Testing the Effects of Cognitive Bias Modification via the TIIM App on the Self-Concept Positive Orientation Bias and State Anxiety Levels of Students

Lytske Wijma

Faculty of Behavioural, Management and Social Sciences, University of Twente

Positive Clinical Psychology and Technology

First Supervisor: Dr Marcel Pieterse

Second Supervisor: Dr Thomas van Rompay

28 June 2023

Abstract

The prevalence of anxiety symptoms in students has been increasing over the past years, bringing about a burden for society and those suffering, which suggests the need for interventions. According to dual process theories, cognitions such as one's self-concept operate in explicit ways, meaning one is conscious of these thoughts, and implicit, or subconscious, ways, where one is not aware of the cognitions. The present study aimed to investigate whether changing students' implicit Positive Orientation (PO) self-concept through Cognitive Bias Modification (CBM), thus trying to strengthen the association of themselves as someone with a positive outlook on their life, could lead to a decrease in state anxiety. An Implicit Association Test (IAT) was used to measure the self-concept PO bias, the State-Trait Anxiety Inventory (STAI) was used to measure state anxiety, and CBM was conducted in the TIIM application. The participants (n = 50) were assigned to either a control or experimental group, and the experimental group followed CBM training for three days with two sessions a day, whereas the control group did not. After three days, both groups completed the IAT and STAI again. Results showed that the experimental group showed a significant increase in PO scores compared to the control group. However, anxiety scores did not decrease after the intervention, and there were no mediation effects of PO on the relationship between CBM and state anxiety. Additionally, there were no moderation effects of baseline anxiety on the relation between CBM and state anxiety. Nevertheless, this study provided a novel CBM training focused on PO and demonstrated preliminary evidence of the effectiveness of this training. Still, more research is needed on the effect of PO on state anxiety, as well as further research on the CBM to assess implications for future use.

Keywords: Positive Orientation, Cognitive Bias Modification, State Anxiety

Testing the Effects of Cognitive Bias Modification via the TIIM App on the Self-Concept Positive Orientation Bias and State Anxiety Levels of Students

According to research, anxiety is one of the most frequent mental health issues. Anxiety is defined as feelings of tension, worry, or fear that negative things may happen in the future (Saviola et al., 2020). It is an uncomfortable feeling of emotional turbulence that frequently goes hand in hand with nervousness, ruminating, and physical symptoms (Seligman et al., 2000). Although anxiety can be a response that enables one to develop coping strategies, it can become debilitating when the anxiety levels are disproportionate, and it can develop into an anxiety disorder (Saviola et al., 2020). Studies have shown that a third of the population is likely to suffer from an anxiety disorder at one point in their lifetime (Bandelow & Michaelis, 2015). Baxter et al. (2014) found that the prevalence of anxiety disorders, such as phobia, social anxiety and panic disorders, rises between the ages of 10 and 19 and reaches its peak when individuals are between the ages of 20 and 34, and high levels of anxiety have been found among university students. Often, students experience university to not only be more intellectually demanding than secondary school, but also to bring about other worries such as social interaction, loneliness, and financial issues, among other things (Mohamad et al., 2021). Research has shown that the prevalence of mental health issues such as anxiety symptoms and risk levels of anxiety disorders among university students is increasing (Eisenberg, 2019). Additionally, the COVID-19 pandemic appears to have worsened these symptoms (Murray et al., 2022). Research by Van der Velden et al. (2022) has shown that the prevalence of moderate anxiety and depression symptoms was 31.9% in 2020 for Dutch adolescents, which was an increase compared to the prevalence in 2016. It was shown that levels of severe symptoms increased over that time period as well (van der Velden et al., 2022). Furthermore, anxiety symptoms have shown high rates of chronicity and relapse, as well as high societal and financial burdens on both healthcare systems and

individuals suffering from anxiety (Nieto & Vázquez, 2021; Bandelow & Michaelis, 2015). Research has additionally shown that anxiety has high rates of comorbidity with other mental health problems, for instance with symptoms of depression (Bandelow & Michaelis, 2015). Jenkins et al. (2021) have shown that for students, anxiety, especially when comorbid with depression, significantly impacts their quality of life. Feelings of anxiety might lead students to suffer from impaired focus, attention, perceptual-motor performance and working memory (Quek et al., 2019). Additionally, it can cause worsened academic performance or even dropping out of university, strained relationships with peers, and low self-esteem (Connolly, 2020). Thus, researchers have suggested a growing need for psychological interventions to reduce the prevalence of anxiety among university students (Murray et al., 2022; Kupcewicz et al., 2022).

