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Brief Use of Behavioral Activation Features Predicts Benefits of Self-Help App on Depression Symptoms: Secondary Analysis of a Selective Prevention Trial in Young People

Emily Bralee[1], Mohammod Mostazir[1], Fiona C. Warren[2], Alexandra Newbold[1], Claire Hulme[2], Timothy Cranston[2], Benjamin Aas[3], Holly Bear[4], Cristina Botella[5, 6], Felix Burkhardt[7], Thomas Ehring[8], Mina Fazel[4], Johnny R. J. Fontaine[9], Mads Frost[10], Azucena Garcia-Palacios[5, 6], Ellen Greimel[3], Christiane Hößle[8], Arpine Hovasapian[9], Veerle E. I. Huyghe[9], Nanna Iversen[10], Kostas Karpouzis[11], Johanna Löchner[8, 12], Guadalupe Molinari[5, 6], Reinhard Pekrun[8, 13, 14], Belinda Platt[3], Tabea Rosenkranz[8], Klaus R. Scherer[15], Katja Schlegel[16], Bjorn W. Schuller[7, 17, 18], Gerd Schulte-Korne[3], Carlos Suso-Ribera[5, 6], Varinka Voigt[3], Maria Voss[8], and Edward R. Watkins[1, 2]

[1] Sir Henry Wellcome Building for Mood Disorders Centre, School of Psychology, University of Exeter
[2] Faculty of Health and Life Sciences, University of Exeter
[3] Department of Child and Adolescent Psychiatry, Psychosomatics, and Psychotherapy, University Hospital, Ludwig-Maximilians-Universität Munich
[4] Department of Psychiatry, University of Oxford, United Kingdom
[5] Department of Psychology and Clinical Psychology, Universitat Jaume I
[6] Centro de Investigación Biomédica en Red Fisiopatología Obesidad y Nutrición (CIBERObn), Instituto Salud Carlos III
[7] audEERING, Gilching, Germany
[8] Department of Psychology, Ludwig-Maximilians-Universität Munich
[9] Department of Work, Organization and Society, Ghent University
[10] Monsenso Aktieselskab, Copenhagen, Denmark
[11] Department of Communication, Media and Culture, Panteion University of Social and Political Sciences
[12] Department of Child and Adolescent Psychiatry, Psychosomatics, and Psychotherapy, University of Tübingen
[13] Department of Psychology, University of Essex
[14] Institute for Positive Psychology and Education, Australian Catholic University
[15] Department of Psychology, University of Geneva
[16] Institute of Psychology, University of Bern
[17] Embedded Intelligence for Health Care and Well-Being, University of Augsburg
[18] Group on Language, Audio and Music, Imperial College London

Objective: To explore which cognitive behavioral therapy (CBT) self-help app usage predicted depression during a selective prevention trial. ***Method***: A recent controlled trial (ECoWeB-PREVENT) randomized young people aged 16–22, at increased risk for depression because of elevated worry/rumination, negative appraisals, and/or rejection sensitivity but without past or current history of major depression, to apps that provided self-monitoring, self-monitoring plus CBT self-help, or self-monitoring plus emotional competency self-help. Self-help included coping strategies for moment-by-moment use (Tools) and self-learning/planning exercises (Challenges). On the primary outcome (depression, Patient Health Questionnaire-9 [PHQ-9]) at 3-months follow-up (primary endpoint), only the CBT app outperformed self-monitoring. In this secondary analysis, only data from participants who used the CBT or self-monitoring apps at least once were analyzed to test what app use predicted change in depression from baseline to 3 months. ***Results***: Of the original 1,262 participants (79% female), 558 were included (CBT, baseline, n = 273, PHQ-9: M = 7.48, SD = 3.9; 3 months, N = 163, PHQ-9: M = 8.83, SD = 4.92; self-monitoring,

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Edward R. Watkins https://orcid.org/0000-0002-2432-5577

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Multiple uses of data are collected from the same sample: The trial protocol for the overall trial related to this article has already been published, and a separate article reporting the main outcomes of this trial (focused on change in Patient Health Questionnaire-9, Generalized Anxiety Questionnaire-7, and Warwick–Edinburgh Mental Wellbeing Scale) is now published (Watkins et al., 2024).

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continued

baseline, $n = 285$, PHQ-9: $M = 7.45$, $SD = 4.26$; 3 months, $N = 183$, PHQ-9: $M = 7.48$, $SD = 3.9$). Neither total app use, self-monitoring, nor use of Tools predicted change in depression (all $ps > .05$). Frequency of use of Challenges predicted lower depression symptoms and caseness at 3 months ($\beta = -0.28$, 95% CI [−0.53, −0.03], $p = .029$). Specifically, the use of behavioral activation challenges mediated the effects of the CBT app on depression over 3 months ($\beta = -0.59$, 95% CI [−1.13, −0.05], $p = .03$). ***Conclusions***: Brief psychoeducation about behavioral activation principles in an app may protect young people from depression over 3 months, even when only used once.

What is the public health significance of this article?
This study suggests that low frequency use of psychoeducation and planning features focused on behavioral activation principles within a self-help app mediates lower depression symptoms over 3 months in at-risk young people. Brief single-session interventions within self-help apps that concentrate on behavioral activation principles may have benefit for selective prevention.

Keywords: young people, depression, smartphone app, cognitive behavioral therapy, behavioral activation

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The global prevalence of depression is increasing rapidly in young people. Therefore, there is a paramount public health need for scalable and cost-effective prevention approaches. Self-guided mobile phone applications may be one viable platform to disseminate such approaches (Bergin et al., 2020; Linardon et al., 2024). These apps are easily accessible, can be used autonomously and unconstrained by the availability of professional support (i.e., nonconsumable), and can provide instant access to evidence-based coping strategies when needed in real time.

Over the past decade, there has been an extensive proliferation of apps for common mental health problems and well-being, with over 10,000 such apps now available (Torous & Roberts, 2017).

