a one-on-one goal-setting session with the study therapist that lasted approximately 45 min. Goals could be set in any domain, but participants were first asked if they wanted to make changes in the domains identified as reduced on the CAINS motivation items. The in-person goal-setting session incorporated techniques from collaborative goal technology (GCT; Clarke et al., 2006), a systematic, recovery goal-setting method focused on identifying the importance and personal meaning of a goal (Clarke et al., 2009). Using GCT and information gathered in the assessments, attempts were made to help participants integrate information to accurately identify and assess the value, effort, and probability of attaining an identified goal. Identified goals were translated into a specific, measurable, achievable, realistic, and timed (Bovend'Eerdt, Botell, & Wade, 2009; Schut & Stam, 1994) goal, and participants discussed and then rated the value/importance of the goal (rated from 1–10), effort required to complete the goal (rated from 1–10), and the participant's confidence in completing the goal (rated 0–100%; a copy of this information was provided to participants). To further overcome effort-cost computation difficulties, for all participants, each overall goal was collaboratively broken down into smaller subgoals to complete each weekday over 8 weeks; these subgoals were then written on calendars, and copies were provided to each participant.

MEMS. Following prior studies (Ben-Zeev, Kaiser, et al., 2014; Granholm et al., 2012), the participants in the MEMS group received in-person training in text-messaging procedures before receiving study messages. Training lasted approximately 15 min and occurred with the participant and the study therapist who sent the text messages. First, the limits of text message confidentiality and ways to improve privacy (e.g., adding an access password) were reviewed. Next, participants were trained to send and receive text messages and modify relevant settings (e.g., text message notification volume, text font size) on their personal phone. Participants then engaged in a practice text-messaging session where they drafted and sent a message and opened and read a received message from the study therapist.

Participants in the MEMS group received three text message sets each weekday from the study therapist for eight weeks through TextIt's (Nyaruka, 2016) web-based text-messaging service. Text messages were sent during three time blocks: (a) 8:30–10:30 a.m., (b) 11:30 a.m.–1:30 p.m., and (c) 5:30–7:30 p.m. Participants selected when they wanted to start receiving messages in each block and were informed that text messages sent outside the blocks may have a delayed reply. Following prior technology-based SMI research (Rotondi, Eack, Hanusa, Spring, & Haas, 2015), efforts were made to create text messages that required a low reading level and used concrete language.

The interactive text messages aimed to reinforce and cue goal completion and target effort-cost computations and future reward-value representation maintenance. Based on preset scripts that were individualized for each goal (see example daily text message exchange in Figure 1 in the online supplemental materials), daily messages occurred in the following order (relevant strategies are labeled with the behavior change technique taxonomy (v1); Michie et al., 2013): (a) reminder of the smaller subgoal they set to complete that day (i.e., goal-setting behavior/outcome [Michie et al., 2013]), inquiry about how much effort the goal would take to complete (on a scale of 1–10), and then positive encouragement to support effort expenditure; (b) encouragement that their subgoal is worth the effort, and reminder of why the goal is valuable to them (based on goal-setting session information), and inquiry about when they wanted to complete the goal that day (i.e., for action planning; Michie et al., 2013); and (c) assessment of subgoal completion and how much effort it took to complete the goal (on a scale of 1–10). If they did not complete the subgoal, participants were asked what might help them reach their subgoal and whether the subgoal could be broken down into smaller steps. If they did complete it, encouragement was provided to reinforce success and support adaptive effort-cost computations (i.e., if they overestimated the effort, then we reinforced that it was less effort then they anticipated). At the end of each week, feedback indicating progress toward their overall goal (i.e., feedback on outcomes; Michie et al., 2013) was provided. Thus, via text messages, effort-cost computations were primarily targeted through inquiry and assessments about subgoal effort, encouragement and positive reinforcement (i.e., social reward; Michie et al., 2013) supporting effort expenditure and adaptive effort-cost computations, as well as messages linking effort expenditure to rewards. Future reward-value representation maintenance was targeted through messages that provided reminders about and enhanced the connection between the value or rewards associated with subgoal completion.

Measures

Interviewer-rated motivation. The aforementioned CAINS four motivation items were used to assess motivation over the past week for the domains of family, close friends and romantic relationships, work and school, and recreational activities. The three-item Motivation Index (Choi, Choi, Felice Reddy, & Fiszdon, 2014; Nakagami, Xie, Hoe, & Brekke, 2008) from the Heinrichs-Carpenter Quality of Life Scale (QLS; Heinrichs, Hanlon, & Carpenter, 1984) was used to assess a person's global degree of motivation to initiate and sustain activities (1 item), curiosity in daily life (1 item), and sense of purpose or having integrated, realistic life goals (1 item) over the preceding 4 weeks. Since the motivation item from the QLS-Motivation Index is also a valid stand-alone motivation measure (Fervaha, Foussias, Takeuchi, Agid, & Remington, 2015), we used this item in exploratory analyses. Both the CAINS and QLS scores have demonstrated good convergent validity and interrater reliability in schizophrenia-spectrum samples (Fervaha, Foussias, et al., 2015; Kring et al., 2013; Luther et al., 2016).

