

**A Mixed Methods Evaluation of a Pilot Open Trial of a Mentor-Guided Digital  
Intervention for Youth Anxiety**

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### **Abstract**

Digital mental health interventions (DMHIs), such as cognitive bias modification for interpretations (CBM-I), offer promise for increasing access to anxiety treatment among underserved adolescents, but data regarding their efficacy are mixed. Paraprofessionals and other caring adults in youth's lives, such as non-parental adult mentors, may be able to support the use of DMHIs and increase teen engagement. The present mixed methods evaluation of a pilot open trial tested the feasibility, acceptability, and preliminary efficacy of implementing MindTrails Teen (an app-based, youth-adapted version of the web-based MindTrails CBM-I intervention) within mentor/mentee dyads. Thirty participants (composed of 15 dyads) participated in remote data collection for 5 weeks. A subset of participants ( $n=7$  mentors;  $n=7$  mentees) also provided qualitative feedback. Intervention outcomes (change in anxiety symptoms, and positive and negative interpretation bias), feasibility and acceptability were assessed via a mix of qualitative interviews, quantitative change in questionnaire scores, and program completion and fidelity metrics. Outcomes were compared to pre-registered benchmarks. Large effect sizes were observed for changes in anxiety among youth. Small to medium effects were observed for change in positive interpretation bias, and no change was found for negative interpretation bias. Interpretation bias results should be interpreted with caution given very low internal consistency of the measure. Acceptability was rated positively by mentors and youth. Feasibility benchmarks were met for mentors but not for youth. Qualitative feedback indicated mentors perceived the app as helpful to their mentees, found that it either improved or did not affect their relationship, but also identified implementation challenges. Youth overall perceived the app as helpful but also identified barriers to engagement.

*Keywords:* Digital mental health, youth, mobile app, anxiety, cognitive bias modification

## **A Mixed Methods Evaluation of a Pilot Open Trial of a Mentor-Guided Digital Intervention for Youth Anxiety**

Anxiety disorders are highly prevalent among adolescents. Approximately 15–20% of U.S. teenagers meet criteria for at least one anxiety disorder, and there is evidence of increased rates of youth anxiety since the onset of the COVID-19 pandemic (Beesdo, Knappe, & Pine, 2009; De France et al., 2022; Magson et al., 2021). Despite this, only one in five anxious adolescents report any lifetime mental healthcare service use, and reported use is even lower for low-income teenagers and youth from historically marginalized groups (e.g., Black, Latinx, & LGBTQ youth: Cook, Barry, & Busch, 2013; Ghandour et al., 2019; Hodgkinson et al., 2017; Merikangas et al., 2011). Digitally delivered (e.g., internet or app-based) interventions are promising tools for increasing access to inexpensive and efficacious anxiety interventions among adolescents (Grist et al., 2017; Temkin et al., 2020). Adolescents present an ideal target population for digital interventions, given the ubiquity of smartphone possession among teenagers (95% of teenagers in the U.S. aged 12–17 report owning a smartphone as of 2023; Anderson, Faverio, & Gottfried, 2023). Digital interventions are feasible and acceptable for adolescents with a range of different anxiety disorders (Grist et al., 2017; Nordh et al. 2017; Temkin et al., 2020;) and may be especially appealing to anxious teenagers, some of whom report preferences for technology-delivered treatments over face-to-face therapy (Boydell et al., 2014).

One promising digital intervention for youth anxiety is digital cognitive bias modification for interpretations (CBM-I). Anxious youth tend to interpret negative or ambiguous cues in their environment as threatening and respond with stress and/or avoidance, reinforcing anxious thinking as ego-syntonic and necessary. CBM-I works by shifting these negative interpretations

to be more positive, benign, or resilience focused, giving individuals repeated practice considering non-threatening explanations for ambiguous scenarios in order to increase cognitive flexibility (Beard et al., 2011). Digital CBM-I has been tested among adults with mostly favorable emotional and behavioral outcomes (e.g., Eberle et al., 2024; Ji et al., 2021; Larrazabal et al., 2023; see Fodor et al., 2020 meta-analysis), but fewer studies have examined its efficacy in youth, and these findings are often mixed (Sicouri et al. 2023). While some studies find improvements in anxious interpretations, social anxiety symptoms, or generalized anxiety symptoms among youth (Mao et al., 2023; Prior et al., 2023; Reuland & Teachman, 2014), others report no change (Sportel et al., 2013; Rogers & Sicouri, 2022; de Voogd et al., 2017). Conversely, nearly all studies of digital CBM-I for youth have found adaptive changes in interpretation bias, even when change in anxiety is not detected (Sportel et al., 2013; de Voogd et al., 2017). This suggests that although digital CBM-I typically succeeds in activating a core change mechanism among youth (interpretation bias), this change may not always be sufficient to prompt clinically significant symptom change. More research is needed to understand how best to adapt and implement CBM-I for youth to promote symptom change.

“MindTrails” is one CBM-I intervention (available in both web and app format) that has been found to reduce anxiety in adults but has not yet been adapted or tested among youth (Eberle et al., 2024; Ji et al. 2021; Larrazabal et al., 2023). Several features of MindTrails suggest it may be well suited to target youth anxiety: the brief nature of the intervention (15–20 minutes sessions) might mitigate common barriers to engagement such as competing time demands and short attention spans (Lehtimaki et al., 2021; Ribanszki et al., 2021). Despite the efficacy of DMHIs such as MindTrails, engaging users remains a challenge. Evidence suggests that most teens who download a mental health app only open it a few times, and adherence varies

widely (10%–94% in recent meta-analyses; Lehtimäki et al., 2021; Tourus et al., 2018). Human support has presented a replicable method of increasing engagement among users of DMHIs, but the shortage of providers hinders scalability (Bernstein et al., 2022; Werntz et al., 2023).

Although MindTrails has primarily been delivered as a fully self-guided intervention, attempts to increase efficacy and reduce attrition via human support have produced mixed results. In one study, low-intensity phone coaching was provided to a subset of users of the MindTrails web platform, but approximately half of those assigned to the coaching condition never responded to attempts to schedule an initial phone call (Werntz et al., 2022). It remains unclear what impact human support might have among youth users with anxiety.

Paraprofessionals (e.g., bachelor’s level coaches, community leaders, teachers, mentors, etc.) present a promising avenue to provide human support with DMHIs, and—when properly trained and supervised—can be as effective as professional providers in delivering quality mental health services (McQuillan et al., 2021). One candidate paraprofessional group for coaching youth in DMHIs is non-parent adult mentors. Relationships with non-parent adult mentors are associated with many mental health benefits among youth, and have been shown to reduce behavioral problems, depression, and anxiety (DeWitt et al., 2016; Dubois & Neville, 1997; Raposa et al., 2019). An added benefit of using pre-existing mentors as coaches is a greater likelihood of established trust between the coach and the user, overcoming a common barrier to rapport and accountability in coached DMHIs (Nitsch et al., 2016; Wallin et al., 2016). Using pre-existing mentors as coaches for DMHIs might also better serve the needs of marginalized communities: a study by Vázquez and Villodas (2019) found that Black caregivers preferred enrolling their children in mentoring programs compared to traditional mental health counseling, possibly due to views of counseling as stigmatizing or less culturally congruent. Integrating a

DMHI into a pre-existing mentoring relationship may also benefit mentors: 25% of parents identified their child's disability or psychiatric illness as a primary reason for enrolling them in a mentoring program. This suggests a need for resources that mentors can use to address mentees' mental health needs in a structured, evidence-based format without requiring mentors to be experts in mental health treatment (Cavell et al., 2021; Sourk et al., 2019).

Given the limited research on and mixed findings associated with digital CBM-I for youth and the need to explore scalable, supportive methods for increasing engagement with DMHIs, we conducted a pilot test of a novel 5-week mentor-guided, app-based CBM-I intervention ("MindTrails Teen") for anxious teenagers participating in formal or informal mentoring programs. To our knowledge, few studies have examined the role of human support in increasing adherence to and engagement with CBM-I for youth anxiety, and no prior studies have used pre-existing mentors as human support for a digital intervention. Prior to the present study, we adapted a version of our existing online adult-focused CBM-I intervention ("MindTrails") into an app for a youth audience through iterative design and content changes supported by feedback from three youth consultants. This study represents the first pilot open trial of MindTrails Teen among youth participants. To this end, intervention and implementation framework feasibility and acceptability, target engagement (e.g., positive and negative interpretations) and preliminary anxiety symptom outcomes among youth are considered primary outcomes. We also present qualitative feedback collected from a subset of participants (more information about this data collection and associated research questions can be found on the Open Science Framework: OSF; preregistration for qualitative analyses: <https://osf.io/pkbd5>).

We propose two sets of hypotheses; one set for anxious youth participants and one tied to inclusion of their mentors (preregistration for quantitative analyses: <https://osf.io/rtcqk>). First, we

hypothesize that MindTrails Teen will be feasible and acceptable for anxious youth. We additionally hypothesize that MindTrails Teen will be accompanied by increased positive and decreased negative interpretation bias among anxious youth, and that MindTrails Teen will be accompanied by reduced youth anxiety symptoms. Second, we hypothesize that including non-parent adult mentors in MindTrails Teen to provide supportive accountability to youth will be feasible and acceptable to both adult mentors and youth mentees.

## **Methods**

### **Participants**

Participants were recruited from across the United States between the period of June 1st, 2022, and May 2nd, 2023. Participants were recruited in dyads, such that each adolescent was required to join with a mentor or vice versa. Mentors were eligible to participate if they were: a) 18 years or older, b) had a smartphone or tablet, and c) served as a formal (e.g., a member of Big Brothers Big Sisters or another official mentoring organization) or informal mentor (e.g., youth pastor, soccer coach) to a teenager aged 13–17. Mentors were ineligible if they were immediate nuclear family members of the teen (as we were seeking to isolate the effects of non-parent adults for this pilot test). Youth were eligible for participation if they were: a) 13–17 years old, b) had a smartphone or tablet, c) had consent of a parent or guardian, d) were living in the United States, e) were participating in a formal or informal mentoring program, f) scored  $>5$  (mild range of anxiety; Spitzer et al., 2006) on the Generalized Anxiety Disorder Questionnaire 7 (GAD-7) or if they self-reported an anxiety diagnosis.

Recruitment took place via postings on social media (e.g., Twitter, Reddit, Facebook), placing flyers in local community centers and mentoring organizations, sending emails to the leadership of a broad range of mentoring organizations, and presenting at national mentoring

conferences. Recruitment proved a significant challenge, and the team ultimately recruited only 21 dyads ( $n = 42$ ) out of our goal of 35 dyads ( $n = 70$ ) over the course of 11 months. Out of these 21 dyads, one was not eligible due to a subclinical youth GAD-7 score. Five completed the consent process and were given an app code but the youth never downloaded the app, leaving a final sample of 15 dyads ( $n = 30$ ; 15 mentors and 15 teens) who completed the study. We have complete demographic data for 28/30 participants, with one mentor and one youth declining to provide their demographic information. Of the mentors who provided demographic data, the sample was 40.21 years old on average ( $SD=8.96$ ; range= 27–55), majority women (64%), White (93%), and non-Hispanic (93%). Of the teens who provided demographic data, the sample was 15.14 years old on average ( $SD=1.01$ ; range= 14–17), majority male (50%, although 34% did not identify within the gender binary), White (67%), and non-Hispanic (83%). For additional sociodemographic information, see Table 1.

### **Study Procedure**

All study procedures were approved by the University of Virginia Institutional Review Board prior to recruitment. Interested participants contacted the study team via email, and youth eligibility was confirmed via a Qualtrics survey. The study team then shared consent forms electronically via DocuSign to the mentor and parent/guardian and an assent form to either the youth or the parent to share with the youth. Once all three parties had consented or assented, the study team contacted the mentor to schedule a 30-minute training session focused on: 1) psychoeducation about anxiety and cognitive bias modification, and 2) how to provide supportive accountability to promote youth engagement with MindTrails Teen. An app download code was also shared with youth at this time.



The study took place over five weeks, with an additional one-month follow-up assessment.<sup>1</sup> Teens were instructed to complete at least two 15–20-minute sessions on the MindTrails-Teen app per week. Mentors were asked to meet with, or at minimum check in via email, phone, or text, with their mentees once a week. Mentors were informed about mentee progress via a weekly email from the research staff. Study staff could view youth progress and sessions completed on an internal dashboard. If the mentee had not completed any sessions during the prior week, mentors were asked to perform an additional check-in.

In addition to the youth mentee completing the initial Qualtrics eligibility survey, both mentors and youth completed Qualtrics surveys at baseline (pre-intervention), three weeks (mid-intervention), and five weeks (post-intervention) into the study. Mentees completed an additional follow-up Qualtrics survey one month following completion of the study. Each week, mentors were also sent a brief survey alongside their mentees' progress report asking about their contact with their mentee. Finally, at the end of the five-week primary study, both mentors and youth were invited to take part in a qualitative interview to better understand participant perspectives on MindTrails Teen and the study procedures. Interviews took place over Zoom, were administered by a member of the study team, and were audio-recorded. At the end of the study, participants (both mentors and youth plus their parent/guardian) were emailed a debriefing form.