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Emily Bralee played a lead role in conceptualization and data curation, a supporting role in formal analysis, and an equal role in writing–original draft and writing–review and editing. Mohammod Mostazir played a lead role in formal analysis and visualization and a supporting role in writing–original draft and writing–review and editing. Fiona C. Warren played a lead role in data curation and formal analysis and an equal role in methodology, resources, and writing–review and editing. Alexandra Newbold played a supporting role in data curation, methodology, and project administration and an equal role in investigation and writing–review and editing. Claire Hulme played an equal role in methodology, resources, and writing–review and editing. Timothy Cranston played a lead role in software, a supporting role in project administration, and an equal role in writing–review and editing. Benjamin Aas played an equal role in resources and writing–review and editing. Holly Bear played an equal role in investigation, methodology, resources, and writing–review and editing. Cristina Botella played a supporting role in funding acquisition and an equal role in investigation, methodology, project administration, and writing–review and editing. Felix Burkhardt played an equal role in resources and writing–review and editing. Thomas Ehring played a supporting role in funding acquisition and methodology and an equal role in investigation, project administration, resources, and writing–review and editing. Mina Fazel played a supporting role in funding acquisition and an equal role in methodology, project administration, resources, and writing–review and editing. Johnny R. J. Fontaine played a supporting role in funding acquisition and methodology and an equal role in investigation, project administration, resources, validation, and writing–review and editing. Mads Frost played a lead role in software, a supporting role in funding acquisition, and an equal role in resources and writing–review and editing. Azucena Garcia-Palacios played an equal role in investigation, project administration, resources, and writing–review and editing. Ellen Greimel played a supporting role in resources and an equal role in writing–review and editing. Christiane Hößle played a supporting role in resources and an equal role in writing–review and editing. Arpine Hovasapian played an equal role in investigation, project administration, resources, validation, and writing–review and editing. Veerle E. I. Huyghe played an equal role in investigation, project administration, resources, validation, and writing–review and editing. Nanna Iversen played an equal role in resources and writing–review and editing. Kostas Karpouzis played a supporting role in funding acquisition and an equal role in resources and writing–review and editing. Johanna Löchner played an equal role in investigation, project administration, resources, and writing–review and editing. Guadalupe Molinari played an equal role in investigation, project administration, resources, and writing–review and editing. Reinhard Pekrun played a supporting role in funding acquisition and an equal role in resources, validation, and writing–review and editing. Belinda Platt played an equal role in resources and writing–review and editing. Tabea Rosenkranz played an equal role in investigation, resources, and writing–review and editing. Klaus R. Scherer played a supporting role in funding acquisition and methodology and an equal role in resources, validation, and writing–review and editing. Katja Schlegel played an equal role in resources and writing–review and editing. Bjorn W. Schuller played a supporting role in funding acquisition and an equal role in project administration, resources, and writing–review and editing. Gerd Schulte-Korne played a supporting role in funding acquisition and resources and an equal role in writing–review and editing. Carlos Suso-Ribera played an equal role in investigation, project administration, resources, and writing–review and editing. Varinka Voigt played an equal role in resources and writing–review and editing. Maria Voss played an equal role in investigation, project administration, resources, and writing–review and editing. Edward R. Watkins played a lead role in funding acquisition, methodology, project administration, and supervision, a supporting role in formal analysis, and an equal role in investigation, resources, writing–original draft, and writing–review and editing.

Correspondence concerning this article should be addressed to Edward R. Watkins, Sir Henry Wellcome Building for Mood Disorders Centre, School of Psychology, University of Exeter, Exeter EX4 4QG, United Kingdom. Email: e.r.watkins@exeter.ac.uk

However, not all publically available apps are based on robust science and established treatment principles (Bakker et al., 2016). Those apps which do have an evidence base for efficacy have tended to adapt existing interventions that have been validated in face-to-face delivery, such as cognitive behavioral therapy (CBT). Systematic reviews and meta-analyses have identified that apps based on evidence-based interventions, including CBT, behavioral activation (BA), and mindfulness, significantly reduce depression and anxiety and improve well-being in young people and adults compared with control conditions (Bakker et al., 2016; Linardon et al., 2024) and can have preventive effects for anxiety and depression (Edge et al., 2023). There is also evidence that the longer participants use and engage with an app, the more helpful it is (Zhang et al., 2019).

Mental health apps incorporate a range of content and components. However, there is currently uncertainty as to which of these elements may be the active ingredients within the app, that is, the individual components of an intervention that facilitate a positive behavior change and lead to improvement in depressive symptoms. Identifying the active ingredients within an intervention potentially provides a means to prioritize and strengthen these components to maximize their effectiveness and benefits (Goldberg et al., 2022; Watkins & Newbold, 2020). This is particularly important for apps because app use is often suboptimal, typically declining within a few weeks and with not all treatment features utilized (Baumel et al., 2019; Linardon & Fuller-Tyszkiewicz, 2020). Selecting and concentrating the elements in the app to those with an active effect would increase the likelihood that users are exposed to the effective aspects of an intervention even with limited app use.

To date, there is preliminary evidence that self-monitoring, BA approaches such as activity scheduling, cognitive restructuring, mindfulness, and relaxation exercises within apps may be associated with reductions in depression (Bakker & Rickard, 2018; Dahne et al., 2019; Furukawa et al., 2018; Kauer et al., 2012; Kwasny et al., 2019; Moberg et al., 2019). Nonetheless, this evidence is preliminary, and recommendations have been made for more granular examination of the techniques in apps to disentangle their potential active ingredients (Bakker et al., 2016; Goldberg et al., 2022). Moreover, evidence to date has focused on the active elements within apps for the acute treatment of depression rather than preventing depression.

The recently completed ECoWeB-PREVENT trial (Newbold et al., 2020; Watkins et al., 2024) provided an opportunity to explore how the use of app features may be associated with the prevention of depression in young adults, via a secondary analysis. The main trial explored the efficacy of three unsupported smartphone self-help apps (self-monitoring app only, a generic CBT self-help app, or an app that focused on training two personalized aspects of emotional competence [EC] skills). Each app included the same self-monitoring features, and in addition the CBT and EC apps included psychoeducation, behavioral experiments, planning and learning exercises (called Challenges), and brief strategies that young people could use in the moment when they needed them (called Tools). The CBT app included elements identified as central to CBT, unlike most mental health apps, which lack core CBT elements such as cognitive restructuring and problem solving (Wasil et al., 2019). The CBT self-help app resulted in reduced depressive and anxiety symptoms and improved well-being, functioning, and quality of life at 3-month follow-up relative to the self-monitoring only app, while there was no benefit for the EC self-help app.

As such, this data set affords the opportunity to examine the relationship of self-monitoring and the use of different CBT strategies (including BA, cognitive restructuring) in influencing future levels of depression in a not currently depressed sample via a secondary analysis of app usage within the CBT app versus the self-monitoring app. The structuring of the CBT app into Challenges versus Tools enabled an exploratory analysis of different ways of delivering CBT within the app. Because engagement with mental health apps is often low (Zhang et al., 2019), the Challenge elements were explicitly designed to be consistent with the single-session intervention concept recognizing that participants may only use each Challenge once. Single-session interventions consisting of only one encounter with a clinician or intervention lasting 5 min to 2 hr and brief psychoeducation focused on increasing knowledge, changing mindsets, and empowering users with increased perceived control can reduce anxiety and depression (Schleider et al., 2020, 2022; Schleider & Weiss, 2016, 2017). Paralleling features identified as useful for single-session interventions (Schleider et al., 2020), our Challenges included psychoeducation, information to normalize user's experience, and action plans. In parallel, Tools were explicitly designed to be brief coping exercises (e.g., a relaxation audio-recording) to be used in the moment as needed by the participant, taking advantage of convenient and ready access to the mobile phone. Such access may support repeated practice, proposed as necessary to effectively change underlying habits of thinking and action (e.g., Harvey et al., 2022; Marteau et al., 2012; Watkins & Nolen-Hoeksema, 2014).