Subjective motivation. The six motivation and effort items from the self-report Motivation and Pleasure Scale (MAP-SR; Llerena et al., 2013) were used to assess perceived motivation and effort over the past week for social, work, school, hobbies, and recreational activities. Items are rated on a variable 5-point Likert scale. Scores on the MAP-SR have demonstrated good convergent and discriminant validity and internal consistency (Llerena et al., 2013).

Effort-cost computations. Effort-cost computations were assessed by the EEfRT (Treadway et al., 2009), which contains trials where participants choose to complete an easy or hard task after viewing the associated monetary rewards for both options and probability of reward receipt. On this task, easy task rewards are always $1.00, while hard tasks rewards vary from $1.24–$4.12. The probability of reward receipt if the chosen task is completed varies (but is the same for each trial option), ranging from high (88%), medium (50%), to low (12%). The easy task asks participants to make 30 button presses in 7 s using their dominant-hand index finger, and the hard task requires 100 button presses in 21 s with their non-dominant-hand pinky finger. The task runs for 20-min, and participants are instructed that earnings from the task are based on two randomly selected tasks. Following prior methods (McCarthy et al., 2016), our main effort-cost computation outcome was the percentage of hard trials selected in the high reward (≥$3.01) high probability (88%) trials. EEfRT scores have shown reliability and validity in schizophrenia samples (Green et al., 2015).

Future reward-value representations. Future reward-value representations were measured using a delay-discounting task (Kirby, Petry, & Bickel, 1999) where participants choose between a smaller immediate monetary reward or a larger delayed reward in 27 trials. For this task, small rewards range from $11–$80, while larger delayed rewards range from ($25–$85). Delays range from seven to 186 days. As studies have failed to find performance differences between hypothetical and real monetary rewards on delay discounting tasks (Bickel, Pitcock, Yi, & Angtuaco, 2009; Lagorio & Madden, 2005), participants were informed that they would not receive the rewards but should make their decisions as if the rewards were genuine. Following Myerson, Baumann, and Green (2014), greater ability to represent the value of a future reward was indexed by the percentage of larger delayed rewards selected.

MEMS usability and satisfaction. MEMS usability and satisfaction were assessed with 14 self-report items based on the Usability, Satisfaction, and Ease of Use Questionnaire (Lund, 2001), which was previously modified to assess the usability and satisfaction of a mobile intervention in a schizophrenia-spectrum sample (Ben-Zeev, Kaiser, et al., 2014). All items were rated on a 7-point Likert scale from 1 (*Strongly Disagree*) to 7 (*Strongly Agree*).

Functioning. Functioning was assessed with the total score of the interviewer-rated Strauss-Carpenter Level of Function scale (Hawk, Carpenter, & Strauss, 1975; Strauss & Carpenter, 1977). Nine items are rated on a 5-point variable scale and assess social contacts, work, symptoms, and general functioning over the past month. Scores on the scale have demonstrated interrater reliability and convergent validity in schizophrenia-spectrum samples (Strauss & Carpenter, 1977).

Quality of life. Quality of life was measured by the self-report overall quality of life item from the World Health Organization Quality of Life BREF Scale (WHOQOL-BREF; Skevington, Lotfy, O'Connell, & the WHOQOL Group, 2004). This item assesses quality of life over the past 2 weeks and is rated on a 5-point scale from 1 (*very poor*) to 5 (*very good*). The WHOQOL-BREF has demonstrated excellent convergent validity in a schizophrenia-spectrum sample (Mas-Expósito, Amador-Campos, Gómez-Benito, Lalucat-Jo, & the Research Group on Severe Mental Disorders, 2011).

Neurocognition. Neurocognition was measured using the updated Brief Neurocognitive Assessment (BNA; Fervaha, Hill, et al., 2015). The BNA assesses working memory with the letter-number sequencing test (Gold, Carpenter, Randolph, Goldberg, & Weinberger, 1997) and processing speed with the symbol coding subtest from the Brief Assessment of Cognition in Schizophrenia (Keefe et al., 2004). Following Fervaha, Hill, et al. (2015), we created an overall BNA standardized z score based on normative data. The BNA has demonstrated reliability and validity in schizophrenia samples (Fervaha, Hill, et al., 2015).

Additional negative symptoms. Anticipatory pleasure was measured with the three CAINS items assessing the frequency of expected pleasure for the upcoming week for the domains of social relationships, work and school, and recreational activities; the CAINS past week pleasure items (2 items) were also used to assess the frequency of pleasurable activities over the past week in the domains of social and recreational activities. Emotion expression and speech were assessed with the four expressive items (facial expression, vocal expression, expressive gestures, and quantity of speech).

