Adapting Cognitive Bias Modification to Train Healthy Prospection

Nauder Namaky¹, Jeffrey J. Glenn^{1,2,3}, Jeremy W. Eberle¹, and Bethany A. Teachman¹

¹University of Virginia

²Durham Veterans Affairs Health Care System

³VA Mid-Atlantic Mental Illness Research, Education and Clinical Center (VISN 6 MIRECC)

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Correspondence concerning this article should be addressed to Nauder Namaky, Department of Psychology, University of Virginia, Box 400400, Charlottesville, VA 22904, E-mail: nn2r@virginia.edu

Abstract

Prospection, the mental simulation of future events, has been theoretically linked to physical and mental health. Prior studies have found that prospection is malleable; however, no research to our knowledge has tested whether a scalable intervention explicitly targeting the simulation of positive future outcomes can lead to more generalized positive prospection, and enhance positive outlook and reduce distress. The current study tested a novel, web-based cognitive bias modification for interpretation (CBM-I) program designed to shift prospective bias towards more positive (as opposed to negative) representations of future outcomes among 172 participants selected for having a relatively negative baseline expectancy bias. Results showed that following CBM-I, participants in active training conditions exhibited more positive expectations about the future, and increased self-efficacy and growth mindset. Also, optimism increased and depression and anxiety symptoms decreased following active training, but this also occurred for the control condition. Analyses did not suggest that changes in positive expectations mediated changes in positive outlook outcomes. Results suggest that an online prospection intervention can lead to more positive expectations about future events and improve positive outlook, though open questions remain about what accounts for the training effects.

Keywords: interpretation, cognitive bias, prospection, expectancy, future

Introduction

Imagine tomorrow is the day of a big race. We all know people who picture themselves leaping across the finish line triumphantly, envisioning a glorious future. But what about the person who pictures not only losing the race, but also falling flat on his face and breaking his leg? Can we help this person have healthier views of his future and avoid these extreme negative representations? The current study investigates an intervention intended to change *prospection*, the mental simulation of future events (Gilbert & Wilson, 2007). The process of creating representations of potential future outcomes may contribute to the outcomes themselves because our expectations guide actions that make certain future scenarios more or less likely and affect how we process novel information (Seligman, Railton, Baumeister, & Sripada, 2013). Thus, healthier prospection should in theory lead to mental health benefits (Seligman et al., 2013) and improvements in motivation, emotion regulation, and decision making (Taylor, Pham, Rivkin, & Armor, 1998). However, no research (to our knowledge) has tested whether a scalable intervention that provides explicit practice envisioning positive future outcomes will lead to healthier prospection and, in turn, enhance positive outlook and reduce distress. This study used a web-based cognitive bias modification interpretation (CBM-I) training program to train prospection to favor the generation of relatively positive (as opposed to extremely negative) representations of possible future states.

Benefits of Improved Prospection

Seligman and colleagues (2013) have argued that prospection serves a central organizing role in cognition, emotion, learning, motivation, and decision making, and have called for novel future-looking approaches to enhancing wellness. Indeed, there is evidence that positive prospection has numerous psychological benefits, including improved emotion regulation (e.g., Pham & Taylor, 1999) and problem-solving abilities (e.g., Cheng, Shein, & Chiou, 2012; Miloyan & Suddendorf, 2015), and low levels of positive prospection have been

linked to negative psychological outcomes, including depression and suicidality (e.g., Bjärehed, Sarkohi, & Andersson, 2010; Schacter, Addis, & Buckner, 2008).

Furthermore, there is some evidence to suggest that overly negative prospection is a transdiagnostic marker for emotional disorders. Miloyan, Pachana, and Suddendorf (2014; 2016) found that, in older adults, depression and anxiety were associated with fixations on negative future scenarios and that depression was linked to reduced expectations of positive future scenarios. With reference to the National Institute of Mental Health's Research Domain Criteria (RDoC) framework, overly negative prospection may be seen as a deficiency in the expectancy/reward prediction error subconstruct of the approach motivation construct, which falls under the positive valence systems domain (Insel et al., 2010). In this framework, overly negative prospection can be thought of as extreme discounting of internal and external stimuli that would normally predict rewarding outcomes. The current study seeks to teach individuals prone to relatively negative prospection (relative to others' more normative, positive future representations) to make reasonably positive prospections as a means to expand their cognitive repertoire and flexibility. Thus, the goal is not to make all expectations about the future positive, but to shift negative thinking among individuals prone to be relatively more negative so that positive representations are more accessible.

Cognitive Bias Modification to Target Prospection

Cognitive bias modification (CBM) programs are increasingly being tested as stand-alone or complementary adjuncts to other interventions. CBM uses basic learning principles to provide individuals with repeated practice processing information in a healthier way. The programs are typically computer based and aim to alter maladaptive biases that are causally linked to poor cognitive, emotional, behavioral, and interpersonal functioning. For example, in the ambiguous scenarios paradigm, a typical CBM program designed to modify interpretation bias (CBM-I), participants read brief, emotionally ambiguous scenarios that are mainly about events that happened in the past or are currently unfolding. The meaning of the scenario

(whether the emotional ambiguity resolves positively or negatively) is determined by completing the last word, which is presented as a word fragment that the participant is asked to solve (Mathews & Mackintosh, 2000). Notably, CBM programs have demonstrated efficacy at shifting biases and improving emotional functioning across many studies, including reductions in anxiety and depression symptoms (see meta-analyses and reviews in Hallion & Ruscio, 2011; Hertel & Mathews, 2011; C. MacLeod & Mathews, 2012; Jones & Sharpe, 2017). At the same time, there are many null or mixed findings (see Cristea, Kok, & Cuijpers, 2015), and effects tend to be largest and most reliable for shifting interpretation biases, rather than symptoms (Menne-Lothmann et al., 2014). In light of these mixed findings, testing theoretically motivated adaptations of CBM-I might provide insight into methods to strengthen the effects of a promising, but unrefined intervention. For example, emphasizing scenarios that occur in the future, rather than the past, may shift interpretations linked to fear of uncertainty and anticipatory anxiety. Since fear of uncertainty and anticipatory anxiety are themselves associated with maladaptive responses to possible future threats, targeting these processes might strengthen the effects of CBM-I on symptom reduction and promoting positive outlook (Grupe, 2013).

Value of generating imagery tied to future events. Prior research using visual imagery indicates potential ways to design and enhance the effects of CBM-I for prospection. Several studies have emphasized the importance of vividly imagining ambiguous scenarios versus only processing their verbal meaning, finding that the former approach leads to more positive interpretation, greater increases in positive affect, and greater decreases in state anxiety than the latter approach in healthy college students and community members (Holmes, Mathews, Dalgleish, & Mackintosh, 2006; Holmes, Lang, & Shah, 2009; Nelis, Vanbrabanta, Holmes, & Raesa, 2012). Furthermore, studies that instruct participants to generate positive visual imagery from a field (i.e., first-person) perspective have demonstrated improved interpretation biases, affect/mood, mental health symptoms, imagery vividness, and performance on a behavioral task

in dysphoric or depressed outpatients, or in community members presented with ambiguous scenarios (Blackwell & Holmes, 2010; Torkan et al., 2014), picture-word cues (Pictet, Coughtrey, Mathews, & Holmes, 2011), or sets of both stimuli (Lang, Blackwell, Harmer, Davison, & Holmes, 2012; Blackwell et al., 2015; Renner, Ji, Pictet, Holmes, & Blackwell, 2017). Although many of these positive imagery CBM-I studies have presented ambiguous scenarios auditorily using headphones, a comparison of visual and auditory formats revealed comparable changes in interpretation bias but more negative mood in the auditory condition (Standage, Ashwin, & Fox, 2009). In line with these findings, in the present study we asked participants to “really try to imagine yourself” in the scenarios (though we did not include specific instructions about how to vividly imagine or a field perspective, in part because some of these studies were not available at the time we designed our intervention), and we presented scenarios as text on a computer screen, akin to the visual format of Mathews and Mackintosh (2000).