The primary objective was to determine which aspect of app usage during the 3-month follow-up period predicted change in self-reported depression. Given the null effects of the EC app in the main trial and the question of what elements within an app may be important for preventative effects, this secondary analysis examined the role of app usage in the comparison between the self-guided CBT app and the self-monitoring app. By discriminating between Tools and Challenges, we examined the relative utility of CBT elements designed to be beneficial for single-session use (Challenges) versus those designed for repeated in-the-moment use (Tools). Based on prior evidence, we hypothesized that (a) the frequency of self-monitoring will be associated with less depression; (b) the use of BA elements would be associated with less depression; (c) the use of cognitive restructuring elements would be associated with less depression.

Method

Study Design

This is a secondary analysis of data from the ECoWeB-PREVENT trial, a superiority parallel three-arm randomized multicenter, multinational trial within a larger cohort multiple randomized controlled trial. Full details on the methods are reported in the protocol and primary articles (Newbold et al., 2020; Watkins et al., 2024) (trial registration: ClinicalTrials.gov NCT04148508). We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Eligible participants were randomized (in 1:1:1 ratio) into one of three

self-help app arms, using a validated, secure, bespoke, encrypted web service created and managed by a U.K. CRC registered Clinical Trials Unit, and minimized according to recruitment country (United Kingdom, Germany, Spain, Belgium), age (under 18 years old vs. 18 years or older), and gender (male, female, both, neither). The control arm involved access to an app that only supports self-monitoring of emotions, plus any additional usual care a participant may receive external to the trial (self-monitoring-app + usual care). The other two arms involved the receipt of generic CBT self-help strategies within the app (the active arm for this secondary analysis as it was found to outperform the self-monitoring app control arm) and of personalized EC self-help strategies within the app (not further examined in this secondary analysis because it did not outperform self-monitoring), with both apps occurring in addition to self-monitoring and usual care. All participants were followed up at 1-month, 3-months, and 12-months postrandomization for the main trial, with this secondary analysis focusing on the 3-month follow-up as the primary outcome. All outcome assessors and statisticians were blind to treatment allocation. The trial sites were four universities in the United Kingdom, Germany, Spain, and Belgium. Ethics approval was provided by each site's respective institutional Research Ethics Boards. The trial was conducted between October 15, 2020, and August 3, 2022.

Participants

For the primary trial, young people (aged 16–22) were recruited across the United Kingdom, Germany, Spain, and Belgium via online and website advertising; a social media and press campaign; newsletters and other circulars; and notice boards within schools, colleges, and universities. Eligibility inclusion criteria were (a) aged 16–22 years old; (b) living in the United Kingdom, Germany, Spain, or Belgium; (c) having basic literacy in at least one of the respective languages; (d) able to provide informed consent and obtain parental consent for those aged under 18 years old in Germany and Belgium; (e) having regular access to a smartphone (Android or iOS); and (f) identified as at elevated risk for future depression based on baseline EC measures that assessed rumination and worry, achievement appraisals (perceived control, achievement value), and rejection sensitivity. Elevated vulnerability was defined as scoring in the worst performing quartile on at least one of each measure assessing each component and scoring in the worst performing tercile on the second measure for the same component if two measures were used (see Supplemental Material S1 for full details). Individuals scoring in the worst quartile on measures of these components have been shown to have elevated risk for subsequent depression and anxiety in previous research (Hankin et al., 2018; Topper et al., 2017). As a trial intended to investigate primary prevention of depression, participants were excluded from the cohort at baseline if they presented with a current or past episode of major depressive disorder (according to *Diagnostic and Statistical Manual of Mental Disorders, fifth edition* psychiatric criteria), determined in structured self-report electronic screening. Other exclusion criteria included active suicidality; any self-reported history of severe mental health problems such as bipolar disorder and psychosis; and currently receiving psychological therapy, counseling, or psychiatric medication including antidepressants. For this secondary analysis, we necessarily only analyzed participants who signed into and accessed the app before the targeted follow-up date (i.e., where there are data to examine app usage against outcome).

Interventions

Both interventions were different versions of the same app, designed for iOS and Android, with identical architecture, menu structure (e.g., dashboard to monitor notifications and progress), format, and design features, but with different content provided subject to the respective condition (see Supplemental Material S2). Both versions included self-monitoring that had a daily mood rating, emotional diary option, and ecological momentary assessments for more detailed analysis of mood, activity, and situational context (with five prompts a day for the first 14 days) and a feature that allowed users to graph and view their self-monitoring entries. Challenges and Tools included text, picture, animated videos, audio exercises to practice, questionnaires with tailored feedback, and quizzes. For example, the "What I Enjoy" Challenge included brief animated videos explaining the value of increasing positive activity to improve mood and an activity scheduling exercise to identify and plan when, where, and how to engage in enjoyable activities. For some CBT elements (thought challenging; problem solving), there were complementary Challenges and Tools. For example, for thought challenging, the Challenge provided psychoeducation, worked examples, and quizzes to illustrate how to challenge thoughts, and the Tool provided prompt questions to guide in-the-moment review of thoughts. All the app interventions were developed with extensive codesign with young people through several iterative cycles of refining and feedback. The CBT app featured generic well-established CBT principles and strategies including BA, relaxation, exposure, problem solving, and spotting and challenging negative thoughts. The self-monitoring app only included the self-monitoring and general features, with no Tools or Challenges.

To increase compliance and adherence on the app, completion of self-monitoring, Challenges, and Tools were gamified, with badges earned for compliance and progress on each and electronic vouchers earned (£10/10€) when sets of badges were completed. For further details on the CBT intervention, see Table 1. All interventions included usual practice, whether that was provision of no intervention, support from general practitioner/family doctor, local health services or youth services, or provision of intervention within their educational institution.

Procedure and Assessments

Potential participants were invited to a study website that provided further information and a brief online prescreener to check age and country, access to electronic informed consent, and an online baseline survey. The survey included standardized, well-validated self-report questionnaires and tasks to assess current and lifetime history of depression; depression symptoms (Patient Health Questionnaire-9 [PHQ-9]; Kroenke et al., 2001); anxiety (Generalized Anxiety Disorder-7; Spitzer et al., 2006); well-being (Warwick–Edinburgh Mental Wellbeing Scale; Tennant et al., 2007); social and education/work functioning; health-related quality of life; and EC skills, in English, German, Spanish, or Flemish Dutch (see protocol article Newbold et al., 2020, and Supplemental Material S3 for further details). The Lifetime Depression Assessment Self-Report questionnaire (LIDAS) assessed lifetime major depression diagnosis