Positive and mood symptoms. We used the factor-analytically derived positive (delusions, hallucinations, unusual thought content, somatic concern, suspiciousness/persecution, and grandiosity items) and emotional discomfort (i.e., mood; depression, anxiety, guilt feelings, and active social avoidance items) symptoms subscales (Bell, Lysaker, Beam-Goulet, Milstein, & Lindenmayer, 1994) on the widely used Positive and Negative Syndrome Scale (PANSS; Kay, Fiszbein, & Opler, 1987). Each interviewer-rated item is rated on a 7-point scale from 1 (*Absent*) to 7 (*Severe*). The PANSS scores have demonstrated satisfactory test–retest reliability and validity in schizophrenia-spectrum samples (Kay et al., 1987).

Analyses

For analyses, we used a full analysis set (United States Department of Health and Human Services, 1998), including data from all randomized participants, regardless of actual intervention use/adherence. We first compared group demographics, motivation levels, and goal-setting ratings (e.g., effort to complete goals) using independent samples *t* tests and chi-square tests. Second, to assess MEMS feasibility and engagement, we examined text message response rates; descriptive statistics were used to assess responses to usability and satisfaction questions. Next, we used a series of analysis of covariances (ANCOVAs) to identify follow-up group differences on outcomes after covarying for the associated baseline outcome level and if necessary, any group demographic differences identified in the first step. We then compared the percentage of overall goals attained ([number of goals attained at follow up divided by number of goals sets at baseline] $\times$ 100) between groups using independent samples *t* tests; as a more stringent test, we also conducted an ANCOVA to compare the percentage of overall goals attained between groups after controlling for participants' goal importance, effort, and confidence ratings. Finally, to identify whether MEMS engagement was related to outcome changes, correlations between text message response rate and outcome change scores (baseline minus follow up) were conducted. Effect sizes were categorized following Cohen (1992).

Results

Recruitment and Participant Characteristics

One hundred people were assessed for eligibility, and 56 were randomized (27 to MEMS, 29 to control). Three participants (5.4%) did not complete the study (see the CONSORT diagram in Figure 1). One participant in the MEMS group withdrew several weeks after starting the text messages because she obtained a job and thought she would not have time for the text messages; a second participant was administratively withdrawn after breaking her phone and becoming unreachable prior to beginning the text messages. One participant in the control group was unreachable at follow up.

At baseline, groups did not significantly differ on demographics (thus, demographics were not controlled for in additional analyses), number of goal-setting session goals set, or CAINS motivation (Table 1). However, participants in the MEMS group rated their overall goals as being more valuable/important ($p = .04$) and requiring more effort ($p = .02$) to complete than the control group; groups did not differ in their confidence in achieving their goals. Information about goal domains and goal examples is in Table 1 in the online supplemental materials. In the full sample, motivation deficits were moderate ($M = 7.6$, $SD = 2.3$), and participants set an average of 3.6 ($SD = 1.7$) overall goals for the 8 weeks; most had unlimited text messages in their service plan (96.4%). Study noncompleters ($n = 3$) and completers ($n = 53$) did not significantly differ on demographics or CAINS motivation.

MEMS Feasibility, Engagement, Usability, and Satisfaction

Feasibility and engagement. Across the 8 weeks, participants received an average of 207.5 ($SD = 62.4$) study text messages and sent an average of 185.8 ($SD = 92.6$) study text messages. Average participant response rate was 86.1% ($SD = 16.7\%$); one participant responded to 18.5%, three responded to 63.1%-73.3%, nine responded to 80–89.4%, and 12 responded to over 93% of the text messages.

Usability and satisfaction. Regarding usability, 96% ($n = 24$) of participants who received MEMS reported they learned MEMS quickly and it was easy to use (Table 2). Sixteen percent ($n = 4$) reported difficulties understanding the text messages and typing their responses, and 12% ($n = 3$) reported difficulties operating their phone. For satisfaction, all participants reported they were satisfied with the text messages, and 92% ($n = 23$) reported the text messages were useful and helped them to become more motivated. Ninety-two percent ($n = 23$) reported the text messages helped them to reach their goals and get more things done. Several participants also made unprompted text message comments about how MEMS helped them (See Table 2 in the online supplemental materials).

Preliminary Effectiveness

Primary outcomes. Consistent with hypotheses, significant medium-sized group effects were found for CAINS motivation ($p = .03$; Table 3); after controlling for CAINS motivation at baseline, participants who received MEMS demonstrated greater motivation at follow up than participants in the control group. No significant group effects were found for the QLS-Motivation Index ($p = .14$), but in exploratory analyses, the participants in the MEMS group had greater follow-up scores on the motivation item of the index than the participants in the control group after adjusting for baseline scores ($p = .04$); effect size was medium. As hypothesized, participants in the MEMS group reached a significantly greater percentage of overall goals than participants in the control group ($p < .001$), with a large effect size. This difference in overall goal attainment (as well as the magnitude of the effect size) remained after accounting for participants' goal value/importance, effort, and confidence ratings ($p = .001$). Contrary to hypotheses, no significant group effects were found for subjective motivation ($p = .61$), future reward-value representations ($p = .33$), or