Although prior CBM-I studies have not focused explicitly on the simulation of positive future events, the literature suggests that a CBM-I program targeting prospection may engage similar mechanisms and confer similar benefits to those focused on positive imagery. Positive imagery CBM-I has used mostly present- or past-tense scenarios to date, but some authors have proposed that resolving the ambiguous part of these scenarios by imagining a specific ending involves episodic simulation (Murphy et al., 2017), or the generation of specific mental images about the future (Lang et al., 2011). That is, even when generating images for present- or past-focused scenarios, participants are simulating events that have not yet occurred. Indeed, positive imagery CBM-I containing both ambiguous scenarios and picture-word cues has been found to increase the vividness of positive future imagery (Blackwell et al., 2015; Murphy et al., 2015), optimism (Murphy et al., 2015), and neural activation associated with the simulation of positive future events and with optimism (Sharot, Riccardi, Raio, & Phelps, 2007). This form of CBM-I has also increased behavioral activation among depressed community adults (Renner et al., 2016), consistent with work suggesting that people who imagine future

events rate them as more probable and are more likely to engage in behaviors related to them (Karniol & Ross, 1996). Given this convergent evidence about the likely positive effects of imagining positive future events, in the present study, we targeted episodic simulation more explicitly with scenarios that directly described future events and solicited predictions about future behaviors in post-scenario comprehension questions to reinforce these links.

Impact on prospection, symptoms, and positive outlook. Other studies that have explicitly trained positive prospection have shown that writing about and simulating one's "best possible self" in the future increases optimism (Meevissen, Peters, & Alberts, 2011; Malouff & Shutte, 2017) and that writing about and imagining ordinary positive future events increases happiness (Quoidbach, Wood, & Hansenne, 2009). Boland, Riggs, and Anderson (2018) also showed that simulating positive future events in response to cue words can increase the perceived likelihood of positive events and decrease the perceived likelihood of negative events in college students with no, moderate, and high dysphoria. However, not all of these studies have included active control groups, and those with active control groups have either not assessed or not found effects on depression and anxiety symptoms in addition to optimism and other positive outlook measures, or have required in-person intervention or laboratory tasks with an experimenter, limiting their scalability. In the present study, we thus build upon this previous research by targeting positive prospection in a randomized controlled trial of a scalable, web-based CBM-I intervention in a transdiagnostic sample of college students and assess its effects on multiple symptoms and measures of positive outlook.

In addition to its explicit targeting of prospection, the CBM-I used in the present study is novel in its focus on expected future outcomes spanning multiple domains of daily living (e.g., work, relationships, health), not only those related to specific types of threats or disorders (e.g., social threat, depression). Given the implicit learning thought to underlie the generation of representations of the future (Seligman et al., 2013), CBM-I's provision of repeated practice assigning a positive meaning to future representations may be especially well-suited to

automate a given representation style. The current study tests whether CBM-I can be modified to promote more positive representations of future states and, in turn, engender more positive beliefs about the future and one's abilities, and reduce symptoms of depression and anxiety. If efficacious, CBM-I could serve as a targeted, simple, brief, cost-effective intervention that can be easily disseminated.

Overview and Hypotheses

The current study used a CBM-I program to train participants to expect relatively positive future outcomes by resolving the emotional ambiguity in scenarios that set up uncertainty about one's future state. Recruitment targeted individuals who had a baseline bias toward envisioning *comparatively* negative outcomes (i.e., more negative relative to the assessed population's average negativity), given the presumed potential for these individuals to benefit from being more flexible in their prospection. Thus, in this case, becoming more positive is viewed as a sign of healthier prospection because it reflects a shift away from habitually negative representations.

Participants were randomly assigned to one of four conditions in the four-session, web-based intervention. The two positive treatment conditions—Positive Prospection, and Negation + Positive Prospection—both involved the presentation of scenarios that resolve in ways indicating a positive future state, but the latter condition also negates negative futures states. For example, in contrast to scenarios in the Positive condition stating that a positive outcome will happen, a Negation + Positive scenario also stated that a *negative* outcome will *not* happen. The negation condition was included to test whether there is added value to explicitly refuting a negative future or whether negation is actually harmful by implicitly reinforcing the negative association (Ouimet, Gawronski, & Dozois, 2009). A 50/50 condition ended positively only 50% of the time. In earlier studies, this condition was considered a control condition given that positive and negative outcomes were presented in equal measure. However, we have come to think this is likely an active condition that, by virtue of requiring individuals to repeatedly change

how they think about ambiguity being resolved, encourages more flexible thinking about outcomes. Thus, in our more recent work, we have described our view that the 50/50 condition is likely an active condition, though likely with weaker effects than the more consistently positive training conditions where a new contingency is learned (see Edwards, Portnow, Namaky, & Teachman, 2018; clinicaltrials.gov number NCT02382003; see also Williams et al., 2015). The Neutral Control condition presented scenarios that are matched for time, format, and task demands, but that are neutral in valence (not particularly positive or negative) and do not involve the resolution of future-oriented emotional ambiguity. We evaluated how training alters prospection, increases positive outlook, and reduces negative mood.

We hypothesized that both CBM-I positive treatment conditions would improve prospection as indicated by enhanced expectations for future positive states. We also hypothesized that CBM-I would enhance positive outcomes and reduce negative outcomes. Specifically, we expected that the Positive and Negation + Positive conditions would experience greater increases in self-efficacy, optimism, and growth mindset and greater decreases in depression and anxiety symptoms, relative to the Neutral Control, and that the 50/50 condition would experience intermediate benefits (between the two other positive training conditions and the neutral control condition). Lastly, we hypothesized that change in prospection would mediate the effects of CBM-I on the trait positive and negative indicators.

Methods

Participants

Participants were recruited through the university's psychology department participant pool in exchange for course credit. Potential participants completed the Expectancy Bias Task (see Expectancy Bias under materials for description and scoring details) during a participant pool pre-selection battery, along with several other measures. Students were invited to participate by email if they scored more than 0.50 standard deviations below the participant pool mean on the Expectancy Bias task. This criterion was chosen to select a sample with *relatively*

negative bias, indicating potential risk for emotional disorders based on a likely transdiagnostic risk factor, rather than one reflecting an established clinical population. This approach is in line with the National Institute of Mental Health's recommended Research Domain Criteria (Cuthbert, 2015). Overall, the initial sample scored a mean of -0.10 ($SD = 0.94$) on the Expectancy Bias Task, indicating virtually no absolute tendency to endorse positive or negative future events on the task, but a score that was notably more negative than the more normative positive expectancy bias score.