Participants were compensated with online gift cards from Tango, a site that allows recipients to choose where they can spend their money online. Youth received up to three gifts cards total: one \$50 dollar Tango gift card following the initial five-week participation, one \$20 gift card for completing an optional qualitative interview after the initial five weeks, and one \$20 gift following a one-month follow-up. Mentors received up to two gifts cards total: one \$50

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<sup>1</sup> For the purposes of this pilot open trial, we examined data from baseline, midpoint, and endpoint assessments only.

dollar Tango gift card following the initial five-week participation and one \$20 gift card for completing an optional qualitative interview after the initial five weeks.

## **Materials and Measures**

This manuscript details only those measures used for the current analyses. See Supplementary Materials for a table containing the full list of measures administered within the trial and the measure administration schedule.

### ***Demographic and Clinical Characteristics***

The following measures were used to characterize the sample:

**Demographics.** All participants completed a demographic questionnaire assessing age, gender, race, ethnicity, and state of residence. Mentors were additionally asked about level of education and occupation, while youth were asked about school grade level.

**Mentorship Questions.** Mentees were asked if they had a mentor, if they were in a specific mentoring program, and how long they had been working with their current mentor. Mentors were asked if they were participating in a specific mentoring program, how long they had worked with their mentee, and if they worked on targeted goals with their mentee.

### ***Interpretation Bias Measures***

**Recognition Rating Task.** Target engagement (change in positive and negative interpretations) was measured via the Recognition Rating Task (modified from Mathews & Mackintosh, 2000). A modified version of the Recognition Rating Task was administered to youth at three study timepoints. This task was included to evaluate baseline interpretation bias and test if CBMI-I training modified interpretation bias in expected directions. The first part of the Recognition Rating task asked youth to read several short stories, adapted to situations common to teenagers and pilot tested with teen consultants. The last word of each story was

incomplete, and youth were asked to click on the missing letter to complete each word fragment. After correctly completing the word, the youth mentee was asked to answer a question about the story. For example, one scenario was titled “The Test”. This story read: “*You have a final test in your math class next week. You know it will be challenging and cover a lot of material. You need a plan to [st\_dy]*” Youth entered the letter u to complete the word “*study*”. Youth were then asked if the test would be difficult (The correct answer was “*Yes*”). In this first task, the correct answer did not resolve the anxiety-related ambiguity of the situation (i.e., how the student performed on the test) and was intended as a comprehension check. Next, youth were asked to read the titles of the nine ambiguous scenarios they had just seen. After each title, four sentences were presented. Two of these sentences were tied to interpreting the situational ambiguity, and two were “foils” that did not assign positive or negative meaning relevant to the anxiety-linked threat. Using “The Test” scenario as an example, one interpretation is negative and anxiety-related (And you think that you will do badly) and one interpretation is positive and resilience-related (And you think that you will do well). The remaining two sentences were foils, meaning that they had positive or negative valence but did not relate to the anxiety-linked emotional ambiguity (e.g., “And you think about how much you like your teacher” – positive foil; “And it will take a long time to finish” – negative foil). Youth were asked to read these four sentences and rate them on a scale of 1-4 (1: *Very Different*; 2: *Different*; 3: *Similar*; 4: *Very Similar*; *Prefer Not to Answer*) based on how similar each sentence was to the original story that was read. They were then instructed to answer based on their understanding of the content of the story, rather than what they would think or do in this situation. It is important to note that post-hoc analyses indicated poor internal consistency for this measure ( $\alpha = 0.35$  for positive

interpretation bias items,  $\alpha = 0.48$  for negative interpretation bias items). Implications of this are discussed further in the paper.

### ***Mood Measures***

**The Generalized Anxiety Disorder Questionnaire-7** (GAD-7; Spitzer et al., 2006) is a seven-item questionnaire that assesses frequency of anxiety and worry in the past two weeks using a four-point Likert scale from *not at all* (0) to *nearly every day* (3). Item ratings were summed to calculate a total anxiety severity, with higher scores reflecting greater severity. This measure was used exclusively at baseline to determine study eligibility; at all other study timepoints the PHQ-4 anxiety subscale was administered.

**Self-Reported Anxiety Diagnosis** is a single-item measure administered at baseline that asked mentees if they have been diagnosed with any anxiety disorder by a doctor or healthcare professional, including panic disorder, specific phobia, generalized anxiety disorder, separation anxiety disorder, social anxiety disorder, or agoraphobia. Responses were “Yes”; “No”; “*I don’t know*” or “*Prefer not to answer*”. It was included to more fully characterize the sample and function as a secondary inclusion criteria for patients whose anxiety might not be captured by the PHQ-4 anxiety subscale.

**The Patient Health Questionnaire-4** (PHQ-4; Kroenke et al., 2009) is a four-item questionnaire that assesses frequency and severity of anxiety and depression in the past two weeks using a four-point Likert scale from *not at all* (0) to *nearly every day* (3). The first two items assess anxiety symptoms, and the second two items assess depression symptoms. Ratings for the first two items (PHQ-4 anxiety subscale) were averaged together and the average multiplied by two to create an overall anxiety score for each time point, with higher scores reflecting greater severity.

### *Acceptability*

#### **MindTrails Acceptability Questionnaires (MAQ) Mentor and Mentee Versions.**

Acceptability was measured for youth via the MindTrails Acceptability Questionnaire (MAQ): Mentee Version, which is a seven-item self-report measure of youth opinions about the MindTrails Teen program delivered immediately post-intervention, following the conclusion of the study at Week 5. Acceptability was measured for mentors via the MindTrails Acceptability Questionnaire (MAQ): Mentor Version, which is a nine-item self-report measure of youth opinions about the MindTrails Teen program delivered immediately post-intervention, following the conclusion of the study at Week 5. Both measures were developed by the study team using modified measures of DMHI acceptability from other pilot feasibility trials (e.g., Beard et al., 2021, Schueller et al., 2019). Both versions use a five-point Likert response scale from “*Strongly agree*” (1) to “*Strongly disagree*” (5).

**Weekly Mentor Survey.** This investigator-designed survey was sent weekly to mentors to monitor program adherence. It contained four questions designed to capture if the mentor had met with their mentee that week, whether the meeting was in-person or virtual, and if and how the mentor and youth had discussed MindTrails Teen during the meeting. Mentors were also asked to write a short paragraph describing interactions with their mentee during the week.

### ***CBM-I Protocol***

All mentees were offered the same CBM-I training program over a five-week period. The training was delivered in brief, 10–20-minute doses designed to give users practice shifting negative interpretations and learning to think in flexible ways. Youth were able to unlock and complete a maximum of one session per day and two sessions per week for a total of 10 sessions across the five-week period. Once the youth enrolled with their QR code, they were prompted to

begin the first session. The first two sessions were designed to be introductory. For details of these sessions, see the Supplementary Materials. The remaining eight sessions were an even split of two different types of training sessions to have a variety of ways of engaging and to encourage cognitive flexibility. We labeled these two sessions “short” training sessions and “long” training sessions, given that the former lasted 10–15 minutes and the latter lasted 15–20 minutes.

The short training sessions were consistent with the typical presentation of MindTrails CBM-I in previous web and app-based versions (Ji et al., 2023; Larrazabal et al., 2023). In this session, youth were presented with a brief, ambiguous scenario followed by a word fragment which, when completed, would resolve the scenario either positively (70% of cases) or negatively (30% of cases). Youth were asked to read the scenario and then complete the word fragment. To personalize this experience, youth were asked prior to each session to select from a list of six domains, generated with help from teen consultants (Academics, Physical Health, Home Life, Social Situations, Social Media, and General), and were presented with scenarios tied to this domain. The primary goal of these short scenarios was to give repeated practice in making positive or resilient interpretations of ambiguous scenarios to reduce the tendency of making rigid negative interpretations.

The long training sessions were a new addition to MindTrails based on work by Silverman, Fua, and Teachman (2023) and focused on generating many different thoughts, feelings, and behaviors that might follow an ambiguous situation. Instead of completing a word fragment in response to a scenario, as in the short-sessions, youth were asked to vividly imagine themselves in a stressful situation related to their chosen domain. After picturing themselves in the situation, youth were presented with five example thoughts, feelings, or behaviors they might have had, two of which were coded to be positive/adaptive, two of which were coded to

encourage tolerance of negative outcomes and build resilience, and one of which was coded to be negative/maladaptive. These were shown to demonstrate to youth the many different types of thoughts, feelings, or behaviors that could occur in response to an ambiguous scenarios, and that not all were negative. For each of the three sections (thoughts, feelings, and behaviors), youth were shown the five examples and asked to spend 30 seconds writing down their own thoughts, feelings, or behaviors in response to the imagined situation. They were then prompted to write down things they could tell themselves in a similar situations to help them handle feelings of anxiety. Thus, the aim of the long training session was to provide examples of the many different reactions a person could have to a stressful situation, and encourage youth to consider how they might prioritize helpful reactions and manage negative reactions.

Each week, youth were instructed to complete a short training session in the first half of the week and a long training session in the second half of the week. Guided imagery exercises were presented in advance of each training session to prime youth for the imaginal component of the sessions and give them practice vividly imagining themselves in a scenario. See the Supplementary Materials for descriptions of the guided imagery tasks and a detailed breakdown of which training sessions were assigned to each week.

### ***Qualitative Interviews***

Both youth and mentors were invited to complete an interview following completion of the program and compensated an additional \$20 for participating. Mentees provided feedback on the app/intervention and offered ideas to improve the aesthetics of the app, increase engagement and adherence, and more broadly increase usability for future teen users. Mentors provided feedback on the training they received and offered ideas to improve mentee engagement with and

adherence to the program. For more information, see the interview guide provided in the Supplementary Materials.

### ***Feasibility Outcomes***

*Intervention feasibility* among youth was measured in two ways. First, we assessed clinical deterioration (based on the assumption that if the program is not safe, then it is not feasible), comparing rates of anxiety score increases on the PHQ-4 scale to benchmarks pulled from existing literature. Second, we assessed adherence to the MindTrails Teen protocol. For youth, adherence was captured based on percentage of program completion (i.e., % of 10 sessions completed).

*Implementation framework feasibility* was measured in two ways. First, we evaluated mentor and youth adherence to the meeting schedule. This was captured by the number of times a “Yes” response was given to Question 1 of the Weekly Mentor Survey, which asked: “Did you meet with your mentee this week?” Second, we evaluated mentor and youth discussion of MindTrails Teen. This was captured by the number of times a “Yes” response was given to Question 3 of the Weekly Mentor Survey, which asked: “If you did meet, did you discuss your mentee’s use of MindTrails?” To avoid conflating missing responses (incomplete surveys) with poor adherence tied to the mentor’s role in supporting the mentee’s use of the program, we only assessed the above markers of feasibility based on completed questionnaires.

### ***Acceptability Outcomes***

Prior to conducting analyses, we identified three items from the MAQ: Mentee version as primary measures of *intervention acceptability* among youth, three items from the MAQ: Mentee version as primary measures of *implementation framework acceptability* among youth, and three items from the MAQ: Mentor version as primary measures of *implementation framework*



*acceptability* among mentors and youth. See Table 2 for more information on specific acceptability questions.

## **Data Analysis Plan**

### ***Quantitative Analysis***

**Feasibility Benchmarks.** To test our hypothesis that the MindTrails intervention would be feasible for youth, we examined rates of clinical deterioration and protocol adherence. See Table 2 for specific feasibility benchmarks.

**Acceptability Benchmarks.** To test our hypothesis that the MindTrails intervention would be acceptable for youth, we examined descriptive data for the three items established *a priori* as acceptability markers and compared these results to benchmarks pulled from the literature (See Table 2). To test our hypothesis that the intervention implementation model would be acceptable to youth and mentors, respectively, we examined descriptive data for three items each that were established *a priori* as implementation acceptability markers and compared these results to benchmarks pulled from the literature. See Table 2 for acceptability benchmarks.

**Intervention Outcomes.** The preliminary nature of the study and small sample size meant we were not powered to detect statistical significance using traditional hypothesis testing. Therefore, to test for change in intervention outcomes (anxiety symptoms and positive and negative interpretation bias, which are our measures of target engagement) we calculated Cohen's *d* effect sizes with confidence intervals separately for the PHQ-4 anxiety subscale, positive interpretation bias, and negative interpretation bias. We report confidence intervals for the sake of transparency, but do not use these to interpret statistical significance given the small sample size. Based on prior work using within-subjects design with a small sample size (Silverman et al., 2024), and consultation with an internal statistics consultant (C. Ford, personal

communication, August 12, 2024), we calculated  $d_{av}$ , using the average standard deviation of the pre and post repeated measures as a standardizer:

$$\text{Cohen's } d_{av} = M_{diff} / ((SD_1 + SD_2) / 2)$$

We then applied Hedge's  $g$  correction, which gives a less biased effect size for small sample sizes ( $n < 20$ ; Lakens, 2013):

$$\text{Hedge's } g_{av} = \text{Cohen's } d_{av} \times (1 - (3 / (4(n_1 + n_2) - 9)))$$

We then compared these results to effect size benchmarks pulled from the literature (See Table 2). To inform future trials and better understand the response pattern, we also calculated percent change in scores from pre-intervention to post-intervention for each participant and on average, but we did not set a benchmark for this descriptive analysis. In the case of missing data for post-intervention, mid-intervention scores were carried forward.