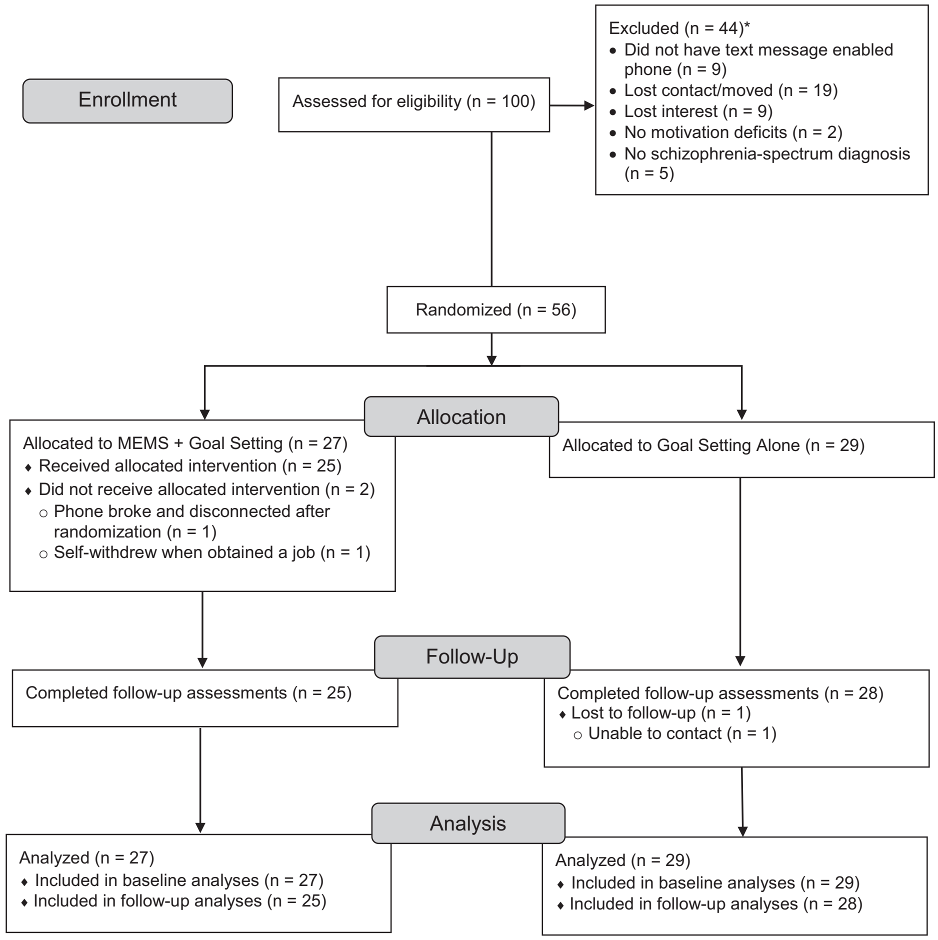

Figure 1. Consort flow diagram. * No participants were excluded for refusing to allow study staff to send text messages to their personal phone; all screened participants agreed to this component of the study.

effort-cost computations ($p = .70$); however, several participants demonstrated baseline ceiling effects or fixed responses on the EEfRT ($n = 12$) as well as fixed or inconsistent responses (Kirby et al., 1999; R. Yu, 2012) on the delay discounting task ($n = 7$; results were statistically the same when these participants were excluded).

Secondary outcomes. After controlling for baseline levels, anticipatory pleasure at follow up was significantly higher for participants in the MEMS group compared to those in the control group ($p = .02$), with a medium effect size (see Table 3). There was also a trend toward higher past week pleasure ($p = .096$) at follow-up for participants in the MEMS group relative to those in the control condition. There were no significant group differences for expressive negative symptoms, positive symptoms, mood symptoms, neurocognition, quality of life, or functioning at follow up (all $ps > .61$).

MEMS engagement and outcome change. Among participants who received MEMS, a higher text message response rate was significantly associated with greater improvement in effort-cost computations ($p = .001$) and anticipatory pleasure ($p = .03$). No other correlations were significant (Table 4).

Discussion

In a small, pilot randomized controlled trial, we tested the feasibility and preliminary effectiveness of MEMS, a motivation treatment delivered via mobile technology and text-messaging that was designed to target reward-processing mechanisms purported to underly reduced motivation. Our results show that MEMS is feasible and may lead to significantly greater improvements in interviewer-rated motivation, anticipatory pleasure, and recovery-oriented goal attainment than a goal-setting session alone. To our knowledge, this study is the first randomized controlled trial demonstrating the feasibility of solely using participants' personal cellphones (rather than study provided cellphones) to deliver an interactive mobile intervention in those with schizophrenia-spectrum disorders, supporting the ecological validity, scalability, and real-world implementation of text-messaging interventions for this population.