Table 1
Description of Challenges and Tools Within the CBT Self-Help App

Name of challenge	Description of feature	Category
MyPersonalMoodCoach	A series of questions asking participants to select what they want to get out of the MyMoodCoach app. Automated recommendations on which tools and challenges to use are provided based on the goals and questions answered by participant.	n/a
What I enjoy	Animated video describing principles of behavior activation, emphasizing the value of increasing positive activities. This is followed by an interactive exercise in which the participant identifies enjoyable activities and then schedules when, where, and how they will engage in these (activity scheduling plan).	Behavioral activation
My goals	Goal setting. A series of questions help the participant to identify and commit to a goal to work toward that week and to identify and plan three activities to work toward achieving the goal. MoodTracker can be used to report completion of each activity, exploring how each activity made them feel. Activity scheduling.	Behavioral activation
Identifying and challenging angry thoughts	Animated video providing psychoeducation on thought patterns and how they influence how we feel. A series of vignettes to work through with multiple choice questions to identify examples of angry thoughts and examples of helpful challenges with the opportunity to practice identifying and challenging the participants own angry thoughts. Psychoeducation on core principles of thought challenging	Cognitive restructuring
Identifying and challenging anxious thoughts	Animated video providing psychoeducation on thought patterns and how they influence how we feel. A series of vignettes to work through with multiple choice questions to identify examples of anxious thoughts and examples of helpful challenges with the opportunity to practice identifying and challenging the participants own anxious thoughts. Psychoeducation on core principles of thought challenging	Cognitive restructuring
Identifying and challenging sad thoughts	Animated video providing psychoeducation on thought patterns and how they influence how we feel. A series of vignettes to work through with multiple choice questions to identify examples of sad thoughts and examples of helpful challenges with the opportunity to practice identifying and challenging the participants own sad thoughts. Psychoeducation on core principles of thought challenging	Cognitive restructuring
Identifying avoidance	Psychoeducation provided as to the negative consequences of avoidance with information on the benefits of reducing avoidance. Scenarios of common situations and activities people avoid are described, and the participant selects and rates how distressing they would find each situation/activity. They choose one of the avoidant situations/activities and plan when/how they will approach it (exposure hierarchy). Psychoeducation for using this exercise as a coping strategy for avoidance.	Tackling problems (or behavioral activation or identifying avoidance)[a]
Problem solving	Psychoeducation is provided about the steps of problem solving. A hypothetical problem is described, and the participant is guided through the steps of CBT problem solving (identifying problem; brainstorming alternatives; rating their pros and cons; selecting an option; putting into action; evaluating outcome). Once problem-solving steps have been applied to the scenario, the participant can identify a problem of their own and apply the problem-solving steps.	Tackling problems

(*table continues*)

Table 1 (*continued*)

Name of challenge	Description of feature	Category
My rules	Psychoeducation describing how a person's rules and beliefs can influence their thoughts, feelings, and responses, highlighting how extreme, unbalanced, and unrealistic beliefs can be unhelpful. Highlights examples of conditional beliefs and unhelpful beliefs, for example, perfectionism. Quiz and psychoeducation exploring thought processes and exploring a balanced/unbalanced view of the world.	Cognitive restructuring
Name of tool	**Description of feature**	**Category**
Relaxation	Psychoeducation on usefulness of relaxation. Three audio exercises to use to relax in the moment reflecting progressive muscular relaxation and focus on present and body scan exercises.	Relaxation
Challenge angry thoughts	Series of Socratic questions reviewing evidence and alternative interpretations for participant to complete to guide them through applying cognitive restructuring to an angry thought in the moment	Cognitive restructuring
Challenge anxious thoughts	Series of Socratic questions reviewing evidence and alternative interpretations for participant to complete to guide them through applying cognitive restructuring to an anxious thought in the moment	Cognitive restructuring
Challenge sad thoughts	Series of Socratic questions reviewing evidence and alternative interpretations for participant to complete to guide them through applying cognitive restructuring to a sad thought in the moment	Cognitive restructuring
Problem solving	Series of Socratic questions working the standard steps of problem solving (identifying the problem; brainstorming possible solutions; reviewing their pros and cons; selecting and making a concrete plan) to be used in the immediate moment	Tackling problems
Instant mood boost	User chooses between a positive action, imagery, or self-affirmation. Participant identifies and records personal strengths/qualities, a happy time, or a thought/behavior to do to make them feel happy	Behavioral activation/cognitive restructuring

Note. We conducted sensitivity analyses of these different categorizations (reported in Supplemental Materials S5, Table S5.1 to S5.4): The same pattern of results was found—use of the behavioral activation challenge subcomponent always had the strongest association with depression outcome. CBT = cognitive behavioral therapy app.

[a] There was some debate as to whether identifying avoidance should be categorized into tackling problems, into behavioral activation, or as its own discrete activity.

according to *Diagnostic and Statistical Manual of Mental Disorders, fifth edition* criteria (Bot et al., 2017). Country of residence and birth, age, self-reported gender (response options: male, female, both, neither), educational level, and family's occupational status were assessed at baseline only. Follow-up assessments repeating these measures took place at 1-, 3-, and 12-months postrandomization, each incentivized with a £10/10€ voucher for completion. Those ineligible for the trial were automatically directed to relevant web pages explaining their exclusion and guided to sources of help where relevant. Parental consent was sought for relevant participants via a link to pass onto parents/guardians. The primary outcome for the main trial was depression symptoms as assessed by PHQ-9 measured at 3-months postrandomization (primary endpoint). For the purposes of this secondary analysis, we therefore focus on PHQ-9 at 3-months postrandomization.

App Use Metrics

Each of the apps was made available to be signed into for each participant at the point of randomization. Participants in the trial were encouraged to use the app frequently, but the use of the app was left entirely up to the participants. There was no set order or limitations on what participants could use; participants were free to navigate each app as they chose and to use any combination of available Tools, Challenges, or self-monitoring in any order. The apps were available to be used throughout the entire duration of the trial, although most use was in the first 2–4 weeks. Because the current analysis focused on how app usage related to the outcomes assessed at 3-month follow-ups, usage metrics were limited to usage within the time window up to the 3-month follow-up. Our primary metric is *frequency of use*, measured as the total number of times an element in the app was used. The user's experience of the CBT app was structured around self-monitoring, Tools, and Challenges, with the dashboard, menus, notifications, and gamified badges arranged around each feature (see Supplemental Figure S2.6). As such, we initially examined app usage by these structural app features. To test our hypotheses regarding BA and cognitive restructuring, we then clustered Challenges into those consistent with BA, cognitive restructuring, or tackling problems categories and separately did the same for Tools (see Table 1 for further details).

Statistical Analysis

The power calculation and the prespecified analyses for the main outcome are described in the trial protocol (Newbold et al., 2020) and main outcome article (Watkins et al., 2024): Based on a minimum clinically important difference (MCID) for the primary outcome (PHQ-9) of 2.59 and *SD* of 5.4 at 90% power and two-sided α of 0.05 and assuming 40% attrition at 3-month follow-up (primary endpoint), we required 155 participants per arm (465 in total). However, because a fire at the server center supporting the app platform during the trial led to the app platform being offline for 1 month, at the advice of our independent Trial Steering Committee, we replenished additional participants to account for those participants potentially impacted by the outage, giving a revised target of 1,107.