Given that this is a pilot open trial, we did not conduct pre-trial power analyses to determine sample size. Based on previous pilot trials of similar scope, we initially set our estimated sample size at  $N=35$  mentor/mentee dyads. However, due to significant recruitment challenges, we ended up closing recruitment at  $N=15$  mentor/mentee dyads, of which  $N=7$  mentees and  $N=7$  mentors consented to post-intervention qualitative interviews. This sample size, though not ideal, is consistent or close to other pilot studies reported in mixed methods literature assessing feasibility and acceptability of DMHIs for youth (Agapie et al., 2022; Balaskas et al., 2023; Reuland & Teachman, 2014; Gionvanelli et al., 2023). Furthermore, due to participant non-completion of surveys across both the midpoint and endpoint time intervals, we analyzed data from two different sub-samples. For each outcome, the intent to treat sample (ITT) aggregates all data available at each pre and post timepoint regardless of full survey completion,

and per protocol (PP) sample examines only those participants who have two available data points for within-person pre-post analysis.

### *Qualitative Analysis*

Audio recordings of qualitative interviews were hand-transcribed by three undergraduate research assistants (YZ, EC, AM) to familiarize themselves with the content of the data. The lead author (EW) supervised this work and read through all transcripts, correcting them against the audio recordings. After all interview transcripts were reviewed, the research team discussed possible themes until a consensus was reached and two initial codebooks (one for mentors and one for youth) were generated. Following this initial code generation, an inductive approach was applied, adding and deleting codes to best fit the data throughout the coding process (Roberts et al., 2019). Text was only coded if it involved concrete feedback (i.e., small talk, pleasantries, or minor clarification questions were disregarded). To enhance rigor, prior to coding, the two codebooks were viewed and supervised by a team of psychologists and engineers with experience with the MindTrails projects and expertise in mHealth interventions.

Interviews were coded using Delve qualitative data analysis software (Ho & Limpaecher, 2023) and coders were trained via intercoder reliability tests (ICR). Intercoder reliability was measured using Krippendorff's alpha, a measure of reliability in content analysis (Hayes & Krippendorff, 2007). For each round of ICR testing that was required, the team selected a transcript from a different group (mentors and youth) to ensure representation of the entire data set (O'Connor & Joffe, 2020). After several unsuccessful rounds of ICR, the codebooks were revised to code only for content related to the research questions (e.g., ignoring content unrelated to perspectives on MindTrails Teen or its implementation, such as history of mentor/mentee relationship). Once an ICR of .80 was reached, two people from the team were assigned to

independently code each of the remaining interviews, and coding discrepancies were discussed among the research team in weekly meetings. For these meetings, nominal group consensus was applied, in which the first author served as the moderator to help settle disputes in coding. After each transcript was discussed, a “final” version was uploaded in Delve. The final mentee codebook consisted of 17 primary codes organized into 5 themes, and the final mentor codebook consisted of 22 primary codes organized into 8 themes (See OSF database for codebooks: <https://osf.io/pkbd5>)

Following the initial coding process, the team engaged in thematic mapping of both codebooks to visualize the codes and their associated relationships (See Figures 4 and 5 in the Appendix). Codes with low saturation (e.g., endorsed by 1/7 participants or less) were collapsed into broader categories, and several codes with higher saturation were separated into new themes. At the conclusion of this process, the team was left with 7 mentee themes containing a total of 18 primary codes (Table 4), and 7 mentor themes containing a total of 14 primary codes (Table 5). These procedures are consistent with those conducted in previous qualitative evaluation of digital mental health intervention and implementation (Nagar et al., 2023; Zhao et al., 2023).

## **Results**

### **Quantitative Analyses**

Pre-set benchmarks and associated results are presented in Table 2. Table 3 (Appendix 1) reports percent change experienced by each participant with at least two available data points (Per Protocol sample). See Supplemental Materials for minor deviations from the quantitative preregistration.

### ***Feasibility (Hypotheses 1A & 2C).***

Regarding *intervention feasibility* for youth, benchmarks were met for clinical deterioration, with no participants displaying a PHQ-4 anxiety subscale score increase >25% over the course of the 5-week intervention period, though one participant experienced a score increase of exactly 25% (score increase from 4 to 5). Neither benchmark for youth protocol adherence was met, with 40% of mentees (6/15) completing 50% of required sessions and only 30% of mentee (3/15) mentees completing 100% of required sessions.

Regarding *implementation framework feasibility* for mentors and youth, benchmarks were met for both measures of protocol adherence. At least 50% of weekly check-ins were completed by 60% of mentors (9/15), and 60% of mentors (9/15) discussed the MindTrails Teen app in at least 50% of completed check-ins.

#### ***Acceptability (Hypotheses 1B, 2A, & 2B)***

Our acceptability benchmarks were met or exceeded (e.g.,  $\geq 3$ ; between “Neither agree or disagree” and “agree”) for both mentors and youth on all ratings of *intervention acceptability* (mentees) and *implementation framework acceptability* (mentors & youth). Mean ratings can be found in Table 2.

#### ***Intervention Outcomes (Hypotheses 1C & 1D)***

**Anxiety Symptoms.** The ITT sample comprised  $n=15$  participants, and the PP sample comprised  $n=10$  participants. Benchmarks were met for both the ITT and PP samples (PP: Hedge’s  $g=1.16$ , 95% CI:[0.19, 2.13]; ITT: Hedge’s  $g=0.88$ , 95% CI:[0.07, 1.69]). In both cases, effect sizes were large. The overall percent decrease from pre- to post-intervention in the PP and ITT samples was 28.3% and 26.2%, respectively. Percent change for each participant in the PP sample was calculated independently and is presented in Table 3 and Figure 1.

**Positive Interpretation Bias<sup>2</sup>.** The ITT sample comprised n=15 participants, and the PP sample comprised n=8 participants. Benchmarks were met for both the ITT and PP sample (PP: Hedge's  $g=0.31$ , 95% CI:[-0.71, 1.33]; ITT: Hedge's  $g=0.60$ , 95% CI:[-0.26, 1.46]). The effect size for the PP sample was small and the effect size for the ITT sample was medium, suggesting an overall small-to-medium effect size for change in positive interpretation bias. The overall percent increase from pre-to-post intervention in the PP and ITT samples was 4.85% and 9.75%, respectively. Percent change for each participant in the PP sample was calculated independently and is presented in Table 3 and Figure 2.

**Negative Interpretation Bias.** The ITT sample comprised n=15 participants, and the PP sample comprised n=8 participants. Benchmarks were not met for either the ITT or the PP sample (PP: Hedge's  $g=-0.12$ , 95% CI:[-1.14, 0.90]; ITT: Hedge's  $g=0.15$ , 95% CI:[-0.70, 1.00]). The effect sizes for both samples were negligible, suggesting no reliable change in negative interpretation bias in either sample from pre-to-post intervention. Percent change for participants in the PP sample was calculated independently and is presented in Table 3 and Figure 3.

### **Qualitative Analyses**

Qualitative results are presented in Table 4 (Youth Mentees; see Appendix) and Table 5 (Mentors; see Appendix). To protect youth privacy given the small study sample size, we have changed pronouns within all quotations to be gender neutral (e.g., [they/them]). See Supplemental Materials for minor deviations from the qualitative preregistration.

### ***Mentee Themes***

**Theme 1: Facilitators of Engagement.** Among mentees who completed an interview, over half (4/7) discussed components of the app that facilitated their engagement, including a

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<sup>2</sup> The results for the positive and negative interpretation bias analyses should be considered in light of the poor consistency of the Recognition Rating Task.

simple aesthetic design, clear instructions, and ease of use. Multiple users (3/7) specified the usefulness of push notifications in keeping them engaged:

*“... there were a lot of times the notification was very helpful because sometimes I would just forget about [the app], or it would be so busy...and then I’d just sit down and take the 15–20 minutes to do [the session].” (Mentee 1)*

Other mentees (5/7) discussed components of the intervention itself they found engaging, including the brevity of the intervention, the gamified components, and the relatability of the scenarios. Relatability of the CBM-I scenarios (4/7) was most often cited as an engaging factor of the intervention, with youth appreciating that the scenarios resembled anxiety-inducing situations in their daily lives:

*“There was a technology one [that had] something to do with social media where your friends were going out without you, and they would post it and they didn’t invite you and I liked that because stuff like that happens all the time...” (Mentee 4).*

**Theme 2: Barriers to Engagement.** Youth also identified specific barriers to engagement with the MindTrails Teen intervention. Some youth (3/7) identified barriers that were a function of the app itself, including technical glitches, an inability to return to the previous page without starting over, and the amount of storage required by the app. Other youth (6/7) were hindered by components of the intervention, including timers on certain sessions, the length and repetitiveness of the sessions, and the perceived unrelatability of the scenarios. The timers were brought up specifically by several youth (3/7). These were included in the “long” training sessions in which mentees were asked to spend sixty seconds writing out their thoughts and feelings in response to an ambiguous situation. The timer was initially included to encourage

youth to stay on the page and not skip through the session, however, some youth expressed frustration with the timer:

*“I didn’t really like the waiting times [after typing] because sometimes I can’t really type more than one or two sentences, so I type something short and concise that conveys the meaning and then I was just sitting there waiting. It was a little bit tedious. (Mentee 4).*

Several youth (3/7) found the CBM-I scenarios monotonous and expressed a desire for more variation in content. Other youth (4/7) reported individual characteristics that served as barriers to engagement, including challenges with attention span, memory capacity, being too busy, or not having a private environment to complete the assigned session. Over half of youth (4/7) specifically identified short attention spans as a barrier to engagement.

**Theme 3: Suggestions for Improving Engagement.** All seven youth offered specific suggestions for improving engagement with the app. These included additional levels of content personalization, the ability to set a specific time to complete sessions, more variety in content, shorter sessions, additional gamification, improved accessibility features, and ability to customize colors and other app features. Youth overwhelmingly (7/7) preferred the short sessions (10–15 minutes) over the long sessions (15–20 minutes) and offered suggestions for optimal time length of sessions, ranging from 5–10 minutes (*Mentee 2*) to 8–11 minutes in length (*Mentee 4*). Suggestions were also offered for app appearance and aesthetics. A brighter color scheme was favored, and changes to the delivery of notifications (e.g., making the notification remain on the home screen vs. disappearing until the session was completed) were also proposed. In general, youth expressed a desire for as much customization as possible, both in terms of the CBM-I scenario content and in terms of app aesthetics and usage:



*“...being able to fully customize the app, place what buttons you want where, even having widgets that come pre-installed with the app, so that way you can click on the widget and instantly get to your next survey. There could be color changing aspects, there’s a lot of things you could do with [the app].” (Mentee 4).*

Although several youth cited the relatability of the CBM-I scenario content as an engaging factor, others (3/7) desired a broader range of scenario content. Two youth reported a desire for increased gamification in the app:

*“Although not feeling anxious is a reward itself I feel like maybe some tokens that lead up to something as a reward could be nice.” (Mentee 6)*

Three youth also suggested inclusion of content related to identity stress, including gender identity. However, one mentee also cautioned against including such stressors as scenarios, on the basis that they might do more harm than good if not properly implemented:

*“I would say be careful as those are heavy topics...swing the wrong way and they could hurt you more than help.” (Mentee 3)*

**Theme 4: Change in mental health due to MindTrails Teen.** Over half of youth (4/7)

discussed the impact of the MindTrails Teen app on their anxiety. Of these, all reported the app having a positive impact on their anxiety symptoms, and no youth reported iatrogenic effects.

One youth reported that the timing of the app was helpful given their anxiety severity at the start:

*“[The app] was extremely helpful, especially since my anxiety just like hit its peak point right as I started the app, and then it started to go downhill and I now have a way to control it.” (Mentee 1).*

When asked how they might describe MindTrails Teen to a friend, youth were equally split between positive (4/7) and neutral or mixed descriptions (4/7), with two youth providing both positive and neutral descriptions.

*“[MindTrails Teen] is an app that lets you talk about your anxiety and tries to get you to be more comfortable with yourself and your surroundings.”*

Among those who described the app more neutrally, youth tended to acknowledge its impact while citing its perceived weakness:

*“I would describe the app as long, kind of annoying, but impactful.” (Mentee 4).*

**Theme 6: Mentor/Mentee Relationship.** Of those interviewed, most youth (6/7) discussed the impact of their mentor on their experience in the program. Over half of youth (5/7) cited their mentor as a positive influence and noted their function of keeping them engaged:

*“[My mentor] was on top of it and made sure I was doing well. He was a huge help with reminding me, and knowing that someone was looking out [for me] was amazing.” (Mentee 3).*

Another youth noted that it was especially helpful working with a mentor who also had anxiety:

*“Because she also has anxiety too, and she’s tried ways to help me with it and then she just sent me this study one day and we, I feel like, it was just easy for me to get it done with someone I knew had gone through it.” (Mentee 1)*

Only one youth did not find working with a mentor as useful, citing a lack of content specifically related to the mentor or their relationship.