Building on growing literature suggesting that text-messaging interventions are feasible and acceptable for most people with schizophrenia (Depp et al., 2010; Naslund et al., 2015), we found that MEMS was highly engaging for most participants. Across the 8-week intervention, the retention rate among participants who received

Table 1
Baseline Participant Demographics by Group

Demographic	MEMS (n = 27), n (%)	Goal setting alone (n = 29), n (%)	Test of significance
Diagnosis			$\chi^2(1) = .25$
Schizophrenia	12 (44.4)	11 (37.9)	
Schizoaffective disorder	15 (55.6)	18 (62.1)	
Gender (n, % female)	15 (55.6)	12 (41.4)	$\chi^2(1) = 1.13$
Race			$\chi^2(2) = .78$
African American	18 (66.7)	21 (72.4)	
White	8 (29.6)	6 (20.7)	
Other or multiple races	1 (3.7)	2 (6.9)	
Unlimited text message plan	26 (96.3)	28 (96.6)	$\chi^2(1) = .003$
	M	*SD*	
Age	46.0 (10.0)	46.3 (7.7)	$t(54) = -0.12$
Education	12.0 (2.7)	11.7 (2.0)	$t(54) = .35$
Chlorpromazine equivalent doses[a]	618.3 (544.6)	416.1 (376.5)	$t(54) = 1.63$
Length of illness	24.0 (12.1)[b]	23.4 (10.5)	$t(52) = .21$
CAINS—Motivation	7.7 (2.6)	7.5 (1.9)	$t(54) = .30$
Number of goals set	3.7 (1.8)	3.5 (1.6)	$t(54) = .48$
Value/importance of goal(s)[c]	9.3 (1.0)	8.5 (1.9)	$t(54) = 2.10^*$
Effort to complete goal(s)[c]	8.8 (1.4)	7.7 (2.3)	$t(54) = 2.36^*$
Confidence in completing goal(s)[c]	84.1 (20.0)	81.9 (16.5)	$t(54) = .45$

Note. MEMS = Mobile Enhancement of Motivation in Schizophrenia; CAINS = Clinical Assessment Interview for Negative Symptoms.
[a] Based on prior studies (Herz et al., 1997; Woods, 2003; Woods, 2011). [b] Data missing for two participants. [c] These were based on ratings completed during the goal-setting session.
* $p < .05$.

MEMS was 92.6%, and the overall mean text message response rate was 86.1%. Although these rates are similar to prior text-messaging intervention studies (Ben-Zeev, Kaiser, et al., 2014; Granholm et al., 2012; Montes et al., 2012; Pijnenborg et al., 2010), our findings are particularly noteworthy since all participants demonstrated at least moderate baseline motivation deficits and were using personal cellphones. In addition, all participants reported satisfaction with the text messages, and almost all reported that the text messages were useful and increased their motivation and that MEMS was easy to use. Several participants also provided unprompted feedback that the text messages were encouraging, motivating, and helpful.

This study builds on feasibility and acceptability studies by using a randomized design to more rigorously test the preliminary effectiveness of MEMS. Results demonstrated that MEMS led to greater

Table 2
Usability and Satisfaction for MEMS Participants

Item	*Strongly disagree*	*Disagree*	*Disagree somewhat*	*Neutral*	*Agree somewhat*	*Agree*	*Strongly agree*
Usability items							
I learned to use the mobile intervention quickly.	0	1 (4%)	0	0	4 (16%)	8 (32%)	12 (48%)
The mobile intervention was easy to use.	1 (4%)	0	0	0	1 (4%)	12 (48%)	11 (44%)
The mobile intervention did everything I would expect it to.	0	0	0	3 (12%)	4 (16%)	8 (32%)	10 (40%)
I had difficulties typing my responses.	14 (56%)	3 (12%)	1 (4%)	3 (12%)	2 (8%)	0	2 (8%)
I had difficulties operating my phone.	15 (60%)	4 (16%)	1 (4%)	2 (8%)	1 (4%)	2 (8%)	0
I had difficulties understanding the text messages.	16 (64%)	2 (8%)	2 (8%)	1 (4%)	0	2 (8%)	2 (8%)
The text messages interfered with my daily activities.	17 (68%)	3 (12%)	1 (4%)	2 (8%)	2 (8%)	0	0
Satisfaction items							
The text messages I received were useful.	0	0	0	1 (4%)	1 (4%)	7 (28%)	16 (64%)
I was satisfied with the text messages I received.[a]	0	0	0	0	2 (8%)	4 (16%)	18 (72%)
I would be interested in participating in similar studies in the future.	0	0	0	0	0	6 (24%)	19 (76%)
I would recommend to others that they should participate in a similar study.	0	0	0	0	2 (8%)	7 (28%)	16 (64%)
The text messages helped me to reach my goal(s).	0	0	0	2 (8%)	2 (8%)	6 (24%)	15 (60%)
The text messages helped me to get more things done.	0	0	1 (4%)	1 (4%)	2 (8%)	5 (20%)	16 (64%)
The text messages helped me become more motivated.[a]	0	0	0	1 (4%)	2 (8%)	7 (28%)	14 (56%)

Note. n = 25. MEMS = Mobile Enhancement of Motivation in Schizophrenia.
[a] n = 1 (4%) missing data for this item.