Two hundred and one participants consented and began the first online session of the study, of which 172 (66.3% female) completed all sessions of CBM-I and are included in the subsequent analyses. The mean age of the sample was 20 years ($SD = 1.88$, range = 18-26). The reported race of the participants was White (70.3%), Asian (16.7%), Black/African American (4.1%), and other (8.9%). This study received approval from, and complies with, the university's institutional review board.

Materials

This study was part of a larger project examining the effects of prospection bias modification on state and trait affect measures. We decided prior to conducting analyses to focus in this paper on the trait measures. For a full list of materials, contact the first author.

Expectancy bias. The Expectancy Bias Task (modified from Cabeleira et al., 2014) is a reading judgment task designed to evaluate participants' tendency to anticipate that positive or negative events will occur in the future. The task is thought to be a good measure of prospective judgments, and at least one review of the literature concerning prospection, positive outlook, and mental health has discussed the task as a measure of *relative* prospective style, meaning the extent of positive relative to negative expectancies (A. Macleod, 2017). Note that the term *bias* is used here to indicate scores that are more extreme than the average score, rather than an absolute level of bias (i.e., participants were selected because they were more negative than

most people in the screening sample, but this did not mean they were significantly more negative than positive).

Twelve scenarios were presented that varied in the extent to which positive, negative, or neutral events occurred. Participants were then asked to judge the likelihood of future valenced events occurring in each scenario. The task is comprised of a Scenario Presentation Component and an Expectancy Rating Component.

In the *Scenario Presentation Component*, participants were instructed to read and imagine themselves in 12 scenarios (“During this task, you will see a number of paragraphs that describe different situations. Please read each paragraph carefully, and **imagine yourself in the situation** described. After each paragraph, you will see a set of sentences describing an event that might happen next. Although we know that you can't be sure what would happen next, and there is no right or wrong answer, we would like you to judge the likelihood of each of the events occurring next, given all the information that has already happened in the paragraph.” [participants saw the text bolded, as shown above]). Each scenario contained a Title, an Orienting Sentence, and four events (see sample in Appendix). The set of 12 scenarios included two scenarios to represent each of the six domains targeted in training (Career/Work, Family/Friends, Fear of Negative Evaluations/Performance, Finances, Health, Romantic/Relationships). Although the target domains were matched, scenarios generated for the Expectancy Bias Task were novel and did not overlap in content with the training scenarios. The scenarios were designed so that the events depicted varied in valence (as occurs in real life) so that we could train expectancies across different contexts (i.e., when events have been going well vs. poorly). Thus, some scenarios included two positive and two neutral events (Positive Valence), some included two negative and two neutral events (Negative Valence), and some included two positive and two negative events (Conflicting Valence). The two scenarios for any given domain always varied in valence (e.g., one Positive and one Conflicting Valence).

In the *Expectancy Rating Component* of the task, participants were instructed to rate the likelihood that different future events would occur for each of the scenarios they had previously read and imagined themselves in. For each trial, participants again saw the Title and Orienting Sentence of one of the previously seen scenarios. These remained on the screen while the participants rated the likelihood that each of three future events (one positive, one negative, one neutral) would follow next in the scenario. The future events were presented one at a time, and order of the positive/negative/neutral event presentation was randomized across the scenarios. Participants rated these events using a scale ranging from 1 (*very unlikely*) to 7 (*very likely*).

An expectancy bias score was obtained by subtracting the average perceived likelihood ratings for negative events from the average perceived likelihood ratings for positive events. Positive scores indicated a positive expectancy bias, whereas negative scores indicated a negative expectancy bias. The absolute value of the score indicated the degree of bias. (Scores on ratings for future neutral events were not analyzed.)

Pilot testing for the Scenario Presentation Component of the task. All 12 scenarios were pre-tested with an online Mechanical Turk sample ($n = 50$) to confirm that the scenarios (without the future continuation events that were rated in the Expectancy Rating Component of the task) clearly reflected the intended valence. Pilot participants were presented with each scenario and asked to rate the overall valence on a scale ranging from 1 (*very negative*) to 7 (*very positive*). To confirm the scenarios represented the intended valences, one-sample t -tests were conducted to check that the ratings for Positive and Negative Valence sets were significantly different from 4 (the neutral point) and that the ratings for the Conflicting Valence set were not significantly different from 4. As anticipated, the Negative ($M = 2.92$, $SD = 0.67$) and Positive ($M = 5.74$, $SD = 0.75$) Valence sets were significantly different from 4, in the expected directions: $t = -11.53$, $d = 1.63$, $p < .001$; $t = 16.31$, $d = 2.31$, $p < .001$; respectively. Note that the absolute value of the Positive and Negative Valence sets' differences from 4 were compared using a paired-sample t -test, which indicated that the positive valence scenarios were

rated slightly more positively than the negative valence scenarios were rated negatively, $t = 6.27$, $d = 0.89$, $p < .001$. Given that our primary interest is in change in positive and negative ratings over time, this small difference was not considered a problem. The Conflicting Valence set ($M = 4.15$, $SD = 0.64$) was not significantly different from 4, as expected, $t = 1.67$, $d = 0.24$, $p = .100$.

Measures of positive outlook.

Optimism. Trait optimism was measured using the Life Orientation Test-Revised (LOT-R; Scheier, Carver, & Bridges, 1994). The LOT-R is a 10-item questionnaire designed to measure participants' optimism versus pessimism (e.g., "In uncertain times, I usually expect the best"). Participants indicated whether they agree with each statement on a 5-point Likert scale ranging from 0 (*strongly disagree*) to 4 (*strongly agree*). Following recommendations by Scheier, Carver, and Bridges (1994), pessimism items were reverse scored and added to the optimism items to derive a single score indicating optimism.

Self-efficacy. Trait self-efficacy was measured using the New General Self-Efficacy Scale (NGSES; Chen, Gully, & Eden, 2001). The NGSES consists of eight items assessing participants' sense of self-efficacy (e.g., "I will be able to achieve most of the goals that I have set for myself"), to which participants indicate their degree of agreement using a 5-point Likert scale ranging from 1 (*disagree strongly*) to 5 (*strongly agree*). A score is obtained by summing the participants' response to all eight items.

Growth mindset. Trait growth mindset was measured using a modified version of the Mindset Survey (MMS; Dweck, 2006), changed to reflect mindset about general personality and thinking style, rather than just intelligence. The MMS consists of eight items asking participants to rate the degree to which they agree or disagree with statements about one's ability to change (e.g. "You can always change basic things about the kind of person that you are"). Participants rate their agreement using a 4-point Likert scale ranging from 1 (*strongly agree*) to 4 (*strongly*

disagree). Items expressing fixed mindset are reverse scored, and all items are summed to obtain a growth mindset score, on which lower scores indicate greater growth mindset.