**Theme 7: Change in Mentor/Mentee Relationship due to MindTrails Teen program.**

Over half of youth (5/7) discussed changes in their relationship with their mentor due to

participation in the MindTrails Teen program. Slightly less than half of youth (3/7) endorsed positive changes in the relationship with their mentor while participating in MindTrails Teen:

*“We were already close, so I would say it just gave us more chances to bond and get to know each other better in all aspects.” (Mentee 3).*

Meanwhile, other youth (2/7) reported no changes in their relationship with their mentors. No youth reported a negative change in their relationship with the mentor as a function of participating in MindTrails Teen.

### ***Mentor Themes***

**Theme 1: Perceived Value of Mentorship.** Over half of mentors (4/7) discussed their perceived usefulness to their mentee during the MindTrails Teen program. Of these four, three thought their presence was useful, and two specifically commented on how they played a different supportive role than a parent or family member would have:

*“I think having that sort of third person, that’s not your dad, not your brother, not your sister, just any sort of third party to sort of bounce stuff off of is good...it’s somebody that doesn’t really have an investment in you – and, I mean, I have an investment in [the mentee] – but it’s a sort of guiding relationship opposed to [their] dad needing [them] to do something. You never have that same level of stress.” (Mentor 2).*

Of the four who discussed this topic, only one mentor did not find their presence useful:

*“As far as I’m concerned, it was easy [for me] because it was so minimal...there wasn’t much for me to offer.” (Mentor 6).*

### **Theme 2: Change in Mentor/Mentee Relationship due to MindTrails Teen program.**

Over half of mentors (5/7) discussed how their relationship with their mentee did or did not change as a function of participating in the MindTrails Teen program, with almost all (4/5)

endorsing at least one positive relationship change. Two mentors discussed how participating in MindTrails Teen improved communication with their mentees about mental health. One of the two mentors also mentioned that the program was a helpful bridge to connect with her mentee over her own experiences of anxiety:

*“It felt good that I could tell [them] I have anxiety too...I liked that I could tell [them] that and [they] can know that adults go through this too and [they are] not the only one going through this.” (Mentor 7)*

Meanwhile, other mentors (2/7) did not perceive a change in their relationship with their mentee as a function of participation. Only one mentor reported a negative change in their relationship with their mentee, due to their mentee being untruthful about their level of program completion.

*“It’s the first time I [had] ever heard that [they] lied to me so that’s not good. But, to look at the bright side, it’s going to give me an opportunity to talk to [them] about that so [they] don’t do it again.” (Mentor 5)*

**Theme 3: Mentorship Meetings.** Almost all mentors (6/7) discussed their experience of and opinions on meeting with their mentees during the MindTrails Teen program. Of these, all six reported brief discussion of MindTrails Teen in weekly meetings and/or check-ins but had diverse reasons for doing so. Three mentors cited the check-ins as a method of offering support and keeping their mentees accountable. Meanwhile, one mentor reported keeping the check-ins short so that they did not interfere with their existing relationship with their mentee, and another mentor cited doing only a brief content discussion given a reticent mentee.

**Theme 4: Benefit of App to Mentee Mental Health.** Over half of mentors (5/7) discussed the perceived impact of the MindTrails Teen app on their mentees’ mental health. Of these five, four reported a positive impact:

*“From my understanding it actually did help [them] overcome a few things like some of [their] anxieties because [the mentee] did say [they were] able to use some of it in [their] daily life. (Mentor 6)*

No mentors identified negative effects of the MindTrails Teen program on mentee mental health, and only one mentor suggested the app as having a neutral or no impact.

**Theme 5: Barriers to Mentee Engagement.** Over half of mentors (5/7) discussed perceived barriers to their mentees’ engagement in MindTrails Teen. All five noted barriers related to external influences, including the timing of the intervention (e.g., holidays, summer vs. school year), boredom of mentee, pressure from parents to participate, and competing demands within teens’ lives:

*“I think that the 5 weeks was difficult because it’s hard to get in a routine with something in just 5 weeks. Plus, you have to add in, we [had] Christmas, we had holidays in there, which was probably a bad time to start.” (Mentor 3).*

Two mentors noted individual characteristics of their mentees that may have impacted engagement, including stressors not appropriate for the app and personality factors of their mentees (e.g., people pleasing tendencies) Finally, three mentors indicated components of the app or intervention that hindered their mentees engagement (e.g., mentees saying they found the app repetitive).

**Theme 6: Suggestions for Program Improvement.** Almost all mentors (6/7) provided suggestions for program improvement. These included giving mentors access to the app, having more specific prompts to engage mentees during meetings, providing a more structured guide to the app and content, sending notifications to mentors when a mentee completed a session, expanding the age range of the app, and attending to local implementation barriers (e.g., level of

mental health literacy in the community). Giving the app to mentors was a common suggestion for improvement, with over half of mentors (4/7) stating that this would have benefited them.

*“I wish I could’ve seen what [they were] doing because then that would’ve been really helpful...I was like, ‘so how’s it going’, and [they were] like, ‘yea it’s good, like I did them all,’ but I couldn’t prod any further.” (Mentor 1)*

Beyond just having the app, some mentors (3/7) thought that being able to see mentee progress on a dashboard would have made them feel more involved, and one mentor suggested that specific prompts of what to talk about each week would have been beneficial. Finally, two mentors (2/7) mentioned that mental health literacy and access to mental health resources generally in the local community was something researchers should consider when implementing the study, particularly in rural areas.

**Theme 7: Mentor Experience of the MindTrails Teen Program.** Over half of mentors (5/7) discussed their personal experience of participating in the MindTrails Teen program. Of these five, four discussed how participation benefited them as mentors. Two mentors appreciated how the app provided them an additional tool to support their mentees:

*“I think a lot of times as mentors we can struggle with: how do I help? And this gives you a tool. This gives you something to focus on and then not [have it be] about me lecturing [them]. More of a ‘hey let’s pull this up and do this together’ or ‘how about you go sit down and do this for a few minutes and then we can talk again.’ It just felt like a good tool in my toolbox, I guess.” (Mentor 5).*

Over half of mentors (4/7) also discussed their experience of the pre-program mentor training, with all four stating that they found it useful. One mentor specifically stated that she liked being trained in a group of other mentors:

*“I think [the training] was super informative and I don’t know if you usually have sessions with multiple people or if its more one on one but I do like...that there were two additional [mentors] on the same call with me.” (Mentor 4)*

Mentors (5/7) also provided specific suggestions to improve training in the future, including creating a more comprehensive packet of training resources (e.g., adding specific prompts to encourage conversation in check-in meetings), and offering mentors in the study the opportunity to meet and talk to one another.

### **Discussion**

The present study investigated the feasibility and acceptability of “MindTrails Teen,” a digital cognitive bias modification intervention implemented via a 5-week, mentor-guided pilot open trial. Quantitative pre-post analyses indicate robust improvements in anxiety, small improvements in positive interpretation bias, and no change in negative interpretation bias. The interpretation bias findings should be interpreted with caution given the poor internal consistency of the measure used. The study met all benchmarks for implementation framework feasibility, but only one out of two benchmarks for intervention feasibility (benchmarks were met for clinical deterioration but not protocol adherence). All acceptability benchmarks related to the intervention and implementation framework were met for both mentors and mentees.

Qualitative results corroborate the quantitative anxiolytic effect found for the app and include suggestions for app improvement (e.g., making sessions shorter, increasing personalization of app features and training content, and including more variety of content). Youth noted both facilitators to their engagement, including app notifications and relatability of content, as well as barriers, including timers on exercises, repetitiveness of content, and self-reported poor attention span. Mentors reported positive changes to their relationship with their

mentees while using MindTrails Teen, usefulness of the app to facilitate mentoring, implementation barriers, and suggestions for program improvement (e.g., giving mentors access to the app).

### **Intervention Feasibility and Acceptability**

Clinical deterioration benchmarks were met for mentees, suggesting that MindTrails Teen is safe and unlikely to lead to iatrogenic effects. Protocol adherence benchmarks were met for mentors but not for mentees. Post-hoc descriptive analyses indicate the mean number of sessions completed by mentees in the trial was 4.7, and the median number of completed sessions was 3, suggesting that most participants received at least a third of the intended dose of 10 sessions. This degree of protocol adherence, though less than expected, is not uncommon in other trials examining the feasibility of DMHIs for youth in real-world implementation settings (Whitehead et al., 2024). Increasingly, research indicates that individuals with differing levels of adherence and engagement can benefit from DMHIs (Weingarden et al., 2023) and there is not a “one-size fits all” approach to use. Still, it is worthwhile to interrogate our low adherence rates. Although our trial included adherence-boosting measures such as compensation and human support, our sample had several characteristics that may have impacted engagement. First, our participants were selected only for elevated anxiety symptoms, and community samples occasionally evidence less robust treatment adherence rates compared to those recruited from schools or mental health clinics (Achilles et al., 2020). Relatedly, our sample reported mild-to-moderate anxiety on average ( $M=9.32$  on the GAD-7 from the eligibility survey), which is higher on average than youth users of DMHIs recruited from unselected samples (Conley et al., 2022). Although some studies associate symptom severity with greater adherence (Caeler et al., 2013), others have identified a curious relationship between symptom improvement and early drop-off,



positing that early gains in a DMHI may unintentionally discourage continued usage (Achilles et al., 2020; Clarke et al., 2009). This may be especially true for our intervention, in which repetitive content was frequently cited as a barrier for youth engagement—perhaps once youth felt they understood and benefited from the paradigm, they no longer felt motivated to engage. Regardless, this unmet benchmark suggests there were barriers to youth adherence that were not fully ameliorated by our added mentor human support.

Results indicate that youth found the app overall acceptable. When asked if they would recommend the app to other teens, the average youth response fell between “Agree” and “Strongly Agree”. Youth were less positive, but still within the acceptable range, when asked if they enjoyed using the app and if they thought the app changed their thinking in anxiety-inducing situations, with average responses for both items falling between “Neither agree nor disagree” and “Agree”. Interestingly, despite less enthusiastic endorsement of the app for their own use, youth were still highly likely to recommend the app to others struggling with anxiety, perhaps implying perceived benefit, if not equivalent personal enjoyment.

### **Implementation Framework Feasibility and Acceptability**

Among those who completed the study, the implementation framework (i.e., youth app use guided by a mentor) was both feasible and acceptable. Mentors rated their enjoyment of the app and their willingness to recommend the app to other mentors more highly than they rated their own preparedness to support their mentee during the program. This is corroborated by qualitative feedback suggesting mentors enjoyed the program but could benefit from additional supports by the research team (e.g., discussion prompts for meetings with youth, opportunities to connect with other mentors). Youth also rated the implementation framework highly, particularly enjoying working with their mentor and finding their mentor helpful during the program.

## Intervention Outcomes

Unexpectedly, changes in positive and negative interpretation bias (small effect size and no change, respectively) were smaller than change in anxiety symptoms. Results from previous trials of digital CBM-I for youth typically demonstrate the opposite pattern, in which change in anxiety is achieved less consistently than change in positive and negative interpretation bias (Mao et al., 2023; Sportel et al., 2013; de Voogd et al., 2017). Given the relative consistency of interpretation bias change observed in prior trials of digital CBM-I, we suspect that the poor internal consistency of our novel measure of interpretation bias may at least partly explain our mixed findings for bias change. While it remains possible that our low protocol adherence reduced target engagement, this seems unlikely given the large effect for anxiety symptom change and limited evidence that number of CBM-I training trials moderates outcomes (Krebs et al., 2018).

Of course, the open trial design means we cannot confidently conclude that the CBM-I training caused the reduction in anxiety. Besides time or regression to the mean, change in the mentoring relationship during the study may also have contributed to the anxiety reduction. While not a primary outcome, we did collect data on mentor/mentee relationship quality at each time point (see Supplementary Materials). Exploratory post-hoc analyses indicate a small to medium improvement in strength of that relationship in both the PP and ITT samples. While not itself evidence of mechanistic effects, presence of a supportive mentor is linked to improvements in youth anxiety (Browne et al., 2022; DeWit et al., 2016), raising the possibility that relationship improvement (plausibly brought on by the app, based on the qualitative feedback) was a mechanism that contributed to the anxiety reduction. Along these lines, qualitative findings highlighted that both mentors and youth reported positive benefit from discussing shared

symptoms of anxiety. Reciprocal self-disclosure in mentoring relationship—when used judiciously—can be a way for mentors to demonstrate trust and closeness with their mentees (Dutton, Deanne, & Bullen, 2021). Furthermore, talking about mental health with trusted confidantes can reduce symptoms and stigma among youth (Mulfinger et al., 2019; Prizemann, McCabe, & Weinstein, 2024). While these mechanisms require further testing in a larger controlled trial, they suggest the likely value of mentor-supported implementation of DMHIs.