Table 3
Measure Descriptive Statistics and Group Effects for Primary and Secondary Outcomes

Measure	MEMS, *M* (*SD*)		Goal setting alone, *M* (*SD*)				
	BL (*n* = 27)	8 week (*n* = 25)	BL (*n* = 29)	8 week (*n* = 28)	F^a	*p*	d^b [95% CI]
Primary outcomes							
CAINS: Motivation[c]	7.7 (2.6)	6.2 (2.5)	7.5 (1.9)	7.4 (2.7)	4.73	.03	−0.58 [−1.14, −.03]
QLS– Motivation Index	8.0 (2.5)	9.6 (3.8)	7.4 (2.8)	8.0 (3.5)	2.23	.14	0.41 [−.14, .95]
QLS: Motivation item	2.5 (1.3)	3.6 (1.4)	2.3 (1.1)	2.9 (1.3)	4.59	.04	0.58 [.03, 1.13]
MAP-SR—Motivation	11.2 (5.4)	11.6 (5.6)	7.9 (5.0)	10.3 (6.5)	0.26	.61	−0.14 [−.68, .40]
Overall goals attained[d]		77.6 (26.7)		46.7 (31.6)	3.82[d]	<.001	1.05[e] [.46, 1.61]
Value representation maintenance: % delayed rewards	35.7 (21.2)	32.7 (19.2)	28.6 (23.0)	30.3 (25.4)	0.96	.33	−0.27 [−.81, .27]
Effort-cost computations: % hard chosen in 88%, high reward trials	45.9 (32.4)	42.0 (35.5)	36.6 (29.2)	38.9 (36.4)	0.15	.70	−0.11 [−.65, .43]
Secondary outcomes							
CAINS: Anticipatory pleasure	6.8 (3.3)	5.3 (2.5)	7.8 (2.8)	7.2 (2.5)	5.93	.02	−0.66 [−1.22, −.11]
CAINS: Past week pleasure	3.6 (2.3)	2.6 (1.9)	4.0 (2.0)	3.4 (1.4)	2.87	.096	−0.46 [−1.01, .08]
CAINS: Expressive symptoms	5.1 (3.3)	4.4 (3.9)	6.0 (4.0)	5.2 (3.4)	0.26	.62	−0.14 [−.68, .40]
PANSS: Positive symptoms	3.2 (.9)	2.7 (1.0)	2.9 (.8)	2.5 (.8)	0.02	.89	−0.04 [−.58, .50]
PANSS: Mood symptoms	3.3 (1.1)	3.0 (1.2)	3.0 (1.1)	2.9 (1.1)	0.01	.94	−0.02 [−.56, .52]
BNA: Neurocognition	−1.7 (1.2)	−1.7 (1.0)	−1.8 (1.1)	−1.6 (1.0)	0.12	.73	−0.10 [−.64, .44]
WHOQOL: Overall QOL	3.4 (1.0)	3.6 (1.0)	3.2 (1.2)	3.6 (1.0)	0.08	.78	−0.07 [−.61, .47]
Strauss-Carpenter: Functioning	16.9 (5.5)	19.4 (4.5)	17.0 (4.8)	19.0 (4.8)	0.11	.74	0.09 [−.45, .63]

Note. Descriptive statistics are simple statistics without co-varying for baseline level of variable. MEMS = Mobile Enhancement of Motivation in Schizophrenia; BL = baseline; CAINS = Clinical Assessment Interview for Negative Symptoms; MAP-SR = Motivation and Pleasure Self-Report; PANSS = Positive and Negative Syndrome Scale; QLS = Quality of Life Scale; QOL = quality of life; WHOQOL = World Health Organization Quality of Life.
[a] Results based on those who completed both assessment points. [b] Unless otherwise noted, effect sizes were calculated with adjusted follow-up means and pooled standard deviations. [c] Higher CAINS and PANSS scores = more symptoms (e.g., greater motivation deficits). Higher BNA, WHOQOL, and Strauss-Carpenter = better neurocognition, QOL, or functioning, respectively. [d] *t* value and associated significance test and effect size (based on follow-up means and pooled standard deviations) are reported. [e] Effect size when controlling for participants' goal importance, effort, and confidence ratings was .98 [.40, 1.54].

improvements in interviewer-rated motivation, anticipatory pleasure, and recovery-oriented goal attainment compared to a goal-setting session, with medium to large effect sizes. Thus, MEMS appeared to improve more objective behavioral components of motivation such as the initiation and maintenance of behaviors that support meaningful goal attainment and the completion of daily activities as well as some internal aspects related to motivation such as one's interest in activities and expectations about the pleasure derived from prospective activities. Although larger trials are needed to confirm these effects, these findings are promising given that there are few relatively brief treatments (i.e., <18 months) that have demonstrated efficacy for improving motivation and anticipatory anhedonia in prolonged schizophrenia. Indeed, this aligns with work suggesting that compared to usual in-person care, mobile interventions may offer a more sustainable, scalable, and potentially cost-effective treatment approach (De La Torre-Díez, López-Coronado, Vaca, Aguado, & de Castro, 2015; Depp et al., 2010).