For this secondary analysis, hierarchical regression models were developed to explore the effects of app use on outcome, with separate models examining frequency of total app use and then exploring the effect of each of the distinct features (Tools, Challenges, self-monitoring features). All models were adjusted for baseline PHQ-9 and trial arm (CBT vs. self-monitoring). We employed mediation models to estimate the indirect effect of trial condition on outcome through the use of challenges and tools as the intermediate meditating variables. The total effect of trial condition (direct + indirect effect) was estimated, and the proportion of the total effect that was mediated by the indirect effect was further calculated (indirect effect/total effect). Standard errors of the indirect effects were bootstrapped 1,000 times. Mediation models were developed using structural equation modeling framework.

Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulation, and all measures in the study. The main study protocol is published at Newbold et al. (2020). Deidentified individual participant data and a data dictionary defining each field used for analysis will be made available after approval of an analysis proposal by the project steering committee, contacted via the corresponding author. All analyses were conducted with the statistical analytical software Stata Version 18.0 (College Station, Texas, 77845, United States). The main study design and analysis were preregistered, but this secondary analysis was not.

Results

Demographic information is presented as frequencies and percentage, and descriptive statistics are presented as mean, standard deviation, and range (see Table 2).

Participants

A total of 558 participants were included in the analyses of app usage for CBT app versus self-monitoring app. A detailed description of all participants, primary outcomes, and a flow diagram is available in the main outcome article. Analyses were conducted according to the intention-to-treat principle. The number of participants in the current analysis is lower than the original trial because of the incorporation of different app components usage variables (as covariates) into the regression models, which dropped cases with missing or no app usage values: 21% of participants across all arms never signed into the app. Table 2 reports the demographics for the participants. Primary outcome (PHQ-9) at 3-month follow-up was available for 64% participants in the self-monitoring arm ($n = 183$) and 60% in the CBT arm ($n = 163$). The missingness in outcome data was assumed to be at least at random, and there was no statistically significant difference in the missingness of PHQ-9 at 3 months between the two arms ($\chi^2 = 1.20$, $p = .273$).

General App Use

Table 2 details the frequency of total app and of feature use for the CBT self-help app and the self-monitoring app. Overall, there was more frequent use of self-monitoring (overall frequency of app use: $M = 133$ occasions, $SD = 56$), with low frequency of use of Tools and Challenges in the CBT app (mean use for each specific Tool or Challenge is less than once). There was no statistical difference in the frequency of app use between the CBT and self-monitoring apps (Δ6.07, 95% CI [−3.39, 15.54], $p = .21$).

Relationship Between App Use and Outcome

The frequency of total app use was not significantly related to change in depression symptoms at 3-month follow-up (see Table 3).[1] Replicating the significant effect from the intention-to-treat analysis in the primary outcome article, depression symptoms (PHQ-9) at 3-month follow-up were significantly lower in participants randomized to the CBT app relative to those randomized to the self-monitoring app (β = −1.05, 95% CI [−1.94, −0.15], $p = .02$), reflecting a smaller increase in depression from baseline to 3-month follow-up for participants receiving the CBT app relative to those receiving the self-monitoring app (although less than the minimum clinically important difference for PHQ-9; see Tables 2, 3). There was a trend toward an interaction between condition and frequency of app use in their relationship with change in depression, $F(1, 341) = 2.93$, $p = .088$, reflecting lower depression symptoms at 3-month follow-up for higher frequency use of the app in the CBT arm compared to the self-monitoring arm. Further analysis showed that at mean level of their app usage, the CBT app arm was significantly lower in depression symptoms relative to the self-monitoring app arm (mean difference PHQ-9: −1.05, 95% CI [−1.95, −.16], $p = .021$).

When we examined the effects of the specific features within the app within the hierarchical regression, after adjusting for baseline depression symptoms (see Table 3), neither the use of self-monitoring nor Tools were significant predictors for depression symptoms at the 3-month follow-up ($p > .05$).[2] Nonetheless, when including the use of self-monitoring and Tools within the model, the use of Challenges was significantly associated with reduction in depression symptoms at 3-month follow-up. In the fully adjusted model, a one unit increase in the use of Challenges was associated with a reduction in depression symptoms by β = −0.28, 95% CI

[1] The analyses described below were repeated with anxiety (Generalized Anxiety Disorder-7) and well-being (Warwick–Edinburgh Mental Wellbeing Scale) as outcomes instead of depression. None of the app usages were associated with change in these outcomes. In the interests of brevity and given the focus on prevention of depression, these results are not reported further in the main text but are summarized in Supplemental Materials S4 Tables 1 and 2.

[2] Hierarchical regression analysis examining the relationship between use of individual Tools and 3-month follow-up PHQ9, controlling for baseline PHQ9, found no significant association between the use of any individual Tool and depression at follow-up—see Table 4.

Table 2

Sociodemographic Characteristics at Baseline, Symptom Scores at Baseline, and 3-Month Follow-Up and App Usage Over 3 Months

Characteristic	Self-monitoring (n = 285)			CBT (n = 273)		
	n	%		n	%	
Country n (%)						
England	101	51		98	49	
Spain	113	54		96	46	
Germany	52	47		59	53	
Belgium	19	49		20	51	
Gender n (%)						
Female	220	49		227	51	
Male	58	60		39	40	
Other	7	50		7	50	
Ethnicity n (%)						
White	236	50		232	50	
Black/Asian/others	49	54		41	46	
Educational attainment n (%)						
Primary/secondary level	114	56		90	44	
College level and above	171	49		181	51	
Continuous variable	M	SD	Range	M	SD	Range
Age	18.64	1.96	15–22	18.88	1.98	16–22
Socioeconomic index	57.9	15.26	10–85	58.46	15.4	10–85
Outcomes						
Baseline PHQ-9	7.45	4.26	0–20	7.48	3.9	0–20
3-month follow-up PHQ-9	8.83	4.92	0–25	7.75	4.51	0–22
Baseline GAD-7	7.26	4.19	0–19	7.01	4.3	0–21
3-month follow-up GAD-7	7.71	4.49	0–19	7.1	4.43	0–21
Baseline WEMWBS	48.22	7.65	29–70	48.44	7.11	28–65
3-month follow-up WEMWBS	46.01	9.31	16–70	47.14	8.71	21–70
App usage						
Total app usage	131.15	51.59	0–344	137.23	62	0–375
Self-monitoring usage	131.15	51.59	0–344	132.4	59.1	0–357
Challenge usage	0	0	0–0	2.44	2.72	0–11
Tools usage	0	0	0–0	2.4	4.61	0–19
Self-monitoring components						
EMA usage	111.27	46.71	0–210	107.49	46.6	0–210
Daily mood rating	10.06	18.83	0–112	12.47	22.6	0–120
Emotion diary rating	9.82	18.53	0–112	12.44	22.6	0–120
Challenge components						
Behavioral activation	0	0	0–0	0.67	0.86	0–5
Cognitive restructuring	0	0	0–0	0.79	1.14	0–5
Tackling problems	0	0	0–0	0.51	0.76	0–2
MyPersonalMoodCoach	0	0	0–0	0.47	0.54	0–2
Tools components						
Challenge angry thoughts	0	0	0–0	0.11	0.36	0–2
Challenge anxious thoughts	0	0	0–0	0.23	0.63	0–4
Challenge sad thoughts	0	0	0–0	0.13	0.39	0–3
CBT: Relaxation	0	0	0–0	0.99	2.71	0–16
Instant mood boost	0	0	0–0	0.72	1.76	0–13
Problem solving	0	0	0–0	0.22	0.54	0–3