### **Limitations**

While the study had multiple strengths, including its mixed methods design, recruitment of a diverse anxious sample, and innovative implementation framework, there were also several limitations. First, our sample of mentors was racially and ethnically homogenous (primarily White and non-Hispanic/Latino). Second, our small sample size and attrition makes it difficult to generalize our findings. Third, the lack of a control/comparison group, while a reasonable choice for this preliminary pilot evaluation, is a significant limitation. Fourth, as noted, measurement issues, especially low reliability of the interpretation bias measure, make it more difficult to validly test effects.

Finally, recruitment difficulties raise questions about implementation framework feasibility. Alongside targeted social media campaigns, our team contacted 140 mentoring organizations, only two of which yielded significant partnerships. Moving from recruitment to enrollment was also difficult given the need to consent parents, youth, and mentors. Out of the 41 parent/mentee/mentor triads sent at least one consent form, 14 of these triads only made it partially through the consent process (i.e., at least one of the 3 members did not sign, preventing enrollment from proceeding). Future research should seek to understand failure points in the recruitment and consent process to determine a more feasible, scalable implementation model.

## **Future Directions**

Based on qualitative feedback, future versions of the app should prioritize shorter sessions, additional content personalization, and increased gamification. Artificial intelligence (AI) may be a logical future avenue for improving personalization (e.g., tailoring scenario content to youth demographic information and domains of concern). Although the mentor delivery model was feasible and acceptable to those users who enrolled and remained engaged, future work should seek to streamline the consent process to be less burdensome for participants.

Mentors referenced several important implementation considerations, such as the possibility that parents pressure youth to participate in mental health programs and the limited mental health literacy in the community. Most mentor/mentee dyads hailed from areas of the US less commonly represented in clinical research (Iowa, South Texas, and Nebraska; McClaren, 2024). Though we lack data on whether participants identified as urban or rural, the response rate from less commonly represented regions suggests the app may help address an unfilled need for youth mental health services in these communities.

Another traditionally-underserved user group that was well represented in the current study are gender non-conforming youth, who made up nearly one-third of our very small sample. We did not specifically outreach to this population when recruiting for this study, and only selected for youth with elevated symptoms of anxiety. This finding dovetails with the elevated rates of anxiety among trans and gender non-conforming youth (Beccera-Culqui et al., 2018) and suggests a critical need for support among members of this community. While CBM-I is not necessarily an ideal tool in its current form to directly address anxiety stemming from stigma and discrimination (because of concerns that attempts to shift users' thinking in these contexts could

come across as gaslighting), future versions of the app should provide additional resources for youth facing stressors related to their identities.

Finally, in addition to refining the mentorship supportive accountability model, future research should explore other implementation pathways. School guidance counselors may be able to fulfil a comparable role to mentors in a school-based implementation framework, and use of the app in peer-support or collegiate mentoring programs could capitalize on the reported usefulness of disclosing and discussing shared lived experiences of mental health. These and other approaches could be investigated for feasibility, acceptability, and efficacy.

## **Conclusion**

Youth participating in the MindTrails Teen program with mentor guidance experienced decreases in anxiety from pre-to-post intervention, though results were mixed for change in interpretation bias. The app and intervention delivery model were overall feasible and acceptable to youth and mentors based on predetermined benchmarks, though youth failed to meet the benchmark for protocol adherence. Qualitative results corroborate the quantitative findings, reiterating the positive impact of participation for both mentors and teens, and offering concrete suggestions for future changes to the app and implementation approach. Future research should test the impact of MindTrails Teen in different environments, with and without different types of human support, and in a larger randomized controlled trial seeking to clarify the impact of the program on target engagement.

### References

- Achilles, M. R., Anderson, M., Li, S. H., Subotic-Kerry, M., Parker, B., & O'Dea, B. (2020). Adherence to e-mental health among youth: Considerations for intervention development and research design. *DIGITAL HEALTH*, 6, 2055207620926064.  
<https://doi.org/10.1177/2055207620926064>
- Agapie, E., Chang, K., Patrachari, S., Neary, M., & Schueller, S. M. (2022). Understanding Mental Health Apps for Youth: Focus Group Study With Latinx Youth. *JMIR Formative Research*, 6(10), e40726. <https://doi.org/10.2196/40726>
- Anderson, M., Faverio, M., & Gottfried, J. (2023, December 11). Teens, Social Media and Technology 2023. *Pew Research Center*.  
<https://www.pewresearch.org/internet/2023/12/11/teens-social-media-and-technology-2023/>
- Balaskas, A., Schueller, S. M., Cox, A. L., Rashleigh, C., & Doherty, G. (2023). Examining young adults daily perspectives on usage of anxiety apps: A user study. *PLOS Digital Health*, 2(1), e0000185. <https://doi.org/10.1371/journal.pdig.0000185>
- Beard, C. (2011). Cognitive bias modification for anxiety: Current evidence and future directions. *Expert Review of Neurotherapeutics*, 11(2), 299–311. <https://doi.org/10.1586/ern.10.194>
- Beard, C., Ramadurai, R., McHugh, R. K., Pollak, J., & Björgvinsson, T. (2021). HabitWorks: Development of a CBM-I smartphone app to augment and extend acute treatment. *Behavior Therapy*, 52(2), 365–378. <https://doi.org/10.1016/j.beth.2020.04.013>
- Becerra-Culqui, T. A., Liu, Y., Nash, R., Cromwell, L., Flanders, W. D., Getahun, D., Giammattei, S. V., Hunkeler, E. M., Lash, T. L., Millman, A., Quinn, V. P., Robinson, B., Roblin, D., Sandberg, D. E., Silverberg, M. J., Tangpricha, V., & Goodman, M. (2018). Mental Health of Transgender and Gender Nonconforming Youth Compared With Their Peers. *Pediatrics*, 141(5), e20173845.  
<https://doi.org/10.1542/peds.2017-3845>

- Beesdo, K., Knappe, S., & Pine, D. S. (2009). Anxiety and anxiety disorders in children and adolescents: Developmental issues and implications for DSM-V. *The Psychiatric Clinics of North America*, 32(3), 483–524. <https://doi.org/10.1016/j.psc.2009.06.002>
- Bernstein, E., Weingarden, H., Wolfe, E., Hall, M., Snorrason, Í., & Wilhelm, S. (2022). Human Support in App-Based Cognitive Behavioral Therapies for Emotional Disorders: Scoping Review. *Journal of Medical Internet Research*, 24, e33307. <https://doi.org/10.2196/33307>
- Boydell, K. M., Hodgins, M., Pignatiello, A., Teshima, J., Edwards, H., & Willis, D. (2014). Using Technology to Deliver Mental Health Services to Children and Youth: A Scoping Review. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 23(2), 87–99.
- Browne, R., Jarjoura, G. R., Keller, T. E., Tanyu, M., Herrera, C., & Schwartz, S. E. O. (2022). Mentoring and depressive symptoms of youth: Examining prospective and interactive associations with mentoring relationship quality. *American Journal of Community Psychology*, 70(3–4). <https://doi.org/10.1002/ajcp.12608>
- Calear, A. L., Christensen, H., Mackinnon, A., & Griffiths, K. M. (2013). Adherence to the MoodGYM program: Outcomes and predictors for an adolescent school-based population. *Journal of Affective Disorders*, 147(1–3), 338–344. <https://doi.org/10.1016/j.jad.2012.11.036>
- Cavell, T. A., Spencer, R., & McQuillin, S. D. (2021). Back to the Future: Mentoring as Means and End in Promoting Child Mental Health. *Journal of Clinical Child & Adolescent Psychology*, 50(2), 281–299. <https://doi.org/10.1080/15374416.2021.1875327>
- Clarke, G., Kelleher, C., Hornbrook, M., Debar, L., Dickerson, J., & Gullion, C. (2009). Randomized effectiveness trial of an Internet, pure self-help, cognitive behavioral intervention for depressive symptoms in young adults. *Cognitive Behaviour Therapy*, 38(4), 222–234. <https://doi.org/10.1080/16506070802675353>

- Conley, C. S., Raposa, E. B., Bartolotta, K., Broner, S. E., Hareli, M., Forbes, N., Christensen, K. M., & Assink, M. (2022). The Impact of Mobile Technology-Delivered Interventions on Youth Well-being: Systematic Review and 3-Level Meta-analysis. *JMIR Mental Health*, 9(7), e34254. <https://doi.org/10.2196/34254>
- Cook, B. L., Barry, C. L., & Busch, S. H. (2013). Racial/Ethnic Disparity Trends in Children's Mental Health Care Access and Expenditures from 2002 to 2007. *Health Services Research*, 48(1), 129–149. <https://doi.org/10.1111/j.1475-6773.2012.01439.x>
- De France, K., Hancock, G. R., Stack, D. M., Serbin, L. A., & Hollenstein, T. (2022). The mental health implications of COVID-19 for adolescents: Follow-up of a four-wave longitudinal study during the pandemic. *The American Psychologist*, 77(1), 85–99. <https://doi.org/10.1037/amp0000838>
- DeWit, D. J., DuBois, D., Erdem, G., Larose, S., & Lipman, E. L. (2016). The Role of Program-Supported Mentoring Relationships in Promoting Youth Mental Health, Behavioral and Developmental Outcomes. *Prevention Science: The Official Journal of the Society for Prevention Research*, 17(5), 646–657. <https://doi.org/10.1007/s11121-016-0663-2>
- DuBois, D. L., & Neville, H. A. (1997). Youth mentoring: Investigation of relationship characteristics and perceived benefits. *Journal of Community Psychology*, 25(3), 227–234. [https://doi.org/10.1002/\(SICI\)1520-6629\(199705\)25:3<227::AID-JCOP1>3.0.CO;2-T](https://doi.org/10.1002/(SICI)1520-6629(199705)25:3<227::AID-JCOP1>3.0.CO;2-T)
- Dutton, H., Deane, K. L., & Bullen, P. (2022). Exploring the benefits and risks of mentor self-disclosure: Relationship quality and ethics in youth mentoring. *Kōtuitui: New Zealand Journal of Social Sciences Online*, 17(1), 116–133. <https://doi.org/10.1080/1177083X.2021.1951308>
- Eberle, J. W., Daniel, K. E., Bae, S., Silverman, A. L., Lewis, E., Baglione, A. N., Werntz, A., French, N. J., Ji, J. L., Hohensee, N., Tong, X., Huband, J. M., Boukhechba, M., Funk, D. H.,



- Barnes, L. E., & Teachman, B. A. (2024). Web-based interpretation bias training to reduce anxiety: A sequential, multiple-assignment randomized trial. *Journal of Consulting and Clinical Psychology*, 92(6), 367–384. <https://doi.org/10.1037/ccp0000896>
- Fodor, L. A., Georgescu, R., Cuijpers, P., Szamoskozi, Ş., David, D., Furukawa, T. A., & Cristea, I. A. (2020). Efficacy of cognitive bias modification interventions in anxiety and depressive disorders: A systematic review and network meta-analysis. *The Lancet. Psychiatry*, 7(6), 506–514. [https://doi.org/10.1016/S2215-0366\(20\)30130-9](https://doi.org/10.1016/S2215-0366(20)30130-9)
- Ghandour, R. M., Sherman, L. J., Vladutiu, C. J., Ali, M. M., Lynch, S. E., Bitsko, R. H., & Blumberg, S. J. (2019). Prevalence and Treatment of Depression, Anxiety, and Conduct Problems in US Children. *The Journal of Pediatrics*, 206, 256-267.e3. <https://doi.org/10.1016/j.jpeds.2018.09.021>
- Giovanelli, A., Sanchez Karver, T., Roundfield, K. D., Woodruff, S., Wierzba, C., Wolny, J., & Kaufman, M. R. (2023). The Appa Health App for Youth Mental Health: Development and Usability Study. *JMIR Formative Research*, 7. <https://doi.org/10.2196/49998>
- Grist, R., Porter, J., & Stallard, P. (2017). Mental Health Mobile Apps for Preadolescents and Adolescents: A Systematic Review. *Journal of Medical Internet Research*, 19(5), e176. <https://doi.org/10.2196/jmir.7332>
- Hayes, A. F., & Krippendorff, K. (2007). Answering the Call for a Standard Reliability Measure for Coding Data. *Communication Methods and Measures*, 1(1), 77–89. <https://doi.org/10.1080/19312450709336664>
- Ho, L., & Limpaecher, A. (2023). The Practical Guide to Qualitative Content Analysis. *Delve*. <https://delvetool.com/blog/qualitative-content-analysis>.