As aforementioned, anxiety appears in the form of disorders, but also in the form of a general feeling of anxiety, that does not necessarily meet the diagnostic threshold. The transitory feelings of anxiety that everybody experiences from time to time have been conceptualised as state anxiety, which consists of feelings of nervousness, apprehension, and physiological arousal such as increased heart rate (Spielberger et al., 1983). Research has shown that students typically experience high levels of state anxiety, even when they do not suffer from anxiety disorders (Peng & Huang, 2014; De Cássia Lopes Chaves et al., 2015). Thus, the focus of this study is not on clinical anxiety disorders, but on general feelings of state anxiety in students, and it will focus on promoting well-being in these students to reduce the feelings of anxiety.

One concept that might prove to be an effective construct in reducing anxiety, is Positive Orientation. Positive Orientation (PO) is defined as a construct that reflects the tendency to think positively about a variety of things regarding oneself, one's life and one's future (Caprara et al., 2010). PO has been shown to be comprised of three specific constructs,

namely self-esteem, optimism and life satisfaction (Costantini et al., 2019). Looking into these constructs, research has indicated that improving these factors might lead to less anxiety or better mental health overall. For instance, according to Baumaister (1993), individuals who possess high levels of self-esteem are at a lower risk for anxiety. Additionally, low optimism can increase the risk of anxiety (Zenger et al, 2010). Furthermore, Guney et al. (2010) found that life satisfaction is significantly and negatively correlated with anxiety, and Yazdanshenas Ghazwin et al. (2016) described anxiety to be one of the major determinants of life satisfaction, suggesting that this relationship is bidirectional. Combining the aforementioned research, it could be hypothesised that the improvement of these specific constructs which together compose PO could potentially reduce anxiety, and thus training a person to be more positively oriented could lead to a lower level of anxiety.

According to dual process theories, cognitive processes, among which the process of Positive Orientation, manifest themselves in both conscious and unconscious ways, as described in two systems (Young et al., 2015). Firstly, there is an implicit system (System 1), which is fast, automatic and primarily in charge of unplanned, automatic and habitual behaviours. In situations where cognitive control or self-regulation is compromised or when emotions are high, System 1 is thought to have a larger influence on behaviour (Lindgren et al., 2017). Secondly, there is the explicit system (System 2), which takes time and is primarily in charge of intentional behaviours and conscious decisions (Young et al., 2015). Thus, this system is more in charge of behaviour when a person is able to consciously process the information at hand (Lindgren et al., 2017).

In cognition, one could speak of cognitive biases. Research has identified many different types of biases in cognitive processes, such as attentional bias, interpretive bias, memory bias, and self-concept bias (Leung et al., 2022; Back et al., 2009). These biases may affect behaviour in their own ways. For instance, self-concept relates to one’s personality,

which may predict behaviour. In line with dual-process theories, it is thought that personality functions in both implicit and explicit ways (Back et al., 2009). How an individual consciously and intentionally describes themselves and their personality is called an explicit self-concept (Asendorpf et al., 2002). The explicit self-concept is constituted by one's preferred behaviour in certain situations, and how they deliberately try to execute this behaviour (Back et al., 2009). The implicit self-concept, on the other hand, is made up of associative representations of the self and specific concepts. By repeatedly activating the self-concept in combination with an impulsive behaviour pattern, these representations are created. The more frequently this happens, the stronger the implicit association of the self with that concept will be, and this implicit self-concept can predict automatic behaviour, such as in System 1 (Back et al., 2009). In the context of PO, one could have an explicit PO self-concept, meaning to what extent one views themselves as a positively oriented person (Costantini et al., 2019), as well as an implicit PO self-concept, the extent to which one subconsciously associates themselves with PO. The implicit self-concept related to one's Positive Orientation is called Self-Concept Positive Orientation Bias (self-concept PO bias) in this report.