Measures of distress (anxiety and depressive mood). Anxiety and depression symptoms were assessed using the Anxiety and Depression subscales, respectively, of the Depression, Anxiety, and Stress Scale—Short Form (DASS-Anxiety and DASS-Depression; Lovibond & Lovibond, 1995). Each subscale consists of seven items, on which participants report how much different statements concerning either anxiety or depression applied to them in the past week using a 4-point Likert scale ranging from 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*). Anxiety items sample physiological indicators of anxiety and concern over losing control or panic (e.g., “I was worried about situations in which I might panic and make a fool of myself”). Depression items ask about anhedonic or dysphoric symptoms of depression (e.g., “I was unable to become enthusiastic about anything”).

Cognitive bias modification for interpretation (CBM-I) task. Participants were instructed to imagine themselves in 48 scenarios (based on the format described in Mathews & Mackintosh, 2000, with modifications to make the training materials slightly different in each session to increase user engagement): “In this task, you will see a series of paragraphs and questions. Please read each paragraph carefully, and **imagine yourself in the situations described**. Some of these situations may be different from your usual experiences, or may describe you doing things you wouldn’t typically do. That’s OK. We want you to really try to imagine yourself in these situations and trying out these different ways of reacting.” [participants saw text bolded and underlined, as shown above]).

Participants were presented with three-sentence-long scenarios about what might happen in their future, to guide a mental simulation of upcoming events. The resolution of the scenario (i.e., whether the ambiguity about future outcomes was resolved positively or negatively) was determined by participants’ completing the last word of the final sentence, which was presented as a word fragment. In the first session of CBM-I, participants completed the final

word fragment of a scenario by filling in a missing letter (e.g., they would fill in the word fragment “we_l” with the letter “l”). For the second session, participants would need to fill in two letters from the word fragment they had seen the previous session (e.g., they would fill in the fragment “we_ _” with “l” and “l”). In the third session, they would need to fill in one letter from a new word fragment at the end of each scenario (the new word fragments ended each scenario with the same meaning and valence). In the fourth session, participants filled in two letters from the word fragments presented in the third session. These small changes were included to reduce the extent participants would respond in an automated way because the required response changed each session.

For the conditions with valenced information, scenarios were written to adequately sample several domains of possible future concerns: physical health, romantic relationships, friends and family, career, finances, and performance. Half of the scenarios dealt with short-term future outcomes, and half dealt with long-term outcomes (short- and long-term were determined subjectively based on the application to that domain; e.g., a date the following week vs. a long-term marriage, or an upcoming job interview vs. a promotion for a company after working there for many years). The valence of each scenario remained ambiguous until the final word fragment was resolved.

In the 50/50 condition, scenarios were written so that half ended in a negative valence (e.g., “You hope to have children of your own in the future and want them to have good educational opportunities. You want your kids to be able to attend good colleges, but understand that this comes with a high price tag. When you think about having children, you think supporting their college education will be i_possible”), and half ended in a positive valence (e.g., “You are currently living with your parents, but you have a stable job now. You feel that it is about time to move out of your parents’ house and be independent. Considering the possibility of moving out, fully supporting yourself will be fea_ible”).

In the Positive Prospection condition, the negative endings in the 50/50 control condition were changed to reflect positive endings so that all scenarios ended with a positive valence. In the Negation + Positive Prospection condition, a phrase negating the possibility of a negative ending was added before resolving the scenario positively (e.g., “Your family has a history of coronary heart disease late in life. You are fit, exercise regularly, and eat well, but worry about whether you will eventually fall victim to the disease. When you think of yourself in old age, you do not believe you will become sick, and you see yourself as being healthy”).

In the Neutral Control condition, scenarios were written so that the content was not strongly positively or negatively valenced and there was no emotional ambiguity about future events (e.g., “You are in a hotel. You notice that there is soft background music playing. You realize the song is one you have heard before”).

Across all conditions, following each scenario in the first two sessions, participants were asked a “yes” or “no” comprehension question to reinforce the positive or negative interpretation assigned to the scenario by completing the word fragment and to ensure that the scenarios were all properly read (e.g., “Will you have trouble fully supporting yourself when you move out?”). Following each scenario in the second two sessions, a multiple choice comprehension question was asked, with participants having to choose the response that best matched the ending of the scenario they read (e.g., if the participant was asked “Thinking about the next few years, you see yourself:” they would be given the choices “Living independently and supporting yourself financially” and “Depending on your parents in order to have a roof over your head”). The change between the first two and last two CBM-I sessions was used to increase user engagement throughout the four-session protocol by changing the format.

Pilot testing of scenarios for CBM-I training materials. A large pool of future events was piloted with an online Mechanical Turk sample ($N = 45$) to select those events that most clearly reflected the intended valence. Pilot participants were presented with each scenario and asked to rate the future events corresponding to each scenario on a scale ranging from 1 (very

negative) to 7 (*very positive*). To be selected as a negative event, the mean rating had to be less than or equal to 2.5; to be selected as a positive event, the mean rating had to be greater than or equal to 5.5; and to be selected as a neutral event, the mean ratings had to fall between 3.0 and 5.0. To further confirm the valence assignment, one-sample *t*-tests were then conducted to check that the selected sets of positive and negative events were significantly different from 4 (the neutral point). As anticipated, the negative ($M = 2.00$, $SD = 0.96$) and positive ($M = 6.09$, $SD = 0.76$) events were significantly different from 4, in the expected directions: $t = -13.92$, $d = -4.20$, $p < .001$; $t = 18.48$, $d = 5.33$, $p < .001$; respectively. The selected set of neutral ($M = 4.32$, $SD = 0.42$) events were slightly different from 4, $t = 5.03$, $d = 1.52$, $p < .001$, suggesting they were not perfectly neutral, but this difference was very small, 95% CI [4.19, 4.44]. Given that the neutral events were included to show a range of possible future options but the neutral ratings were not being used for the primary analyses, this was not considered problematic. Finally, a paired-sample *t*-test demonstrated that the absolute value of the selected sets of negative and positive events were not significantly different, $t = 1.03$, $d = 0.154$, $p = .314$, illustrating that the negative and positive future events were comparable in valence intensity.

Procedure

Participants who qualified for the study based on their score on the Expectancy Bias Task were sent an email outlining the details of the study, and the informed consent procedure. Once consent was obtained, participants were randomized to one of the four CBM-I conditions (50/50, Positive Prospection, Negation + Positive Prospection, or Neutral Control) using a sequence determined by freely available true-random software (Haahr, 1999; for a breakdown of the number of participants in each condition, see Figure 1). All four CBM-I sessions were completed online by participants using links emailed to them by the researchers. Before starting their first CBM-I session, all participants completed the Expectancy Bias Task, LOT-R, NGSES, MMS, DASS-Anxiety, and DASS-Depression in a random order. After completing the first

session, participants had to complete the second session within one week, and they were instructed to complete the next two sessions the following week. Thus, participants were asked to complete two sessions a week for two weeks. Participants completed the Expectancy Bias Task, with the same stimuli, after every session except the first. After finishing the fourth session, participants signed up for an in-lab assessment, which took place within one week of completing all of the CBM-I sessions. At this in-lab session, participants again completed the Expectancy Bias Task, LOT-R, NGSES, MMS, DASS-Anxiety, and DASS-Depression in a random order.