Note. PHQ-9 3-month follow-up: self-monitoring (n = 183), CBT (n = 163). Socioeconomic index (SEI) was indexed with an international SEI of occupational status (Ganzeboom et al., 1992) based on highest reported occupation from individual participant or either of their parents. SEI was available for 90% of the sample (n = 504/558; self-monitoring: n = 282; CBT: n = 272). Those not available either responded with "prefer not to answer" or "student." Example occupation scores include 25 for manual worker, 49 for nurse, 58 for associated health care professionals (e.g., optician, physiotherapist, occupational therapist, radiologist), teacher 71, and medical doctor 85. CBT = cognitive behavioral therapy app; EMA = ecological momentary assessment; the challenge and tools components reported in detail were only available in the CBT app; MyPersonalMoodCoach was a challenge common to both apps that pointed users to relevant content for their goals and concerns for each version; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Questionnaire-7; WEMWBS = Warwick–Edinburgh Mental Wellbeing Scale.

Table 3
Relationship of App Component Usage With Depression at 3-Month Follow-Up, Accounting for Baseline Depression

Variable		Estimate (*B*)	*SE*	95% CI		R^2
				LL	*UL*	
Frequency of total app usage						
Step-0	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
Step-1	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
	Total app usage	−0.00	0.00	−0.01	0.00	
Step-2	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	Total app usage	−0.00	0.00	−0.01	0.01	
	Trial condition	−1.05*	0.46	−1.94	−0.15	
Step-3	Baseline PHQ-9	0.55***	0.06	0.44	0.66	0.23***
	Total app usage	0.01	0.01	−0.01	0.02	
	Trial condition	0.77	1.15	−1.50	3.04	
	Trial condition by app usage	−0.01	0.01	−0.03	0.00	
Frequency of app features usage						
Step-0	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
Step-1	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
	Self-monitoring usage	−0.00	0.00	−0.01	0.01	
Step-2	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	Self-monitoring usage	0.00	0.00	−0.01	0.01	
	Challenge usage	−0.24*	0.10	−0.43	−0.05	
Step-3	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	Self-monitoring usage	0.00	0.00	−0.01	0.01	
	Challenge usage	−0.28*	0.13	−0.53	−0.03	
	Tools usage	0.03	0.07	−0.11	0.18	
Step-4	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	Self-monitoring usage	−0.00	0.00	−0.01	0.01	
	Challenge usage	−0.20	0.15	−0.50	0.09	
	Tools usage	0.04	0.07	−0.11	0.18	
	Trial condition	−0.59	0.59	−1.74	0.57	

Note. CI = confidence interval for *B*; *SE* = standard error; *LL* = lower limit; *UL* = upper limit. Trial condition = CBT app arm relative to self-monitoring arm as control. PHQ-9 = Patient Health Questionnaire-9.
* $p < .05$. *** $p < .001$.

[−0.53, −0.03], $p = .029$, that is, a direct relationship between Challenge use and symptom reduction.

In a further planned hierarchical regression analysis, we examined the nature of which categories of Challenges may be most associated with benefit for depression (see Table 4). This model found that the use of BA Challenges in the CBT app was significantly associated with fewer depression symptoms at 3-months follow-up, after controlling for the other categories of Challenges (β = −1.27, 95% CI [−2.26, −0.29], $p = .011$; the use of cognitive restructuring Challenges showed a trend to be associated with fewer depression symptoms (β = −0.59, 95% CI [−1.22, −0.04], $p = .06$), but the use of tackling problems Challenges was associated with increased depression symptoms (β = 1.59, 95% CI [0.43, 2.76], $p = .008$).

We also examined the relationship between app use and caseness of depression as determined by a well-established threshold on the PHQ-9 score (≥10) (see Supplemental Material S6 for full details). In brief, after controlling for baseline PHQ-9, the odds of depression caseness at 3 months were significantly lower in the CBT app arm relative to the self-monitoring app arm (*OR*: 0.54, 95% CI [0.33, .088], $p = .031$). Replicating our prior analyses, only the use of Challenges was significantly associated with lower caseness of depression at 3-month follow-up (*OR*: 0.86, 95% CI [0.75, 0.99], $p = .043$). The use of BA Challenges (*OR*: 0.33, 95% CI [0.16, 0.65], $p = .002$) and cognitive restructuring Challenges (*OR*: 0.29, 95% CI [0.48, 1.01], $p = .057$) were both associated with lowered incidence of depression caseness at 3 months. In contrast, the use of tackling problems Challenges was associated with increased depression caseness (*OR*: 3.35, 95% CI [1.55, 7.26], p = .002).

App Use as a Potential Mediator of the Effect of Treatment on Outcome

Because the CBT self-help app resulted in a smaller increase in depression symptoms than the self-monitoring app and only the use of BA Challenges was significantly associated with reduced depression symptoms at 3-month follow-up, we tested whether the use of Challenges mediated the benefit of the CBT self-help app. First, the model tested whether trial condition influenced the potential mediator; unsurprisingly, this was significant for Tools and Challenges overall and for their specific categories, given that the Challenges were only available in the CBT self-help app arm (see Table 5). Critically, there was also a significant indirect effect, reflecting a significant interaction between the effect of trial condition on the use of BA Challenges and of the use of BA Challenges on depression symptoms, indicating that the use of BA Challenges mediated the benefits of the CBT app on depression symptoms (β = −0.59, 95% CI [−1.13, −0.05], $p = .03$), accounting for 55.1% of the total effect on PHQ-9. The use of none of the other app features met criteria for a mediator of the change in depression symptoms, although there was a trend for the use of cognitive restructuring Challenges to mediate changes in depression symptoms (β = −0.41, 95% CI [−0.86, 0.05], $p = .06$). The use of BA Challenges similarly

Table 4

Relationship of App Subcomponent Usage With Depression at 3-Month Follow-Up, Accounting for Baseline Depression