- Hodgkinson, S., Godoy, L., Beers, L. S., & Lewin, A. (2017). Improving Mental Health Access for Low-Income Children and Families in the Primary Care Setting. *Pediatrics*, 139(1), e20151175. <https://doi.org/10.1542/peds.2015-1175>
- Ji, J. L., Baee, S., Zhang, D., Calicho-Mamani, C. P., Meyer, M. J., Funk, D., Portnow, S., Barnes, L., & Teachman, B. A. (2021). Multi-session online interpretation bias training for anxiety in a community sample. *Behaviour Research and Therapy*, 142, 103864. <https://doi.org/10.1016/j.brat.2021.103864>
- Krebs, G., Pile, V., Grant, S., Degli Esposti, M., Montgomery, P., & Lau, J. Y. F. (2018). Research Review: Cognitive bias modification of interpretations in youth and its effect on anxiety: a meta-analysis. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 59(8), 831–844. <https://doi.org/10.1111/jcpp.12809>
- Kroenke, K., Spitzer, R. L., Williams, J. B. W., & Löwe, B. (2009). An ultra-brief screening scale for anxiety and depression: The PHQ-4. *Psychosomatics*, 50(6), 613–621. <https://doi.org/10.1176/appi.psy.50.6.613>
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4. <https://doi.org/10.3389/fpsyg.2013.00863>
- Larrazabal, M. A., Eberle, J. W., Vela de la Garza Evia, A., Boukhechba, M., Funk, D. H., Barnes, L. E., Boker, S. M., & Teachman, B. A. (2023). Online cognitive bias modification for interpretation to reduce anxious thinking during the COVID-19 pandemic. *Behaviour Research and Therapy*, 104463. <https://doi.org/10.1016/j.brat.2023.104463>

- Lehtimäki, S., Martić, J., Wahl, B., Foster, K. T., & Schwalbe, N. (2021). Evidence on Digital Mental Health Interventions for Adolescents and Young People: Systematic Overview. *JMIR Mental Health*, 8(4), e25847. <https://doi.org/10.2196/25847>
- Magson, N. R., Freeman, J. Y. A., Rapee, R. M., Richardson, C. E., Oar, E. L., & Fardouly, J. (2021). Risk and Protective Factors for Prospective Changes in Adolescent Mental Health during the COVID-19 Pandemic. *Journal of Youth and Adolescence*, 50(1), 44–57. <https://doi.org/10.1007/s10964-020-01332-9>
- Mao, N., Liu, T., Li, C., Ding, R., Zhang, Q., & Cui, L. (2023). Smartphone-Based Training of Cognitive Bias Modification: Efficacy for Reducing Social Anxiety in Chinese Adolescents. *Journal of Child and Family Studies*, 32, 1–12. <https://doi.org/10.1007/s10826-023-02619-8>
- Mathews, A., & Mackintosh, B. (2000). Induced emotional interpretation bias and anxiety. *Journal of Abnormal Psychology*, 109(4), 602–615.
- McLaren, M. (2024, October 3). Clinical trial access in the US: Where are today's trials missing? *Clinical Trials Arena*. <https://www.clinicaltrialsarena.com/sponsored/clinical-trial-access-in-the-us-where-are-todays-trials-missing/>
- McQuillin, S. D., Hagler, M. A., Werntz, A., & Rhodes, J. E. (2022). Paraprofessional Youth Mentoring: A Framework for Integrating Youth Mentoring with Helping Institutions and Professions. *American Journal of Community Psychology*, 69(1–2), 201–220. <https://doi.org/10.1002/ajcp.12546>
- Merikangas, K. R., He, J., Burstein, M., Swendsen, J., Avenevoli, S., Case, B., Georgiades, K., Heaton, L., Swanson, S., & Olfson, M. (2011). Service utilization for lifetime mental disorders in U.S. adolescents: Results of the National Comorbidity Survey-Adolescent Supplement (NCS-A).

*Journal of the American Academy of Child and Adolescent Psychiatry*, 50(1), 32–45.

<https://doi.org/10.1016/j.jaac.2010.10.006>

Mulfinger, N., Rüsch, N., Bayha, P., Müller, S., Böge, I., Sakar, V., & Krumm, S. (2019). Secrecy versus disclosure of mental illness among adolescents: II. The perspective of relevant stakeholders. *Journal of Mental Health (Abingdon, England)*, 28(3), 304–311.

<https://doi.org/10.1080/09638237.2018.1487537>

Nagar, R., Quirk, H. D., & Anderson, P. L. (2023). User experiences of college students using mental health applications to improve self-care: Implications for improving engagement. *Internet Interventions*, 34, 100676. <https://doi.org/10.1016/j.invent.2023.100676>

Nitsch, M., Dimopoulos, C. N., Flaschberger, E., Saffran, K., Kruger, J. F., Garlock, L., Wilfley, D. E., Taylor, C. B., & Jones, M. (2016). A Guided Online and Mobile Self-Help Program for Individuals With Eating Disorders: An Iterative Engagement and Usability Study. *Journal of Medical Internet Research*, 18(1), e7. <https://doi.org/10.2196/jmir.4972>

Nordh, M., Vigerland, S., Öst, L.-G., Ljótsson, B., Mataix-Cols, D., Serlachius, E., & Högström, J. (2017). Therapist-guided internet-delivered cognitive-behavioural therapy supplemented with group exposure sessions for adolescents with social anxiety disorder: A feasibility trial. *BMJ Open*, 7(12), e018345. <https://doi.org/10.1136/bmjopen-2017-018345>

O'Connor, C., & Joffe, H. (2020). Intercoder Reliability in Qualitative Research: Debates and Practical Guidelines. *International Journal of Qualitative Methods*, 19, 1609406919899220. <https://doi.org/10.1177/1609406919899220>

Prior, K., Salemink, E., Piggott, M., Manning, V., Wiers, R. W., Teachman, B. A., Teesson, M., Baillie, A. J., Mahoney, A., McLellan, L., Newton, N. C., & Stapinski, L. A. (2023). Web-Based Cognitive Bias Modification Program for Young People With Social Anxiety and Hazardous

Alcohol Use: Feasibility, Acceptability, and Preliminary Efficacy Study. *JMIR Formative Research*, 7(1), e46008. <https://doi.org/10.2196/46008>

Prizeman, K., McCabe, C., & Weinstein, N. (2024). Stigma and its impact on disclosure and mental health secrecy in young people with clinical depression symptoms: A qualitative analysis. *PLoS ONE*, 19(1). <https://doi.org/10.1371/journal.pone.0296221>

Raposa, E. B., Rhodes, J., Stams, G. J. J. M., Card, N., Burton, S., Schwartz, S., Sykes, L. A. Y., Kanchewa, S., Kupersmidt, J., & Hussain, S. (2019). The Effects of Youth Mentoring Programs: A Meta-analysis of Outcome Studies. *Journal of Youth and Adolescence*, 48(3), 423–443. <https://doi.org/10.1007/s10964-019-00982-8>

Reuland, M. M., & Teachman, B. A. (2014). Interpretation bias modification for youth and their parents: A novel treatment for early adolescent social anxiety. *Journal of Anxiety Disorders*, 28(8), 851–864. <https://doi.org/10.1016/j.janxdis.2014.09.011>

Ribanszki, R., Saez Fonseca, J. A., Barnby, J. M., Jano, K., Osmani, F., Almasi, S., & Tsakanikos, E. (2021). Preferences for Digital Smartphone Mental Health Apps Among Adolescents: Qualitative Interview Study. *JMIR Formative Research*, 5(8), e14004. <https://doi.org/10.2196/14004>

Roberts, K., Dowell, A., & Nie, J.-B. (2019). Attempting rigour and replicability in thematic analysis of qualitative research data; a case study of codebook development. *BMC Medical Research Methodology*, 19(1), 66. <https://doi.org/10.1186/s12874-019-0707-y>

Rogers, J., & Sicouri, G. (2022). A single-session online cognitive bias modification of interpretations modified for adults with anxiety and depressive symptoms. *Behavior Therapy*, 53(5), 967–980. <https://doi.org/10.1016/j.beth.2022.04.006>

- Schueller, S. M., Glover, A. C., Rufa, A. K., Dowdle, C. L., Gross, G. D., Karnik, N. S., & Zalta, A. K. (2019). A Mobile Phone-Based Intervention to Improve Mental Health Among Homeless Young Adults: Pilot Feasibility Trial. *JMIR mHealth and uHealth*, 7(7), e12347. <https://doi.org/10.2196/12347>
- Sicouri, G., Daniel, E. K., Spoelma, M. J., Salemink, E., McDermott, E. A., & Hudson, J. L. (2023). Cognitive bias modification of interpretations for anxiety and depression in children and adolescents: A meta-analysis. *JCPP Advances*, 4(1), e12207. <https://doi.org/10.1002/jcv2.12207>
- Silverman, A. L., Vela de la Garza Evia, Á. F., Boukhechba, M., Barnes, L., & Teachman, B. A. (2023, November). Pilot feasibility and acceptability of a culturally enhanced web-based interpretation training for anxiety among Spanish-speaking Latinx individuals. Paper presented at the annual meeting of the Association for Behavioral and Cognitive Therapies, Seattle, WA.
- Silverman, A. L., Fua, K. C.-H., & Teachman, B. A. (2023). More than One Way to Say I Love You: An Internet-Based Intervention for Training Flexible Thinking in Romantic Relationships. *Journal of Clinical Psychology*, 79(4), 909–936. <https://doi.org/10.1002/jclp.23443>
- Sourk, M., Weiler, L. M., & Cavell, T. A. (2019). Risk, support, and reasons for wanting a mentor: Comparing parents of youth in community versus school-based matches. *Children and Youth Services Review*, 99, 156–164. <https://doi.org/10.1016/j.childyouth.2019.01.046>
- Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, 166(10), 1092–1097. <https://doi.org/10.1001/archinte.166.10.1092>
- Sportel, B. E., Hullu, E. de, Jong, P. J. de, & Nauta, M. H. (2013). Cognitive Bias Modification versus CBT in Reducing Adolescent Social Anxiety: A Randomized Controlled Trial. *PLOS ONE*, 8(5), e64355. <https://doi.org/10.1371/journal.pone.0064355>

- Temkin, A. B., Schild, J., Falk, A., & Bennett, S. M. (2020). Mobile apps for youth anxiety disorders: A review of the evidence and forecast of future innovations. *Professional Psychology: Research and Practice*, 51(4), 400–413. <https://doi.org/10.1037/pro0000342>
- The Practical Guide to Qualitative Content Analysis*. (2023, March 24). Delve. <https://delvetool.com/blog/guide-qualitative-content-analysis>
- Torous, J., Nicholas, J., Larsen, M. E., Firth, J., & Christensen, H. (2018). Clinical review of user engagement with mental health smartphone apps: Evidence, theory and improvements. *Evidence-Based Mental Health*, 21(3), 116–119. <https://doi.org/10.1136/eb-2018-102891>
- Vázquez, A. L., & Villodas, M. T. (2019). Racial/ethnic differences in caregivers' perceptions of the need for and utilization of adolescent psychological counseling and support services. *Cultural Diversity & Ethnic Minority Psychology*, 25(3), 323–330. <https://doi.org/10.1037/cdp0000255>
- Voogd, E. L. de, Hullu, E. de, Heyes, S. B., Blackwell, S. E., Wiers, R. W., & Salemink, E. (2017). Imagine the bright side of life: A randomized controlled trial of two types of interpretation bias modification procedure targeting adolescent anxiety and depression. *PLOS ONE*, 12(7), e0181147. <https://doi.org/10.1371/journal.pone.0181147>
- Wallin, E. E. K., Mattsson, S., & Olsson, E. M. G. (2016). The Preference for Internet-Based Psychological Interventions by Individuals Without Past or Current Use of Mental Health Treatment Delivered Online: A Survey Study With Mixed-Methods Analysis. *JMIR Mental Health*, 3(2), e25. <https://doi.org/10.2196/mental.5324>
- Weingarden, H., Garriga Calleja, R., Greenberg, J. L., Snorrason, I., Matic, A., Quist, R., Harrison, O., Hoepfner, S. S., & Wilhelm, S. (2023). Characterizing observed and effective behavioral engagement with smartphone cognitive behavioral therapy for body dysmorphic disorder: A

methods roadmap and use case. *Internet Interventions*, 32, 100615.

<https://doi.org/10.1016/j.invent.2023.100615>

Werntz, A., Amado, S., Jasman, M., Ervin, A., & Rhodes, J. E. (2023). Providing Human Support for the Use of Digital Mental Health Interventions: Systematic Meta-review. *Journal of Medical Internet Research*, 25(1), e42864. <https://doi.org/10.2196/42864>

Werntz, A., Silverman, A. L., Behan, H., Patel, S. K., Beltzer, M., Boukhechba, M. O., Barnes, L., & Teachman, B. A. (2022). Lessons Learned: Providing Supportive Accountability in an Online Anxiety Intervention. *Behavior Therapy*, 53(3), 492–507.