Plan for Analyses

A subset of 57 individuals completed all CBM-I sessions, but elected not to come in for the in-lab follow up. To include these individuals in the analyses of trait measures gathered at follow-up, their post-treatment scores were imputed using the MICE algorithm and a random forest imputation, implemented using R's "mice" package (Royston, 2004, 2005, 2009; van Buuren & Groothuis-Oudshoorn, 2011)¹. Following the guidelines from Bodner et al. (2008) and White et al. (2011), 30 imputations were calculated and averaged, with 30 iterations per imputation. This was chosen over a last observation carried forward (which in this case is also a baseline carried forward) method, given some evidence that multiple imputation is a more reliable estimate of time effects and is not necessarily less conservative (Jørgensen et al., 2014). Sex, age, race, condition, each session's total expectancy bias, baseline LOT-R, baseline NGSES, baseline MMS, baseline DASS-Anxiety, and baseline DASS-Depression scores were used as predictor variables for imputing post treatment LOT-R, NGSES, MMS, DASS-Anxiety, and DASS-Depression. While sex, age, and race were not included in the

¹ Note, the imputation models used in these analyses assume that data are missing at random (MAR), meaning that when conditioned on the other variables in the dataset, missing data is not dependent on a missing variable (Rubin, 1976). While this assumption is difficult to prove quantitatively or conceptually, visual inspection of our imputation models' density plots revealed that imputed datasets uniformly displayed similar densities to the original, which is an indicator that the MAR assumption has been met (Zhang, 2015).

overall models (because any differences by condition occurred as a result of random assignment), they were included in the imputation to provide more complete, *a priori* information about participants' levels of closeness to aid a more accurate imputation. A burn-in sequence of 10 iterations was used.

Mixed-effects models were run to test for the effect of time (measured in terms of session number) and treatment condition on expectancy bias. Before any effects were analyzed for statistical significance or effect size, separate linear, quadratic, cubic, quartic, and quintic² models were fitted and compared to see what shape and curvature best described the effects of time on the overall expectancy bias. Given that no model significantly fit better than a linear model, the linear model was subsequently analyzed and used for the expectancy bias models.

A linear mixed-effects model was fit to see the effects of time and condition (using Neutral Control as the comparison condition) on the overall expectancy bias score. Time, condition, and the time-by-condition interaction were entered as fixed effects, and a random intercept and random slope for time were entered for each participant. Then, the same model was applied to predict the average positive expectancy ratings and average negative expectancy ratings, respectively. This was done to test if the effect of CBM-I on expectancy bias was the result of changes in positive expectations, negative expectations, or both.

Linear mixed-effects models were also run to test the effects of time and condition on each trait measure. These models included time, condition (using Neutral Control as the comparison condition), and the time-by-condition interaction as fixed effects, and a random intercept was entered for each participant. In models in which there were no significant interaction coefficients with the Neutral Control condition as the comparison, the 50/50 condition was also compared. Two participants did not complete the MMS at baseline and so were left out of the analysis for trait growth mindset.

² While a quintic model was run, it should be noted that, given 5 data points, it would not be possible to detect a reliable quintic trend. It is included in our description of analyses for transparency.

Mixed-effects models were run using the “lme4” package in R (Bates, Maechler, Bolker, & Walker, 2014; R Development Core Team, 2013). Significant interactions in each of the models were plotted and analyzed according to techniques described by Preacher, Curran, and Bauer (2006). Effect sizes are reported using estimates of standardized β . Properly interpretable R^2 statistics are not yielded by linear mixed-effects regressions (see Peugh, 2010), so this alternative measure of effect size is used. Standardized β estimates are usually smaller, more conservative estimates of r (see Ferguson, 2009). The models were stepwise; with random effects being entered first, then simple fixed effects, then fixed effect interactions. Separate models were run for each imputed data set (30 in total per model), and results were pooled using R’s “mice” package (Royston, 2009; van Buuren & Groothuis-Oudshoorn, 2011).

For all models with a significant time-by-condition interaction, subsequent *causal mediation models* were run to test whether overall expectancy bias, positive expectancy, or negative expectancy mediated training effects on the trait measures (following the procedure outlined by Imai, Keele, & Tingley, 2010; Imai, Keele, Tingley, & Yamamoto, 2010, 2011; Imai, Keele, & Yamamoto, 2010; Imai & Yamamoto, 2013). *Causal mediation* analyses were run using the “mediation” package in R (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014).

Intention-to-treat analyses. Because there was no significant difference in drop-out rate by condition, $\chi^2(3) = 1.63$, $p = .653$, intention-to-treat analyses were carried out using a multiple imputation method (following suggestions by White, Carpenter, & Horton, 2012). The intention-to-treat analysis includes all individuals randomized to conditions. The MICE algorithm was used to implement multiple imputations, using the random forest method in R’s “mice” package, following the same procedure described earlier, with sex, age, race, condition, each session’s total expectancy bias, baseline LOT-R, baseline NGSES, baseline MMS, baseline DASS-Anxiety, and baseline DASS-Depression scores used as predictor variables for imputing post treatment Expectancy Bias, LOT-R, NGSES, MMS, DASS-Anxiety, and DASS-Depression for the entire 201 individual sample. A burn-in sequence of 10 iterations was used. The

expectancy bias models showed very similar results for the intention-to-treat and completer analyses. For models of positive outlook and distress, the only notable difference was for the model predicting self-efficacy. This difference is noted in the Results section, but given the overall similarity between the intention-to-treat and completer models, subsequent results are reported only for the completer model. See Figure 1 for a flowchart of participation and drop out.

Results

Descriptive Statistics

All participants answered at least 85% of the comprehension questions correctly for each session, and thus data were considered valid from the standpoint of task understanding and engagement. Training conditions did not differ for participant gender, ethnicity, or race (χ^2 test $ps > .05$), or for participant age, pre-intervention optimism (LOT-R), self-efficacy (NGSES), depression (DASS-Depression), or expectancy bias (all linear regression $ps > .05$). However, pre-intervention anxiety (on DASS-Anxiety) differed across conditions, $F(3, 167) = 3.00$, $p = .032$, $R^2 = .05$, such that participants in the Negation + Positive Prospection condition reported significantly less anxiety than those in the Positive Prospection, $F(1, 86) = 6.65$, $p = .012$, $R^2 = .07$, and Neutral Control, $F(1, 87) = 6.48$, $p = .013$, $R^2 = .07$, conditions. Post-hoc analyses were thus conducted including DASS-Anxiety as a covariate. There were no changes to the significance of results in any of the models when it was included, and so the results reported are from the models without DASS-anxiety as a covariate³. See Table 1 for full descriptive statistics.