In addition, the observed effects of MEMS on recovery-oriented goal attainment did not seem to be due to group differences in goal ratings of importance and effort. Indeed, at baseline, participants in the MEMS group rated their goals as being more valuable/important but also requiring more effort than those in control group, while we found no group differences in participants' reported confidence in achieving their goals. Prior research has shown that perceptions of goal importance and difficulty as well as confidence in completing a goal can impact goal attainment (Locke & Latham, 2002; Clarke et al., 2006). Thus, we also controlled for baseline participant goal ratings of value/importance, effort, and confidence in completing their goal(s) when comparing group overall goal attainment, and the group differences in overall attainment and the large effect size remained. Although it is possible that setting more important and valuable goals could have helped the participants in the MEMS group to achieve more overall goals than the control group, our results suggest that the group differences in goal attainment remained even after accounting for participants' ratings of value/importance as well as the effort and confidence in achieving their goal(s).

However, in contrast to our hypotheses, we did not find that MEMS was more effective at improving effort-cost computations, future reward-value representations, or self-reported motivation than a goal-setting session. This lack of findings for the performance-based tasks was particularly surprising because these tasks were putatively assessing the targeted mechanisms through which we expected motivation to improve; we speculate this may be due to power limitations or the near ceiling level or fixed responses at baseline for several participants, with the latter issues suggesting that these performance-based tasks have limited utility as outcome measures in clinical trials. Alternatively, these tasks may have not effectively represented the constructs we were targeting in MEMS (e.g., were too different, distal) or the tasks may have been "too easy," particularly in comparison to real-world goals that generally require greater effort than button presses.

Table 4
Correlations Between MEMS Engagement and Outcome Change

Measure	*r*
CAINS: Motivation	0.20
QLS–Motivation Index	−0.07
QLS: Motivation item	−0.28
MAP-SR: Motivation	−0.31
Value representation maintenance: % delayed rewards	−0.26
Effort-cost computations: % hard chosen in 88%, high reward trials	−0.61**
CAINS: Anticipatory pleasure	0.43*
CAINS: Past week pleasure	0.21
CAINS: Expressive symptoms	0.21
PANSS: Positive symptoms	−0.09
PANSS: Mood symptoms	−0.06
BNA: Neurocognition	−0.17
WHOQOL: Overall QOL	−0.24
Strauss-Carpenter: Functioning	−0.09

Note. $n = 25$. For Clinical Assessment Interview for Negative Symptoms (CAINS) and Positive and Negative Syndrome Scale (PANSS), positive correlation = higher response rate associated with greater reduction in symptoms. For other measures, negative correlation = higher response rate is associated with greater improvement in measure. MEMS = Mobile Enhancement of Motivation in Schizophrenia; BNA = Brief Neurocognitive Assessment; MAP-SR = Motivation and Pleasure Self-Report; WHOQOL = World Health Organization Quality of Life; QLS = Quality of Life Scale; QOL = quality of life.
* $p < .05$. ** $p < .01$.

Further, this is the first study to our knowledge to use the EEfRT in a clinical trial. Although we chose our primary EEfRT outcome score based on what we believed best aligned with the mechanism we were targeting, given that prior studies have used a range of EEfRT administration modifications and scoring methods (Luther, Firmin, Lysaker, Minor, & Salyers, 2018), additional work could examine whether alternative EEfRT administration and scoring methods may have greater utility and sensitivity in clinical trials. However, importantly, contrasting prior work guiding our decision to select the EEfRT (Barch et al., 2014; Fervaha et al., 2013), recent work has found limited overlap between the EEfRT and the CAINS and QLS–Motivation Index (Luther, Fischer, Firmin, & Salyers, 2019; Luther et al., 2018), suggesting they may measure disparate constructs. To better assess mechanisms of MEMS improvement and to more precisely identify whether effort-cost computations and future reward-value representation maintenance are effective motivational enhancement treatment targets, future work could use more recent performance-based tasks, such as effort discounting tasks (Hartmann et al., 2015), which have shown greater concordance with motivation/negative symptom measures (Luther et al., 2019).