<https://doi.org/10.1016/j.beth.2021.12.002>

Whitehead, L., Robinson, S., Arabiat, D., Jenkins, M., & Morelius, E. (2024). The Report of Access and Engagement With Digital Health Interventions Among Children and Young People: Systematic Review. *JMIR Pediatrics and Parenting*, 7. <https://doi.org/10.2196/44199>

Zhao, X., Stadnick, N. A., Ceballos-Corro, E., Castro Jr, J., Mallard-Swanson, K., Palomares, K. J., Eikey, E., Schneider, M., Zheng, K., Mukamel, D. B., Schueller, S. M., & Sorkin, D. H. (2023). Facilitators of and Barriers to Integrating Digital Mental Health Into County Mental Health Services: Qualitative Interview Analyses. *JMIR Formative Research*, 7, e45718.

<https://doi.org/10.2196/45718>



**Tables****Table 1.***Sociodemographic Characteristics of the Samples*

Baseline Characteristics	Teens		Mentor	
	n	%	n	%
Gender				
Female	3	21.43	9	64.29
Male	7	50	5	35.71
Other/nonbinary identity	3	21.43	0	0
Prefer Not to Answer	1	7.14	0	0
Race (Participants could select more than one category)				
American Indian/ Alaskan Native	1	7.14	0	0
Black/African Origin	0	0	1	7.14
White/European	8	57.14	13	92.86
More than one race	3	21.43	0	0
Other/Unknown	2	14.29	0	0
Ethnicity				
Hispanic/Latino	2	14.29	1	7.14
Non-Hispanic/ Latino	12	85.71	13	92.86
State of Residence				
Iowa	5	35.71	5	35.71
Indiana	1	7.14	1	7.14
Massachusetts	1	7.14	1	7.14
North Carolina	1	7.14	1	7.14
Nebraska	3	21.43	3	21.43
Texas	3	21.43	3	21.43

## Grade

7 <sup>th</sup> Grade	2	14.29	0	0
8 <sup>th</sup> Grade	4	28.57	0	0
9 <sup>th</sup> Grade	3	21.43	0	0
10 <sup>th</sup> Grade	5	35.71	0	0

## Length of Mentoring

## Match

1 years	4	28.57	4	28.57
2 years	5	35.71	5	35.71
3 years	1	7.14	1	7.14
4 years	4	28.57	4	28.57

## Type of Mentorship

## Program

Formal	12	85.71	12	85.71
Informal	2	14.29	2	14.29

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*Note:* One teen and one mentor did not provide demographic data, thus the demographic data reflects  $n=28/30$  participants.

**Table 2.***Benchmark Descriptions, Rationales, and Results*

<b>Benchmark</b>	<b>Rationale</b>	<b>Result</b>	<b>Benchmark Met?</b>
<b>Intervention Feasibility (Mentee)</b>			
<p>Clinical deterioration</p> <ul style="list-style-type: none"> <li>Less than 20% of participants (3/15) will experience an increase in symptoms on the anxiety subscale of the PHQ-4 &gt; 50% above their pre-intervention score</li> </ul>	<p>Prior studies evaluating the standard English version of MindTrails have used similar criteria to assess for iatrogenic effects, with results indicating very few negative effects for participants (Eberle et al., 2023; Ji et al., 2021). For example, in Ji et al., only 18 participants (out of the 807 randomized to a training condition) experienced an increase in symptoms on the OASIS greater than 50% above their baseline score.</p>	<p>Clinical deterioration</p> <ul style="list-style-type: none"> <li>0/15 participants experienced an increase in symptoms on the anxiety subscale of the PHQ-4 &gt; 50% above their pre-intervention score</li> </ul>	<b>Yes</b>
<p>Protocol Adherence</p> <ul style="list-style-type: none"> <li>At least 46% of enrolled mentees (7/15) will complete ½ of assigned CBM-I training sessions (5/10 sessions).</li> <li>At least 33% of enrolled mentees (5/15) will complete all assigned CBM-I training sessions (10/10 sessions)</li> </ul>	<p>Based on our literature review of feasibility of digital CBM-I for anxious youth, youth completed around half or slightly less than half of their assigned CBM-I sessions (Participants completed an average of 5.85/8 sessions, de Voogd et al., 2017; 49% completed at least half of all assigned sessions, Prior et al., 2023) and around a third completed all sessions (38%; Sportel et al., 2013; 37%; Prior et al., 2023). Notably, all three of these trials included &gt;100 participants and were compensated, and therefore rates of completion may not reflect real-world implementation of digital CBM-I for anxious youth. All three trials were also</p>	<p>Protocol Adherence</p> <ul style="list-style-type: none"> <li>40% of enrolled mentees (6/15) completed ½ of assigned CBM-I training sessions (5/10 sessions).</li> <li>20% of enrolled mentees (3/15) completed all assigned CBM-I training sessions (10/10 sessions)</li> </ul>	<b>No</b>

	<p>unguided (e.g., children/adolescents completed their CBM-I independently): the broader literature on DMHIs for youth is mixed as to whether human support improves adherence to DMH interventions but at least one meta-analysis has suggested higher adherence with human support (Grist et al., 2017). Given the small, compensated, guided nature of our trial, we expect adherence and enrollment among youth to follow similar trends to the existing literature.</p>		
<b>Implementation Framework Feasibility (Mentor &amp; Mentee)</b>			
<p><b>Protocol Adherence</b></p> <ul style="list-style-type: none"> <li>At least 53% of mentors (8/15) will complete ½ of all check-ins.</li> <li>At least 53% of mentors (8/15) will discuss MindTrails with their mentees in ½ of all completed check-ins.</li> </ul>	<p>Given that this is a real-world implementation study, we do not expect that all mentors will maintain perfect fidelity to the protocol, and we have set these benchmarks based on what we would expect as the minimum necessary contacts and program check-ins given real-world implementation hurdles. There is not a rich literature base to guide the specific percentages, but we would hope that at least half the people who engage with the program as a mentor will do so in a way that allows for a substantive ‘dose’ of the mentorship component of the MindTrails Teen program.</p>	<p><b>Protocol Adherence</b></p> <ul style="list-style-type: none"> <li>60% of mentors (9/15) completed ½ of all check-ins.</li> <li>60% of mentors (9/15) discussed MindTrails with their mentees in ½ of all completed check-ins.</li> </ul>	<b>Yes</b>
<b>Intervention Acceptability (MAQ: Mentee Version)</b>			
<i>Acceptability of MindTrails Intervention</i>			
1. “I enjoyed using the MindTrails app.”	Mentee Intervention Acceptability Items #1–3:	1. “I enjoyed using the MindTrails app.”	<b>Yes</b>

<ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>	Youth DMHIs tend to rate high on acceptability. Studies using similar 5-point Likert scales to measure intervention acceptability tend to report mean ratings between 3 and 4 (Van Doorn et al., 2022; Garnefski & Kraaij, 2023; Peynenburg et al., 2022).	<ul style="list-style-type: none"><li>Mean = 3.56 (SD=1.59)</li></ul>	
2. “I would recommend MindTrails to other mentees or teens.” <ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>		2. “I would recommend MindTrails to other mentees or teens.” <ul style="list-style-type: none"><li>Mean = 4.11 (SD = 1.17)</li></ul>	Yes
3. “MindTrails changed the way I think during anxiety-provoking situations.” <ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>		3. “MindTrails changed the way I think during anxiety-provoking situations.” <ul style="list-style-type: none"><li>Mean= 3.56 (SD = 0.73)</li></ul>	Yes
Implementation Framework Acceptability (MAQ: Mentee Version)			
Acceptability of Mentorship Framework for Mentee			
1. “I enjoyed working with my mentor to apply the skills I learned in MindTrails.” <ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>	Mentee Implementation Acceptability Items #1–3: Research on implementation framework acceptability among youth is limited and often not distinct from intervention acceptability. Therefore, our benchmark is based on what the research team views as the minimum necessary score to consider the implementation model acceptable for broader dissemination among mentor/mentee dyads. A mean score of <3 would indicate overall youth dissatisfaction with the implementation framework.	1. “I enjoyed working with my mentor to apply the skills I learned in MindTrails.” <ul style="list-style-type: none"><li>Mean = 4.22 (SD = 0.67)</li></ul>	Yes
2. “I would recommend using MindTrails with a mentor to other mentees or teens.” <ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>		2. “I would recommend using MindTrails with a mentor to other mentees or teens.” <ul style="list-style-type: none"><li>Mean = 3.89 (SD = 1.17)</li></ul>	Yes
3. “It was helpful to have my mentor support my use of MindTrails.” <ul style="list-style-type: none"><li>Mean <math>\geq 3</math> (between “Neither agree nor disagree” and “Agree”)</li></ul>		3. “It was helpful to have my mentor support my use of MindTrails.” <ul style="list-style-type: none"><li>Mean = 4.22 (SD = 0.83)</li></ul>	Yes
Implementation Framework Acceptability (MAQ: Mentor Version)			
Acceptability of Mentorship Framework for Mentor			

1. “I enjoyed participating in this project.” <ul style="list-style-type: none"><li>Mean ≥ 3 (between “Neither agree nor disagree” and “Agree”)</li></ul>	Mentor Implementation Acceptability Items #1–3: Research on implementation framework acceptability among mentors and/or coaches is limited and often not distinct from intervention acceptability. Therefore, our benchmark is based on what the research team views as the minimum necessary score to consider the implementation model acceptable for broader dissemination among mentor/mentee dyads. A mean score <3 would indicate overall mentor dissatisfaction with the implementation framework.	1. “I enjoyed participating in this project.” <ul style="list-style-type: none"><li>Mean = 4.21 (SD = 0.80)</li></ul>	Yes
2. “I felt prepared to help my mentee use MindTrails.” <ul style="list-style-type: none"><li>Mean ≥ 3 (between “Neither agree nor disagree” and “Agree”)</li></ul>		2. “I felt prepared to help my mentee use MindTrails.” <ul style="list-style-type: none"><li>Mean = 3.87 (SD = 0.99)</li></ul>	Yes
3. “I would recommend MindTrails with mentor assistance to other mentees.” <ul style="list-style-type: none"><li>Mean ≥ 3 (between “Neither agree nor disagree” and “Agree”)</li></ul>		3. “I would recommend MindTrails with mentor assistance to other mentees.” <ul style="list-style-type: none"><li>Mean = 4.40 (SD = 0.83)</li></ul>	Yes
Intervention Outcomes			
Pre- to post-intervention change in target engagement: <ul style="list-style-type: none"><li>Negative interpretation bias score Hedge’s <math>g \geq .2</math></li></ul>	All studies in our literature review examining multi-session digital interventions found at least a small effect of the intervention on changes in interpretation bias (Sportel et al., 2013; Mao et al., 2023; Prior et al., 2023; de Voogd et al., 2017). The only studies that did not produce an impact on bias were single session interventions (Fu et al., 2013; Rogers & Sicouri, 2022). This reflects trends in the broader literature on CBM-I among anxious youth in which CBM-I has small to moderate effects on positive and negative interpretations (Krebs et al., 2018).	Pre- to post-intervention change in target engagement: <ul style="list-style-type: none"><li>PP: Hedge’s <math>g = -0.12</math></li><li>ITT: Hedge’s <math>g = 0.15</math></li></ul>	No
Pre- to post-intervention change in target engagement: <ul style="list-style-type: none"><li>Positive interpretation bias score Hedge’s <math>g \geq .2</math></li></ul>		Pre- to post-intervention change in target engagement: <ul style="list-style-type: none"><li>PP: Hedge’s <math>g = 0.31</math></li><li>ITT: Hedge’s <math>g = 0.60</math></li></ul>	Yes
Pre- to post-intervention change in anxiety symptoms:	Anxiety outcomes among youth using digital CBM-I interventions are mixed. Some suggest a small to	Pre- to post-intervention change in anxiety symptoms:	Yes

<ul style="list-style-type: none"> <li>• PHQ-4 anxiety subscale score Hedge's <math>g \geq .2</math></li> </ul>	<p>moderate effect of CBM-I on anxiety (Mao et al., 2023; Prior et al., 2023) while others either find no effect of CBM-I on anxiety or a significant main effect of time such that both the control group and CBM-I group show changes in anxiety (Sportel et al., 2013; Rogers &amp; Siccouri, 2022; de Voogd et al., 2017). While we anticipate that change in anxiety will be a smaller effect than change in interpretation bias, we expect at least a small anxiety reduction effect based on our prior MindTrails outcomes in adults and given the predicted positive impact of mentorship on intervention adherence and engagement.</p>	<ul style="list-style-type: none"> <li>• PP: Hedge's <math>g = 1.16</math></li> <li>• ITT: Hedge's <math>g = 0.88</math></li> </ul>	
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**Table 3**

*Percent Change in Mentees' Anxiety, Positive Interpretation Bias, and Negative Interpretation Bias from Pre-to-Post Intervention (Per Protocol Sample)*

Participant	Percent Change (Anxiety Symptoms)	Percent Change (Negative IB)	Percent Change (Positive IB)
P1	- 33.3%	- 12.5%	+ 15.8%
P5	- 57.1%	- 3.7%	- 36.4%
P8	- 14.3%	- 7.4%	+ 9.1%
P11	- 25%	0	- 16%
P12	- 50%	0	- 21.7%
P14	0	+ 13.6%	+ 15.8%
P15	+ 25%	+ 5.3%	- 5.3%
P19	- 25%	*	*
P21	- 50%	*	*
P22	- 33.3%	+ 27.8%	+ 12.5%