Variable		Estimate (*B*)	*SE*	95% CI *LL*	95% CI *UL*	R^2
Frequency of self-monitoring subcomponent use						
Step-0	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
Step-1	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
	EMA usage	−0.00	0.01	−0.01	0.01	
Step-2	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
	EMA usage	−0.00	0.01	−0.01	0.01	
	Daily mood rating	−0.00	0.01	−0.02	0.02	
Step-3	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	EMA usage	−0.00	0.01	−0.01	0.01	
	Daily mood rating	0.06	0.09	−0.11	0.23	
	Emotion diary rating	−0.06	0.09	−0.23	0.11	
Step-4	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	EMA usage	−0.00	0.01	−0.01	0.01	
	Daily mood rating	0.04	0.09	−0.13	0.22	
	Emotion diary rating	−0.05	0.09	−0.22	0.13	
	Trial condition	−1.06*	0.46	−1.96	−0.16	
Frequency of challenge subcomponent use						
Step-0	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
Step-1	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	Behavioral activation	−0.90**	0.31	−1.52	−0.29	
Step-2	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	Behavioral activation	−0.68	0.39	−1.44	0.09	
	Cognitive restructuring	−0.28	0.29	−0.85	0.29	
Step-3	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.25***
	Behavioral activation	−1.38**	0.47	−2.30	−0.45	
	Cognitive restructuring	−0.62*	0.31	−1.24	0.00	
	Tackling problems	1.53**	0.58	0.38	2.68	
Step-4	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.25***
	Behavioral activation	−1.27*	0.50	−2.26	−0.29	
	Cognitive restructuring	−0.59	0.32	−1.22	0.04	
	Tackling problems	1.59**	0.59	0.43	2.76	
	MyPersonalMoodCoach	−0.39	0.65	−1.67	0.90	
Step-5	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.25***
	Behavioral activation	−1.21*	0.51	−2.21	−0.20	
	Cognitive restructuring	−0.55	0.33	−1.19	0.09	
	Tackling problems	1.59**	0.59	0.42	2.76	
	MyPersonalMoodCoach	−0.27	0.68	−1.61	1.07	
	Trial condition	−0.37	0.59	−1.52	0.79	
Frequency of tool subcomponent use						
Step-0	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
Step-1	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.21***
	CBT: Relaxation	−0.08	0.09	−0.26	0.11	
Step-2	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	CBT: Relaxation	−0.02	0.10	−0.21	0.18	
	Instant mood boost	−0.26	0.15	−0.57	0.04	
Step-3	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	CBT: Relaxation	−0.03	0.11	−0.24	0.18	
	Instant mood boost	−0.28	0.16	−0.59	0.03	
	Problem solving	0.20	0.56	−0.91	1.30	
Step-4	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	CBT: Relaxation	−0.03	0.11	−0.24	0.18	
	Instant mood boost	−0.31	0.17	−0.64	0.02	
	Problem solving	0.08	0.60	−1.10	1.25	
	Challenge angry thoughts	0.56	0.97	−1.35	2.48	
Step-5	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	CBT: Relaxation	−0.04	0.11	−0.26	0.17	
	Instant mood boost	−0.32	0.17	−0.65	0.02	
	Problem solving	0.04	0.60	−1.14	1.23	
	Challenge angry thoughts	0.48	0.99	−1.47	2.43	
	Challenge anxious thoughts	0.24	0.52	−0.78	1.25	

(*table continues*)

Table 4 (*continued*)

Variable		Estimate (*B*)	*SE*	95% CI		R^2
				LL	*UL*	
Step-6	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.22***
	CBT: Relaxation	−0.04	0.11	−0.26	0.18	
	Instant mood boost	−0.31	0.17	−0.65	0.02	
	Problem solving	0.08	0.62	−1.13	1.30	
	Challenge angry thoughts	0.52	1.00	−1.45	2.49	
	Challenge anxious thoughts	0.27	0.53	−0.77	1.32	
	Challenge sad thoughts	−0.24	0.83	−1.87	1.39	
Step-7	Baseline PHQ-9	0.54***	0.06	0.43	0.65	0.23***
	CBT: Relaxation	−0.02	0.11	−0.23	0.20	
	Instant mood boost	−0.25	0.17	−0.59	0.09	
	Problem solving	0.26	0.62	−0.96	1.49	
	Challenge angry thoughts	0.49	1.00	−1.47	2.45	
	Challenge anxious thoughts	0.40	0.53	−0.65	1.44	
	Challenge sad thoughts	−0.15	0.83	−1.77	1.48	
	Trial condition	−1.02*	0.51	−2.02	−0.02	

Note. CI = confidence interval for *B*; *SE* = standard error; *LL* = lower limit; *UL* = upper limit. Trial condition = CBT app arm relative to self-monitoring arm as control. PHQ-9 = Patient Health Questionnaire-9; EMA = ecological momentary assessment; CBT = cognitive behavioral therapy app.
* $p < .05$. ** $p < .01$. *** $p < .001$.

mediated the effect of the CBT app on rates of depression caseness at 3 months (see Supplemental Table S6.3).

Discussion

This secondary analysis of a large-scale trial of self-help apps for young people sought to explore what use of app features predicted the previously observed benefits on depression symptoms for the CBT self-help app compared to the self-monitoring app after a 3-month intervention. Based on prior findings (Zhang et al., 2019), we hypothesized that total app use would predict treatment benefit. In relation to specific app features, we hypothesized that the use of self-monitoring and of CBT features, especially BA and cognitive restructuring, would predict smaller increases in depression. We also investigated the relative value of CBT elements designed to be single-session components providing psychoeducation, new learning, and new plans (Challenges) relative to elements designed for use in the moment as needed to cope with difficulties (Tools).

Counter to the hypothesis that overall app use and engagement would be related to outcome and inconsistent with prior findings, the frequency of overall app use was not associated with change in depression symptoms. Also contrary to hypotheses, we failed to find any association between the use of self-monitoring and outcomes. The use of the current apps in a preventive rather than acute treatment context may account for these differences. The specific app design and structure may also be important: The apps examined here were open such that any feature could be used in any order, whereas other apps are structured like traditional therapy, such that elements can only be completed in a fixed or contingent sequence, such that access to certain features requires increased use.

Nonetheless, the pattern of results was consistent with the hypothesis that use of BA features would be associated with better depression outcomes: The frequency of use of BA Challenges mediated the beneficial effect of the CBT app on change in depression symptoms over 3 months, relative to the self-monitoring app. There was also evidence that the use of cognitive restructuring Challenges may be associated with benefit. These findings have two major implications for our understanding of what may be beneficial within self-help apps for selective prevention of depression.

First, these results highlight the use of BA features as a key element within the app, consistent with prior findings that use of BA features in apps is associated with reduction in depression (Dahne et al., 2019; Furukawa et al., 2018; Kwasny et al., 2019). This finding is also consistent with the broader literature implicating BA as an active ingredient in CBT interventions, most notably, a large-scale individual participant data component network meta-analysis of 76 internet CBT trials for depression that found that of all the CBT components examined, only BA had evidence that it might be beneficial (Furukawa et al., 2021). The present study suggests that this potential benefit of BA extends from acute treatment to selective prevention of depression symptoms, at least over a 3-month period in higher risk young adults. Our data indicate that it is activity scheduling and planning to increase positive activities that is associated with benefit, rather than planning to reduce avoidance or tackle problems. In an unguided format, activity scheduling may be easier and less triggering than avoidance and problem solving, which could potentially make difficulties more salient without effective resolution.