Change in Expectancy Bias Following CBM-I

Comparable results were observed in the linear mixed-effects models for overall expectancy bias and its components (average positive rating and average negative rating), so to

³ This analysis was conducted before considering the effects of random intercepts and slopes (mentioned above) and before becoming aware of Altman's (1985) and Boer et al.'s (2015) suggestions that such analyses not be carried out if baseline differences occur in spite of random assignment. In light of these considerations, no other baseline measures were tested as covariates in these analyses.

be concise, only the findings for overall expectancy bias are reported here, but full tables for all three expectancy bias models are included in Supplement 1. As anticipated, significant time-by-condition interaction coefficients were found in the model for overall expectancy bias (largest $\beta = 0.11$ [95% CI: 0.02, 0.20], $p = .022$). Follow-up linear mixed-effects models revealed that participants developed a more positive expectancy bias over the course of training in the Positive Prospection ($\beta = 0.15$ [95% CI: 0.07, 0.23], $p < .001$), Negation + Positive Prospection ($\beta = 0.16$ [95% CI: 0.08, 0.24], $p < .001$), and 50/50 ($\beta = 0.08$ [95% CI: 0.00, 0.16], $p = .050$) conditions. Also, as expected, participants' expectancy bias did not change significantly over time in the Neutral control condition ($\beta = 0.05$ [95% CI: 0.00, 0.16], $p = .095$). It should be noted that although participants in the 50/50 condition did show significant increases in their overall expectancy bias score, these gains were not significantly different from those in the Neutral Control condition ($\beta = 0.03$ [95% CI: -0.07, 0.12], $p = .587$). Thus, in line with our predictions, participants in all active conditions experienced improvements in expectancy bias, while those in the neutral condition did not change.

Change in Positive Outlook Following CBM-I

Optimism. A main effect was found for time ($\beta = 0.15$ [95% CI: 0.05, 0.25], $p = .001$), indicating that participants became more optimistic over the course of CBM-I, regardless of condition, but no significant time-by-condition interaction coefficients were found in the model for LOT-R scores (largest $\beta = 0.04$ [95% CI: -0.21, 0.29], $p = .379$).

Self-efficacy. Significant time-by-condition interaction coefficients were found in the model for NGSES scores (largest $\beta = 0.68$ [95% CI: 0.60, 0.76], $p < .001$). Follow-up linear mixed-effects models revealed that self-efficacy increased significantly from pre- to post-treatment in the Positive Prospection ($\beta = 0.31$ [95% CI: 0.25, 0.37], $p < .001$), Negation + Positive Prospection condition ($\beta = 0.19$ [95% CI: 0.12, 0.24], $p < .001$), and 50/50 ($\beta = 0.20$ [95% CI: 0.16, 0.24], $p < .001$) conditions. By contrast, self-efficacy decreased significantly from pre- to post-treatment in the Neutral Control condition ($\beta = -0.37$ [95% CI: -0.43, -0.31], $p < .001$).

.001). It should be noted that in the intention-to-treat model, the 50/50 condition's treatment effect was not significant.

Growth mindset. Significant time-by-condition interaction coefficients were found in the model for MMS scores (largest $\beta = -0.54$ [95% CI: 0.44, 0.64], $p < .001$). In line with our predictions, participants in the Positive Prospection ($\beta = -0.33$ [95% CI: -0.51, -0.15], $p < .001$) and 50/50 ($\beta = -0.49$ [95% CI: -0.78, -0.23], $p = .001$) conditions showed significantly greater growth mindset after CBM-I than at baseline. Participants in the Negation + Positive Prospection ($\beta = -0.08$ [95% CI: -0.32, 0.15], $p = .254$) and Neutral Control ($\beta = 0.05$ [95% CI: -0.23, 0.13], $p = .291$) conditions did not change significantly over the course of CBM-I.

Change in Distress Following CBM-I

Anxiety. A main effect of time was found for anxiety, showing that participants generally dropped in anxiety from pre- to post-treatment ($\beta = -0.43$ [95% CI: -0.48, -0.37], $p < .001$), regardless of condition. No significant time-by-condition interaction was found in the model for anxiety (largest $\beta = 0.16$ [95% CI: -0.06, 0.38], $p = .076$).

Depression. A significant time-by-condition interaction coefficient was found in the model for depression, which indicated that the effect of time on depression scores was significantly different for the Positive Prospection ($\beta = -0.36$ [95% CI: -0.67, -0.05], $p = .013$) and the 50/50 condition. Follow-up linear mixed-effects models showed that participants experienced a significant decrease in depression symptoms from pre- to post-treatment in the Positive Prospection ($\beta = -0.38$ [95% CI: -0.62, -0.14], $p = .002$), Negation + Positive Prospection ($\beta = -0.28$ [95% CI: -0.51, -0.04], $p = .018$), and Neutral Control conditions ($\beta = -0.18$ [95% CI: -0.30, -0.06], $p = .009$). However, participants in the 50/50 condition did not show significant changes in depression symptoms following CBM-I ($\beta = -0.01$ [95% CI: -0.26, 0.24], $p = .951$). Though the changes in depression symptoms in the Negation + Positive Prospection and Neutral Control conditions were significant, the effects were not great enough to be significantly different from the 50/50 condition.

See Figure 2 for significant time-by-condition effects and Table 2 for a summary of all time effects testing whether each condition changes over the intervention.

Expectancy Bias as a Mediator of Change Following CBM-I

No significant mediation by change in expectancy bias from baseline to post-treatment was found for the effects of condition on changes in self-efficacy, growth mindset, or depression symptoms from baseline to post-CBM-I (full details of the models are listed in Supplement 1).

Discussion

The current study examined the effects of a novel CBM-I intervention on biased expectations of future events and assessed whether the intervention effected a variety of positive outlook and negative mood measures. Over the course of the intervention, participants in active treatment conditions shifted expectations about future events in a more positive direction, whereas participants in the Neutral Control condition did not see a change in their expectations. Overall, training effects on positive outlook outcomes were mostly in the expected direction for two out of the three measures. Specifically, in the Positive Prospection and 50/50 conditions, self-efficacy and growth mindset did increase after CBM-I, as predicted. No significant changes were observed for the Neutral condition in self-efficacy or growth-mindset, as expected, and there were no condition differences for the change in optimism (instead, participants became more optimistic over time, regardless of condition). In the Negation + Positive Prospection condition, self-efficacy did increase after CBM-I, but growth mindset did not. Anxiety and depression symptoms were generally lower post-treatment when compared to baseline, but the drop in symptoms for the active training conditions was not reliably greater than the drop for the Neutral Control condition. None of the effects on positive outlook or distress were mediated by changes in future expectations from pre- to post-treatment. The current study contributes to our understanding of the role of prospective bias in promoting positive outcomes, and tests a relatively short, easy-to-disseminate intervention aimed at augmenting prospective bias. The Positive Prospection condition successfully changed future

expectancies, increased self-efficacy and belief in an ability to change, and showed some signs of reducing depressive symptoms. These results point to a broad range of benefits from positive prospection training, but, given the failure to find mediation effects and limited unique effects on symptoms, questions still exist concerning the mechanisms of change and ultimate clinical utility.

Shifting Prospective Style

Although there has been work linking expectations about the future to various outcomes, little research has been devoted to methods explicitly designed to experimentally promote a healthier style of prospection and the present study is the first to our knowledge to use CBM-I with ambiguous scenarios explicitly about the future. In the current study, participants in all active conditions showed an increasing positivity in their future expectations over the course of the intervention and follow-up, whereas those in the neutral condition experienced no change. Furthermore, the degree to which the CBM-I condition had the participants engage in positive simulation was related to the degree to which participants' prospective bias was changed. That is, effect sizes in the Positive Prospection and Negation + Positive Prospection conditions ($\beta = 0.15$ & $\beta = 0.16$, respectively) were nearly double the effect size for the 50/50 condition ($\beta = 0.08$). In fact, although the trend for the 50/50 condition was positive, it was not significantly more positive than the trend for participants in the neutral control condition ($\beta = 0.05$). This study provides promising preliminary evidence that practicing positive future simulation, even in a short, online context, can shift prospective style.