For secondary outcomes, there were significantly greater improvements in anticipatory pleasure for those who received MEMS compared to those in the control group (medium effect size). Past week pleasure also trended toward greater improvement for those in the MEMS group relative to participants in the control group. It may be that as participants worked more regularly toward their goals or had more success attaining subgoals, they had greater anticipated and experienced enjoyment for goal-related activities. The text message reminders about why the subgoals were worth the effort and valuable could also have helped participants to more readily represent future rewards such as pleasure as well as strengthen the mental link between subgoal completion and future rewards, leading to greater anticipated pleasure (Heerey & Gold, 2007). These results suggest that MEMS may reduce the consummatory-anticipatory pleasure gap found in those with schizophrenia (Gard, Kring, Gard, Horan, & Green, 2007). However, there were no significant group differences in the secondary outcomes of positive, mood, and expressive symptoms or neurocognition, quality of life, and functioning. Longer-term studies may help to determine whether the identified effects of MEMS translate into improvements in these more distal symptoms or broader outcomes.

It is possible that the observed improvements related to MEMS in interviewer-rated motivation and recovery-oriented goal attainment as well as anticipatory pleasure were due to alternative mechanisms of change. Although speculative, one possibility is that the social interaction and accountability provided through the text messages may have led to the observed improvements. Indeed, in line with Self-Determination Theory (Ryan & Deci, 2000), which suggests that a sense of connection and belonging is an important component for fostering well-being and motivation, it is possible that interacting daily with someone and receiving more social support via text messages helped to improve interviewer-rated motivation and goal-attainment. It is also possible that the daily text message reminders about participants' subgoals and the anticipated inquiry about subgoal completion could have by themselves helped to directly improve these outcomes. Alternatively, other factors that have been linked to reduced motivation and pleasure such as defeatist beliefs (Grant & Beck, 2009) or decreased competence (Ryan & Deci, 2000) may have been improved by MEMS. It may be that the text messages encouraging participants to engage in activities to support their goals combined with reminders about why the activity is worth the effort and valuable could have reduced defeatist attitudes about goal-related activities (e.g., "It is too hard or will take too much effort, so why try"; "I can't do this well, so why try at all."). Similarly, reinforcing successful goal completion and providing feedback about discrepancies between participants' anticipated effort and actual effort for their daily subgoal, especially when subgoals were easier than expected, could also have helped to improve participants' sense of competence and expectancies of future successful goal completion and associated rewards such as pleasure. Together, MEMS could have resulted in improvements in defeatist thinking and/or competence, which in turn led to improvements in interviewer-rated motivation, recovery-goal attainment, and anticipatory pleasure. Future work is needed to identify whether these alternative mechanisms of change account for the observed effects of MEMS or play a role in other mobile interventions, particularly those targeting motivation reductions or other negative symptoms.

Exploratory analyses revealed that higher MEMS engagement was associated with greater improvements in effort-cost computations and anticipatory pleasure. For effort-cost computations, this may suggest that only those with higher MEMS engagement saw improvements on this domain. Alternatively, the goal-setting session and breaking down overall goals into daily subgoals could have helped to improve effort-cost computations in both groups, obscuring the additional benefits of MEMS on effort-cost computations when conducting group comparisons. Relatedly, MEMS engagement was not significantly associated with interviewer-rated motivation improvements; however, the correlation magnitudes between engagement and the CAINS motivation items, the QLS-motivation item, and self-reported motivation on the MAP-SR were small to medium, further supporting the need for a future trial with a larger sample to provide better estimates of these effects.

Several limitations should be considered. First, we did not examine whether MEMS group improvements were maintained over time. Second, although consistent with or larger than prior text-messaging studies (Ben-Zeev, Kaiser, et al., 2014; Pijnenborg et al., 2010), our sample was relatively small and may have been underpowered to detect some effects; thus, additional work with larger samples is needed to confirm the observed effects. The use of personalized text messages may also pose a challenge for widespread dissemination, given the need for clinical personnel. However, more automated approaches are now available, and future studies could compare the efficacy of a completely automated approach to our more personalized clinician-based approach. Further, although we found that the large majority of participants with at least moderate motivation reductions had a personal cell phone, it may be that those with more significant motivation reductions may be less likely to own a personal cell phone, ultimately impacting the feasibility and scalability of using personal cell phones to deliver mobile interventions. Relatedly, future work is needed to identify who may be most likely to engage and benefit in mobile interventions and identify what factors might impact engagement when mobile interventions are delivered on personal cell phones. Also, we reimbursed text message costs; however, almost all participants had unlimited text message service plans, suggesting reimbursement may not be needed in future work. Finally, although study procedures were in place to have outcome assessors be blind to study conditions, we did not assess whether the blind was broken during follow-up assessments.

Our findings highlight the feasibility of using personal cellphones to deliver text-messaging interventions to support those with schizophrenia-spectrum disorders in real-time, real-world settings. Although more work with higher powered samples is needed to further examine the precise effects of MEMS, our results indicate that MEMS may be an efficacious mobile treatment to improve one of the most debilitating symptoms of schizophrenia—motivation deficits—as well as help participants attain meaningful life-goals supporting their recovery.

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