As explicit self-concepts are readily available to a person's consciousness, they can be assessed with direct measurements such as questionnaires. Implicit self-concepts, however, need to be measured with indirect methods, as they might involve aspects that are not accessible to the individual through introspection (Asendorpf et al., 2002). A common way of assessing these concepts is with an Implicit Association Test (IAT; Greenwald et al., 1998). The IAT is one of the most valid and reliable instruments to measure implicit processes and self-concepts (Costantini et al., 2019). In an IAT, participants are presented with different categories, and they are asked to place certain concepts into the categories. The relative speed at which they make these categorisations of bias-congruent and bias-incongruent associations

shows their level of implicit association (Greenwald et al., 1998). Costantini et al. (2019) developed an IAT specifically for PO (PO-IAT). The PO-IAT demonstrates to which extent an individual has a self-concept PO bias, or simply put, their level of implicit PO.

One possible way to implicitly change cognitive biases, and thus the self-concept PO bias as well, is through Cognitive Bias Modification (CBM). CBM is a treatment method that aims to change biases that one may have in cognitive processes (Beard, 2011). CBM builds on the idea of dual process theories and aims to change maladaptive, implicit cognitive biases through repeatedly performing a cognitive task that requires quick processing (Gladwin et al., 2016; Beard, 2011). There have been several studies on CBM in the context of anxiety, as it is thought that these implicit biases play a role in the development and maintenance of anxiety disorders (Leung et al., 2022). Most of this research has been done on interpretation, attention and memory biases when faced with threat-related information (Leung et al., 2022). Because of its flexible nature, and because CBM interventions require less guidance than conventional therapies do, CBM interventions are an effective way of providing online treatment for individuals who struggle with anxiety (Nieto & Vázquez, 2021).

However, in the present study, the focus is on the effects of PO on anxiety. With CBM, the self-concept PO bias is targeted, and individuals are trained to associate themselves with positively coded concepts rather than negative ones. By focusing on improving PO instead of directly on anxiety, this approach is more in line with the positive psychology approach than traditional CBM interventions, as traditional CBM focuses on psychopathology. The two-continua model describes that mental health and mental illness are two distinct yet related concepts (Westerhof & Keyes, 2010). In the past, mental health has been defined as the absence of mental illness, but the two-continua model argues that it is more than that, as it defines mental health as its own concept, distinguishing levels of mental health as *flourishing* or *languishing* (Westerhof & Keyes, 2010). The focus of the present

study is not on reducing anxiety as a mental illness, but more on improving the mental health of individuals to encourage flourishing by increasing PO. This distinguishes the current study from past CBM interventions, as they usually focus on targeting attentional biases in anxiety.

Therefore, the aim of this research is to test whether the use of CBM could lead to an improvement in PO. Additionally, it will be investigated whether a potential increase in PO will lead to a reduction of state anxiety levels in university students. The CBM training is done in the TIIM application, a mobile app that allows treatment to be distributed to a large group of participants. This research could provide insight into the effectiveness of the TIIM app in improving PO levels, and in indirectly reducing anxiety in students when PO is a mediator.

Research questions/hypotheses

RQ1: What is the effect of CBM training with the TIIM app on PO bias?

Hypothesis 1: The experimental group will show a significant improvement in PO bias with the use of the TIIM app, compared to the control group.

RQ2: What is the effect of CBM training with the TIIM app on anxiety?

Hypothesis 2: State anxiety decreases between pre- and post-measurements with the use of the TIIM app for the experimental group, compared to the control group.

RQ3: Does a change in PO-IAT scores mediate the effect of the CBM training in the TIIM app on anxiety?

Hypothesis 3: The effect of CBM training on state anxiety levels is mediated by a change in PO-IAT scores.

Methods

Design

The study was approved by the University of Twente's Ethics Committee BMS/Domain Humanities and Social Science (Requestnr. 230191). Data was collected in

April 2023. The study involved a non-randomised controlled experiment with a pre-and posttest design. Afterwards, participants' scores were compared on a between-subject and within-subject level. The influence of the CBM training in the TIIM App was measured on the dependent variables implicit PO and anxiety.

Participants

The sample consisted of 54 participants. Four participants were excluded as they did not finish the first IAT and thus provided no useful data for the analysis. Three participants were excluded from the intervention group, while one was excluded from the control group. Thus, the intervention group consisted of 28 participants and the control group out of 22 participants. Besides that, no further participants were excluded. Thus, data were analysed from 50 participants of which eleven were male (22%), 37 were female (74%) and two identified as non-binary (4%). The age range goes from 19 to 31 (M = 22.4, SD = 5.37) and 17 participants were Dutch (34%), 29 were German (58%) and four came from another country (8%). Furthermore, one participant indicated that secondary school (2%), two that vocational education (4%), six that University of Applied Sciences (12%), 31 that a University Bachelor's degree (62%), and ten that a University Master degree (20%) is either their current or highest achieved education level.