Second, the specific benefit of Challenges relative to Tools suggests that learning key ideas and perspectives or making new plans, as covered in the Challenges, was a more helpful element within this self-help app than applying coping strategies to tackle distress or low mood in the moment, as provided in the Tools. A single use of a CBT BA challenge that provided psychoeducation on key value and principles of BA may have provided participants with the necessary information to develop new insights and perspective for mood management, consistent with theories that propose that change in knowledge, mindset, and sense of agency may be a sufficient element to produce benefit. Critically, the mean use of BA Challenges was 0.67 (*SD* = 0.36, range 0–5), which suggests that one or two uses are sufficient to have a 3-month benefit. This parallels recent research that suggests that single-session

Table 5
Mediation Models for App Usage Features With Depressive Symptoms (PHQ-9) at 3-Month Follow-Up as Outcome

Model	Potential mediator	Direct effect of condition on mediator variable	Direct effect on PHQ-9			Indirect effect (Condition × Mediator) B [95% CI]	Total effect of condition on PHQ-9 B [95% CI]	% Mediation
		B [95% CI]	Mediator variable: B [95% CI]	Condition: B [95% CI]	Baseline PHQ-9: B [95% CI]			
a	*c*	*d*	*e*	*f*	*g*	*h* = (*d* X *e*)	*i* = (*f* + *h*)	*j* = (*h*/*i*)
1	Total app use	11.60 (−1.34–24.54)+	−0.00 (−0.01–0.01)	−1.05 (−1.93 to −0.17)*	0.54 (0.43–0.65)***	−0.02 (−0.12–0.08)	−1.07 (−1.94 to −0.20)*	1.9
2	Self-monitoring use	5.04 [−7.24, 17.33]	−0.00 [−0.01, 0.01]	−1.06 [−1.94, −0.17]*	0.54 [0.43, 0.65]***	−0.01 [−0.06, 0.04]	−1.07 [−1.95, −0.18]*	0.9
3	EMA use	−5.05 [−14.39, 4.29]	−0.00 [−0.01, 0.01]	−1.08 [−1.97, −0.18]*	0.54 [0.43, 0.65]***	0.01 [−0.05, 0.08]	−1.07 [−1.96, −0.17]*	0.9
4	Daily emotion rating	4.89 [−0.36, 10.14]+	0.00 [−0.02, 0.02]	−1.07 [−1.94, −0.19]*	0.54 [0.43, 0.65]***	0.00 [−0.09, 0.09]	−1.07 [−1.94, −0.19]*	0.0
5	Emotion diary rating	5.21 [0.05, 10.36]*	0.00 [−0.02, 0.02]	−1.07 [−1.95, −0.18]*	0.54 [0.43, 0.65]***	0.00 [−0.10, 0.10]	−1.07 [−1.93, −0.20]*	0.0
6	CBT challenges	3.00 [2.59, 3.41]***	−0.16 [−0.38, 0.05]	−0.58 [−1.78, 0.63]	0.54 [0.43, 0.65]***	−0.49 [−1.14, 0.16]	−1.07 [−1.97, −0.16]*	45.8
7	CBT tools	3.56 [2.70, 4.42]***	−0.02 [−0.12, 0.07]	−0.99 [−1.98, 0.00]+	0.54 [0.43, 0.65]***	−0.08 [−0.42, 0.26]	−1.07 [−1.93, −0.20]*	7.5
8	Behavioral activation	0.82 [0.69, 0.95]***	−0.71 [−1.39, −0.04]*	−0.48 [−1.60, 0.65]	0.54 [0.43, 0.65]***	−0.59 [−1.16, −0.02]*	−1.07 [−1.93, −0.20]*	55.1
9	Cognitive restructuring	1.00 [0.81, 1.19]***	−0.41 [−0.86, 0.05]+	−0.66 [−1.63, 0.31]	0.54 [0.43, 0.65]***	−0.41 [−0.85, 0.04]+	−1.07 [−1.90, −0.23]*	38.3
10	Tackling problems	0.63 [0.50, 0.75]***	0.19 [−0.52, 0.89]	−1.18 [−2.24, −0.13]*	0.54 [0.43, 0.65]***	0.12 [−0.32, 0.56]	−1.07 [−1.96, −0.17]*	11.2
11	MyPersonal MoodCoach	0.55 [0.47, 0.63]***	−0.57 [−1.68, 0.55]	−0.75 [−1.83, 0.33]	0.54 [0.43, 0.65]***	−0.31 [−0.93, 0.30]	−1.07 [−1.96, −0.17]*	29.0

Note. CI = confidence interval; condition = CBT app arm relative to self-monitoring arm as control. PHQ-9 = Patient Health Questionnaire-9; EMA = ecological momentary assessment; CBT = cognitive behavioral therapy app.
+$p < .10$. * $p < .05$. *** $p < .001$.

interventions can be efficacious (Schleider et al., 2020, 2022). Specifically, the current results are consistent with a recent trial that found that a therapist-delivered single-session intervention incorporating BA principles significantly reduced depressive symptoms in adolescents (Schleider et al., 2022). Nonetheless, caution is necessary with respect to inferring the precise mechanism of change, since both Tools and Challenges could change wider perceptions, perceived control, and practice of skills, and the low use of Tools observed here would not be expected to change any underlying habit.

At a practical and clinical level, app engagement is often suboptimal, with apps only used for a brief time and in short bursts (Torous et al., 2020; Zhang et al., 2019). As such, ensuring that an app only includes the most active treatment components and that these are made as salient and accessible as possible is likely to increase their therapeutic benefit from the app. The current results suggest that foregrounding and emphasizing BA strategies, especially psychoeducation about the value, key ideas, and steps of BA and immediate planning of next steps to increase enjoyable activities and to work toward goals, might improve the effect of apps intended to prevent depression.

The strengths of the study include the randomized design; inclusion of young people recruited from schools, universities, and via social media across four European countries; the relatively large sample size; exclusion of participants with current or past history of major depression to ensure the study was not testing treatment of acute symptoms; the comparison of matched apps using the same architecture and design but with different treatment component; and a CBT app containing well-established components organized into different delivery formats (Challenges, Tools).

There were some important limitations. First, we were only able to analyze data for those participants in the trial who signed onto the app, with 21% of those randomized not setting up on the app. Further, the sample was predominantly female and White and overrepresented by young people in school or university education. These aspects may limit the generalizability of our findings. Second, there were relatively high levels of follow-up attrition and low frequency of use of the specific CBT features, although these rates are consistent with trials of similar apps, especially when there is no direct human support or contact (Torous et al., 2020). Third, we only examined apps in a self-guided format. Support from a human professional may improve engagement and outcome, although at the cost of constraining capacity. Fourth, we can only comment on app usage—lessons or strategies covered in the app could be generalized to use off the app, although low levels of app use suggest that extensive off-app practice is unlikely. Fifth, the change in depression produced by the CBT app relative to the self-monitoring app did not meet clinical significance for continuous symptom change, although this was not a clinical sample and there was a clinically meaningful benefit in preventing increased incidence of caseness of depression.

In sum, our findings indicate that contrary to hypotheses, overall use of an app and use of self-monitoring features were not associated with benefit for depression symptoms. Consistent with hypotheses, the use of BA features in the app was associated with lower levels of depression at 3-month follow-up, with this effect specific to psychoeducation about BA and making BA plans. The use of these BA features mediated the benefit of the CBT self-help app on depression, despite very low frequency of use, suggesting that these elements may act as an effective single-session intervention.

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