*Note: \* indicates missing data*



**Table 4.***Main Themes Identified and Frequency of Codes among Mentees*

Theme	Code	Number Mentors Endorsed (out of N=7)
<b>Theme 1:</b> Facilitators of Engagement	Components of the intervention that increased engagement	5
	Components of the app that increased engagement	4
<b>Theme 2:</b> Barriers to Engagement	Components of the intervention that decreased engagement	6
	Individual characteristics that decreased engagement	4
	Components of the app that decreased engagement	3
	External factors that decreased engagement	2
<b>Theme 3:</b> Suggestions for Improving Engagement	--	7
<b>Theme 4:</b> Change in Mental Health due to MindTrails Teen	Positive change	4
	No change	--
	Negative change	--
<b>Theme 5:</b> Description of MindTrails Teen	Positive description	4
	Neutral description	4
	Negative description	1
<b>Theme 6:</b> Perceived Value of Mentorship while using MindTrails Teen	Positive impact	5
	Neutral/no impact	1
	Negative impact	--
	Positive change	3

<b>Theme 7:</b> Change in mentee/mentor relationship due to MindTrails Teen	Neutral/no change	2
	Negative change	--

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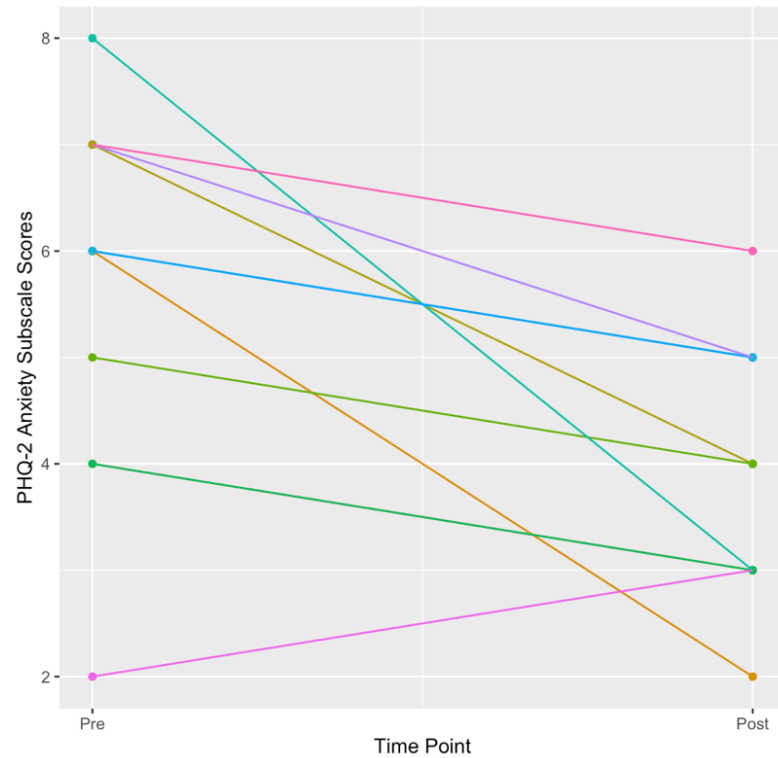
**Table 5.***Main Themes Identified and Frequency of Codes among Mentors*

<b>Themes</b>	<b>Code</b>	<b>Total Endorsements Total (N=7)</b>
<b>Theme 1:</b> Perceived Value of Mentorship	Useful	3
	Not useful	1
<b>Theme 2:</b> Change in mentor/mentee relationship due to MindTrails Teen	Positive change	4
	Neutral/no change	2
	Negative change	1
<b>Theme 3:</b> Mentorship Meetings	Incorporation of MindTrails in meetings	6
<b>Theme 4:</b> Benefit of MindTrails Teen to Mentee Mental Health	Perceived changes in anxiety levels of mentee	5
<b>Theme 5:</b> Barriers to Engagement	External factors that decreased engagement	3
	Individual characteristics that decreased engagement	2
	Components of the app that decreased engagement	2
<b>Theme 6:</b> Suggestions for program improvement	Suggestions for improving mentor experience	5
	Implementation considerations	2
<b>Theme 7:</b> Mentor Experience of MindTrails Teen	Helpfulness of app for mentor	4
	Additional Training Suggestions	5
	Usefulness of training	4

## Figures

**Figure 1.**

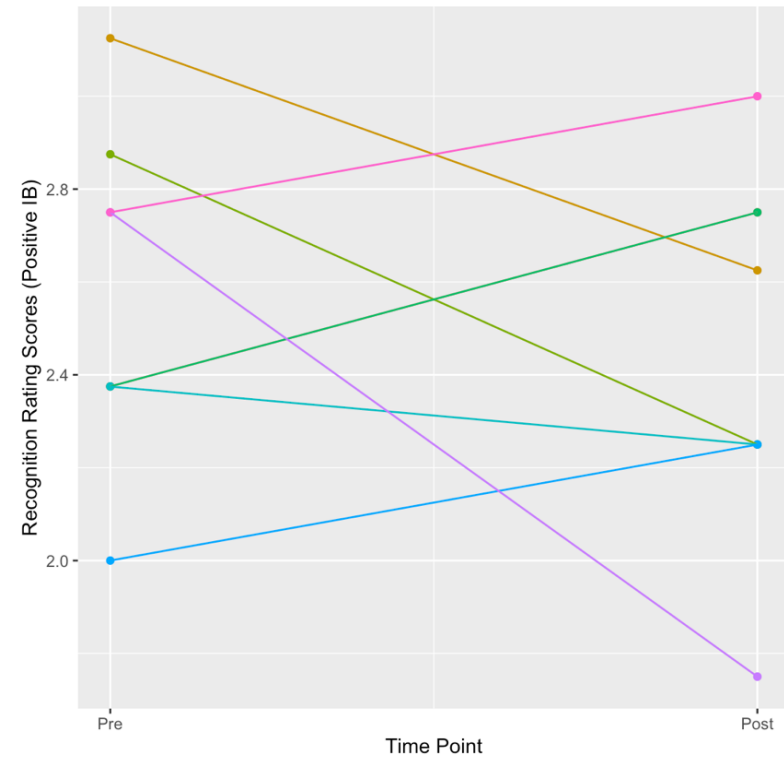
*Change in Anxiety Scores Over Time (Per Protocol Sample)*



*Note:* Each line indicates a single participant. The scale of the y-axis ranges from 1–8 and scores represent the sum of the first two items on the PHQ-4 (i.e., the PHQ-2 anxiety subscale).

**Figure 2.**

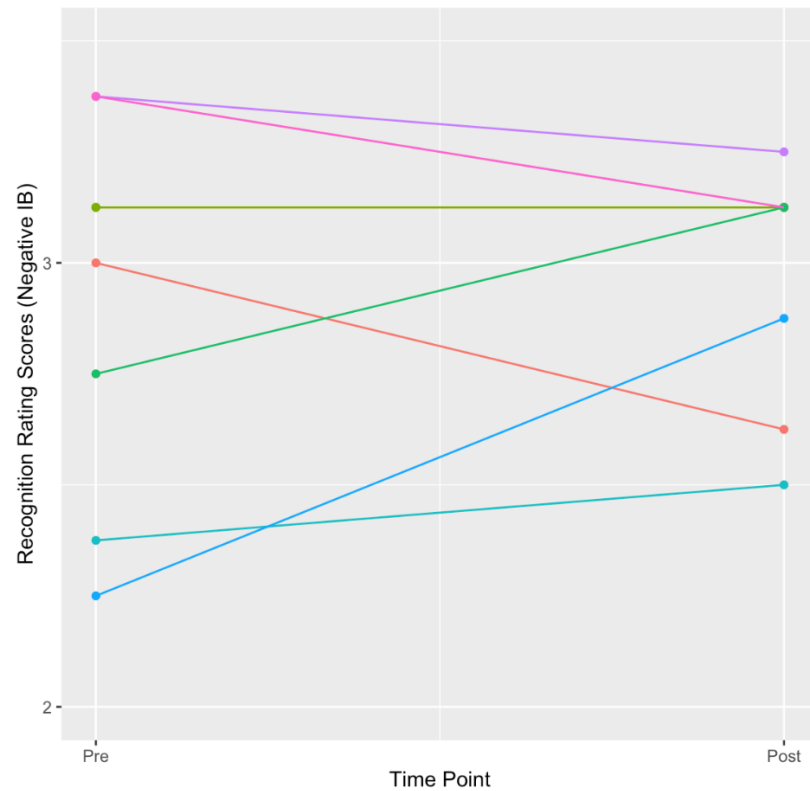
*Change in Positive Interpretation Bias Over Time (Per Protocol Sample)*



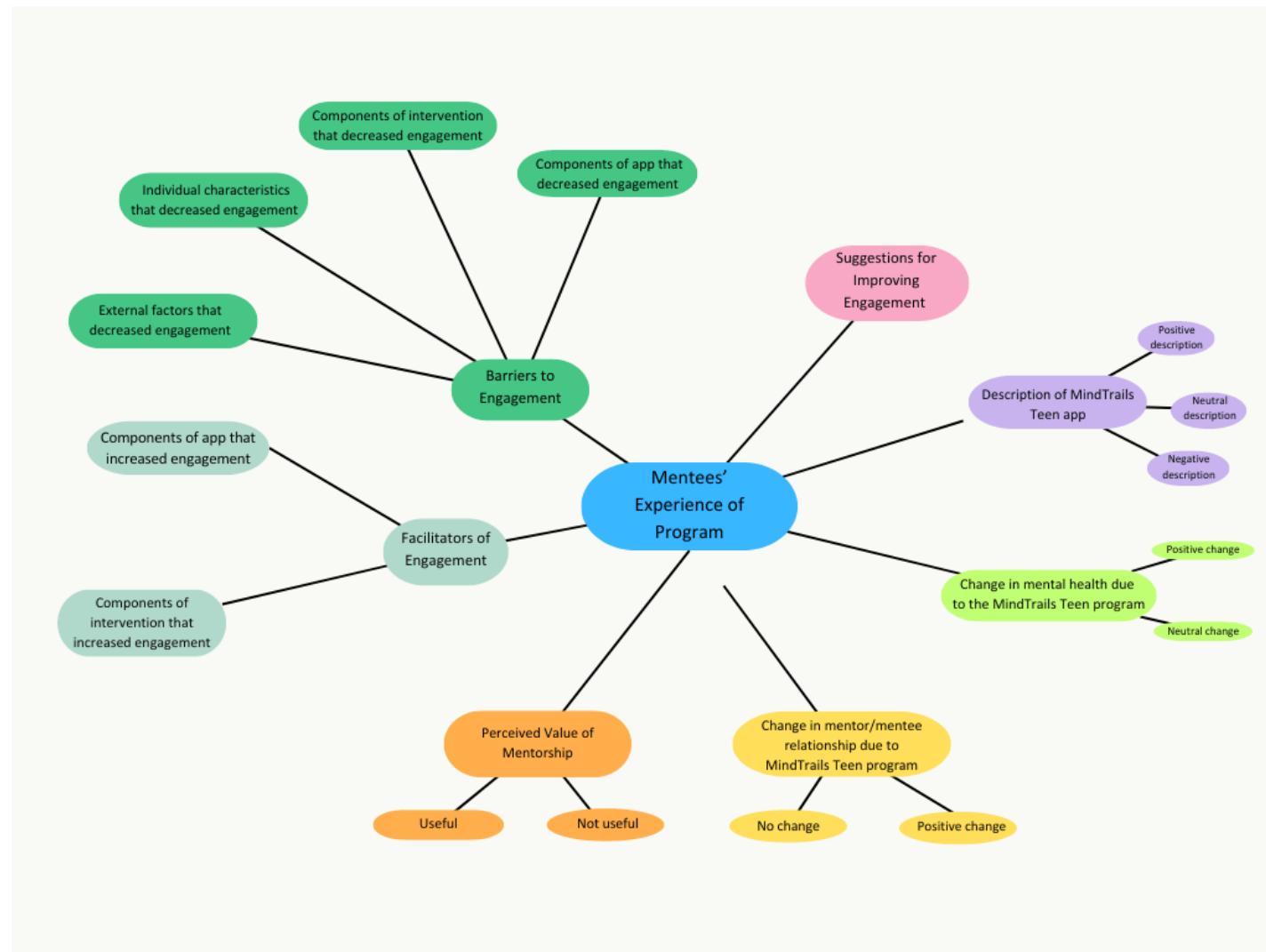
*Note:* Each line indicates a single participant. The scale of the y-axis ranges from 1–4 and scores represent the average of all positive interpretation bias items at each time point.

**Figure 3.**

*Change in Negative Interpretation Bias Over Time (Per Protocol Sample)*



*Note:* Each line indicates a single participant. The scale of the y-axis ranges from 1–4 and scores represent the average of all negative interpretation bias items at each time point.

**Figure 4.***Revised Thematic Map: Mentee Version*

**Figure 5***Revised Thematic Map: Mentor Version*