These findings complement and extend prior intervention studies that explicitly trained positive prospection using methods other than CBM-I. For example, previous studies in which participants were asked to simulate positive future events or positive versions of themselves included manipulation checks to confirm participants were engaging with the training correctly, but did not include measures to see if these interventions affected prospection with an independent measure of the target (which was the Expectancy bias task in our case; Quoidbach

et al., 2009; Meevissen et al., 2011; Malouff & Shutte, 2017). Prior studies' manipulation checks often also asked participants to explicitly report the valence of their projections, likely creating demand effects for reports of those valenced projections. By measuring prospective bias in the current study with a task that was separate from training and that did not ask participants to explicitly report the valence of their prospective simulation, the present study provides some initial evidence that CBM-I for prospection can shift prospective bias in a positive direction, in a manner that generalizes beyond the training task.

One previous study instructed participants to explicitly simulate 90 events of a positive, negative, and neutral nature, after participants practiced simulating a subset of the events. They found that those positive and negative events that had been practiced more showed an increase in participants' ratings of the events' plausibility (Szpunar & Schacter, 2013). The current study similarly showed that repeated practice imagining emotional situations during training can shift the plausibility of positive scenarios, even when those positive scenarios are presented on a separate task (i.e., the Expectancy bias task).

Enhanced Positive Outlook

Although other studies have examined the relationship between positive prospection and various positive psychological and performance outcomes, the current study is the first CBM-I study we know of to assess whether explicitly targeting prospection style results in improved measures of psychological positive outlook. One reason for assessing such positive beliefs is that enhancing them may be a mechanism by which an improved prospective style might benefit overall health given greater perceived self-efficacy, health-related growth mindset, and optimism have been linked to better health-related behaviors (Conversano et al., 2016; Johnson, 2009; Schwarzer & Fuchs, 1995). The current study found consistent results for two of the three measures of positive outlook; namely, participants in the Positive Prospection and 50/50 conditions reported increased self-efficacy and growth mindset at follow-up than pre-intervention. Interestingly, participants in the Negation + Positive Prospection condition did

experience significant enhancements to self-efficacy, but not growth mindset. In the self-efficacy domain, it should be noted that participants in the neutral condition actually experienced a decrease in their sense of self-efficacy though this unexpected finding should be interpreted with caution until it is replicated.

One possible reason for the more modest results for Negation + Positive Prospection may be due to the impact of explicitly raising negative outcomes. Namely, this condition was included in part to test whether there is added value to explicitly refuting a negative future state (“disconfirming unrealistic prospections” as described in Seligman et al., 2013), or whether negation is harmful because it implicitly reinforces the negative association (see Ouimet et al., 2009). The current results are consistent with the idea that there may be some unintended reinforcement (or at least rehearsal) that occurs when actively making the possible negative outcomes salient, even though they are being directly refuted. Perhaps rehearsing the negative outcomes as part of the negation process makes them more accessible and reduces the impact of the training to promote positive beliefs about one’s abilities. This idea is clearly speculative, and more work is needed to investigate the possible link between negation and accessibility in this training context.

Negative Mood

Explicitly targeting future thinking with CBM-I had only limited unique effects on depression and anxiety symptoms. Though anxiety lowered over the course of treatment for all participants, no effect of CBM-I condition on this decrease was found. Similarly, most groups showed less depressive symptoms over the course of treatment (except the 50/50 condition), and although there was some indication of a greater drop in depression symptoms for the Positive Prospection condition when compared to the 50/50 condition, the overall pattern did not indicate a clear advantage for the active training conditions. This was surprising given prior work has linked negative future expectations to anxiety and depression symptoms in older adults (see Miloyan et al., 2016) and depressed adolescents assigned to a positive mood induction

generated fewer negative events during a future imagining task than those assigned to a negative mood induction (de Jong-Meyer, Kuczerma, & Tripp, 2007). At the same time, there have been mixed results regarding CBM-I's impact on symptoms. For instance, a series of studies on positive imagery CBM-I found that this intervention decreases depression symptoms in depressed community adults (Blackwell & Holmes, 2010; Lang et al., 2012; Torkan et al., 2014); however, when delivered online it was not superior to a 50/50 control condition that asked participants to simulate using verbal processing rather than mental imagery (Blackwell et al., 2015). Further, previous studies that have explicitly targeted positive prospection with writing about positive future events in various ways have either not assessed or not found effects on depression and anxiety symptoms (e.g., Boland et al., 2018; Quoidbach et al., 2009), and studies of other approaches that have shown improvements in these symptoms in addition to optimism have lacked active control groups or required in-person intervention (Malouff & Shutte, 2017).

In light of the mixed findings, it is difficult to know in the current study why specific training effects were not observed on negative mood, especially when they were observed for changes in prospective style and multiple measures of positive outlook. Given that participants were not recruited for elevated anxiety and depression symptoms, it is possible that more robust effects would be observed in a sample with more pronounced clinical symptoms. Alternatively, it could be that changes to prospection have a greater impact on promotion-focused outcomes, like self-efficacy and growth mindset, compared to prevention-focused states (like anxiety) or past-focused ruminative states (like depression). Yet another possibility is that more time is needed to practice the new prospective style before benefits to anxious and sad mood will be realized. Testing these possibilities will be important to determine the ultimate clinical utility of prospection training.

Limitations, Future Directions, and Conclusion

The current study has some limitations, particularly related to the study sample. This was a student sample so questions of generalizability to other populations, especially clinical samples, are paramount. Also, 14% of participants did not complete the full course of CBM-I, even in the context of a research study for which they received course credit. This raises some questions about the possibility of non-compliance outside of a research setting. In addition, although the sample was selected for having a relatively negative future expectancy bias (in line with an RDoC framework that focuses on potential transdiagnostic risk factors), more research is needed on the effects of shifting prospection in individuals with severe positive outlook deficits and distress.

Also, the study relied on self-reported outcomes and had a short follow-up period (approximately one week), leaving important questions about the ecological validity and duration of effects unanswered from this initial study. Another consideration is that the materials presented were standardized and normed on a pilot sample, and so may not have reflected the ideographic concerns of the specific participants in the study. Ideally, scenarios could be tailored to a participant's specific concerns about the future and thus be more relevant to an individual's relatively negative prospection patterns. This would, of course, provide significant practical challenges, given the necessity to create and norm a pool of scenarios large enough to capture many individuals' areas of concern. The study could also have benefitted from multiple measures of expectancy bias. It is difficult to draw strong conclusions about the effects of the training on bias, which only had one index, while positive outlook and distress measures had multiple. Another study limitation was the difference in baseline responding between conditions (conditions differed significantly on the baseline measure of anxiety; see Table 1 for results of χ^2 tests of baseline differences), though this is somewhat mitigated by the fact that differences are due to random assignment and by the selection of models that account for random intercepts.

Future studies could focus on further theory-driven modifications to enhance the efficacy of CBM-I training. For example, the method used in this study to enhance engagement—

namely, varying the response type and difficulty of CBM-I—is one of several possible approaches (see Mathews et al., 2007, for a different proposed engagement method). Further, open questions remain about what precisely accounts for CBM-I's positive effects. The current training included an imagery component, future-oriented scenarios, and a positive resolution emphasis. Further dismantling studies are necessary to see which, if any, of these features is responsible for shifts in positive outlook and distress, and consideration of additional features (e.g., tied to cognitive flexibility; see Parsons, Kruijt, & Fox, 2016, and Blackwell et al., 2015) may help to increase the robustness of effects. Another avenue for future study will be designing a study that can more readily answer the question of whether or not changes in bias mediate changes in positive outlook and distress. Given positive outlook and distress were only measured twice in this study, more robust, longitudinal methods of analyzing mediation—such as cross-lagged panel models or latent growth curves—could not be fit to the data. Also, without a longer follow-up period, it is not known whether changes in bias simply take time to have a pronounced and proportional change on positive outlook and distress.

In spite of these limitations and open questions, the current study is the first to examine whether practice with simulating explicitly future-oriented ambiguous scenarios can change prospection style, and whether such practice can lead to increased positive outlook and decreased negative mood. It also tested this using a brief, online CBM-I treatment that participants could engage with at home. The demonstration that prospection style can be shifted and that practice with future simulation can enhance positive outlook serves as a proof-of-concept for theories espousing the positive effects of changes to prospective style. Many open questions remain, but these results raise the prospect that a simple computer-based task that requires no therapist may one day be shared widely to change thinking about the future and enhance positive outlook.

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Table 1
Demographic Variables and Outcome Measures at Baseline

	Condition						
	100% positive	100% + negation	50/50	Neutral control			
<u>Variable</u>					<u>χ^2</u>	<u>df</u>	<u>p</u>
Race	74.42	62.22	77.5	68.12	16.34	15	0.360
Ethnicity	13.95	11.11	12.5	6.81	1.4	6	0.966
Gender	67.44	60.00	65.00	72.73	1.67	3	0.644
	<u>m (sd)</u>	<u>m (sd)</u>	<u>m (sd)</u>	<u>m (sd)</u>	<u>F</u>	<u>df</u>	<u>p</u>
Age	20 (2.25)	20 (1.98)	20 (1.45)	20 (1.74)	0.48	3, 168	0.698
Expectancy Bias	0.89 (0.92)	1.16 (0.74)	0.95 (0.88)	0.64 (0.94)	2.64	3, 168	0.051
Self Efficacy (on NGSES)	30.14 (3.90)	29.73 (4.38)	29.63 (5.30)	31.16 (4.28)	1.06	3, 168	0.369
Optimism (on LOT-R)	18.4 (3.68)	18.11 (3.01)	18.00 (3.76)	19.7 (3.24)	2.29	3, 168	0.081
Growth Mindset (on MMS)	19.79 (3.27)	19.53 (3.62)	19.77 (3.38)	19 (2.71)	0.54	3, 166	0.654
Anxiety (on DASS-A)	13.16 (3.95)	11.08 (3.59)	12.64 (3.60)	12.95 (3.31)	3.00	3, 168	0.032*
Depression (on DASS-D)	13.39 (5.64)	12.29 (4.91)	12.28 (4.52)	12.45 (3.79)	0.53	3, 168	0.659

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$

Notes: Race: Percentage White, Ethnicity: Percentage Hispanic, Gender: Percentage Female, Expectancy Bias: Average Positive Expectancy Bias Rating – Average Negative Expectancy Bias Rating, NGSES: New General Self-Efficacy Scale, LOT-R: Life Orientation Test-Revised, MMS: Modified Mindset Survey, DASS-A: Depression, Anxiety and Stress Scale – Anxiety, DASS-D: Depression, Anxiety and Stress Scale – Depression.

Table 2

Condition by Time Effects Testing Whether Each Condition Changes Over the Intervention

Measure	Time Effect for Each Condition	Std. β	SE	p
Expectancy bias				
	Positive prospection	0.15	0.04	< .001***
	Negation + positive prospection	0.16	0.04	< .001***
	50/50	0.08	0.04	.050*
	Neutral control	0.05	0.03	.095
Optimism (on LOT-R): no condition by time effect; only a main effect of time				
	Positive prospection	0.19	0.03	< .001***
	Negation + positive prospection	0.19	0.04	< .001***
	50/50	0.20	0.02	< .001***
	Neutral control	0.17	0.02	< .001***
Self-efficacy (on NGSES)				
	Positive prospection	0.31	0.03	< .001***
	Negation + positive prospection	0.19	0.03	< .001***
	50/50	0.20	0.02	< .001***
	Neutral control	-0.37	0.03	< .001***
Growth mindset (on MMS)				
	Positive prospection	-0.33	0.09	< .001***
	Negation + positive prospection	-0.08	0.12	.254
	50/50	-0.49	0.15	.001**
	Neutral control	0.05	0.09	.291
Depression (on DASS-D)				
	Positive prospection	-0.38	0.12	.002**
	Negation + positive prospection	-0.28	0.12	.018*
	50/50	-0.01	0.13	.951
	Neutral control	-0.18	0.06	.009**

Anxiety (on DASS-A): no condition by time effect; only a main effect of time	Positive prospection	-0.49	0.10	< .001***
	Negation + positive prospection	-0.38	0.12	.002**
	50/50	-0.33	0.10	.002**
	Neutral control	-0.48	0.12	< .001***

* = $p < 0.5$, ** = $p < 0.01$, *** = $p < 0.001$

Notes: LOT-R: Life Orientation Test-Revised, NGSES: New General Self-Efficacy Scale, MMS: Modified Mindset Survey, DASS-D: Depression, Anxiety and Stress Scale – Depression, DASS-A: Depression, Anxiety and Stress Scale – Anxiety. Higher scores on Expectancy bias reflect a more positive bias; Higher Optimism scores reflect more optimism; Higher Self-efficacy scores reflect greater self-efficacy; Lower Growth mindset scores reflect greater growth mindset; Lower Depression scores reflect less depression; Lower Anxiety scores reflect less anxiety.

Figure 1
Flowchart of participation and dropout

Notes: Boxes in grey indicate the sample used in the Expectancy Bias analysis (N=172). The final box, labeled “Returned for in-lab follow up,” is the sample used for the imputations in the outcome analyses (N=109).

Figure 2

Clockwise from top left:

A) Standardized expectancy bias (Average Positive Rating – Average Negative Rating) as a function of Session and Condition

B) Standardized NGSES (self-efficacy) scores as a function of Session and Condition

C) Reverse Standardized MMS (growth mindset) scores as a function of Session and Condition

D) Standardized DASS-D (depression) scores as a function of Session and Condition

Notes: NGSES: New General Self-Efficacy Scale, MMS: Modified Mindset Survey, DASS-D: Depression, Anxiety and Stress Scale – Depression. Greater Expectancy Bias scores mean a greater positivity bias; Greater NGSES scores mean greater self-efficacy; Higher Reverse MMS scores mean greater growth mindset; Lower DASS-D scores mean less depression. Sessions 1-4 included training, while session 5 was a follow-up, post-training assessment.