Participants were recruited via the SONA System, which is the test subject pool system of the University of Twente, as well as via convenience sampling of the researchers' networks. The eligibility criteria for this study were that participants needed to be at least 18 years old and have sufficient reading skills and an understanding of the English language. Besides that, they must have had access to a computer or laptop with a functioning keyboard in order to complete the tests. Before starting the pretests, participants had to give clear consent and it was made sure that they understood that taking part was voluntary (see Appendix A).

Materials

STAI

In order to measure anxiety, the STAI was used in this study. The STAI (State-Trait Anxiety Inventory) was developed as a self-report measure to distinguish feelings of anxiety as a current emotional state from anxiety as a type of personality trait (Sydeman, 2018). Nowadays, the second version of this form, the STAI-Y, is a commonly used measure of anxiety (Sydeman, 2018). It includes 20 items to measure state anxiety (Form Y-1) and 20 items about trait anxiety (Form Y-2), giving 40 items in total which should take participants no longer than ten minutes to complete (Spielberger et al., 1983).

For the context of this study, only Form Y-1 was used (see Appendix B). As the intervention aimed to investigate whether a change in self-concept positive orientation bias would affect feelings of anxiety, it was expected that state anxiety would show more change than trait anxiety, as the latter is a stable, inflexible personality trait and is not likely to change through a very brief intervention (Spielberger et al., 1983; Mascarenhas & Smith, 2011). State anxiety, on the other hand, could be affected by the training.

Thus, participants only filled in form Y-1, to measure their current feelings of anxiety. In Form Y-1, participants are asked to indicate their feelings of anxiety "right now, at this very moment". Examples of items are "I feel tense" or "I am strained" (Spielberger et al., 1983). The questions are scored on a 4-point Likert scale, with the options listed as (1) *Not at all*, (2) *Somewhat*, (3) *Moderately* so, and (4) *Very much so* (Spielberger et al., 1983). Several items on this scale should be scored in reverse when analysing the data, because the items refer to an absence of feelings of anxiety, such as "I feel calm". In this study, this was done during the data collection by the website that was used to conduct the questionnaire, namely SoSci Survey (Leiner, 2016). Thus, a higher total score refers to a higher level of state anxiety. The potential range of scores for the subscale is between 20 and 80. Low, moderate,

and severe anxiety are indicated by scores of 20–39, 40–59, and 60–80, respectively (Skapinakis, 2014).

Spielberger & Sydeman (1994) described the reliability and validity of the STAI Form Y-1 as follows. As for test-retest validity, the median coefficient of 0.33 shows that Form Y-1 is not very stable, which can be explained as the definition of state anxiety entails that it is not stable over time and might be subject to change due to several factors. To describe the internal consistency of the subscale, the researchers used Cronbach's alpha coefficient, which turned out to be 0.93, demonstrating excellent reliability. During this study, Cronbach's alpha was analysed as well. For the STAI pretest, the scale showed excellent internal consistency ($\alpha = 0.95$), which is in line with the statements made by Spielberger & Sydeman (1994). Regarding construct validity, it has been shown that the scores for state anxiety on the STAI are significantly higher during stressful times such as university exam periods than during other times.

Measuring Implicit PO with the PO-IAT

Implicit PO was measured using an Implicit Association Test (IAT), which is a computer-based reaction time test that assesses the strength of automatic associations between concepts (Costantini et al. 2019). Together with the questionnaires, the IAT was generated using SoSci Survey (Leiner, 2016) and was made available to users via www.soscisurvey.de. To measure implicit PO, the PO-IAT required participants to categorise stimuli that are presented on a computer screen into different categories as quickly and accurately as possible. By pressing the appropriate keys "E" or "I" on their keyboard, participants were asked to categorise words as positive or negative as either "Me" or "Other" and pronouns such as "Them" or "l" as either "negativity" or "positivity" (see Appendix C). For example, when the positive stimulus "confident" appeared, it needed to be categorised as "positivity/me" as fast as possible. In case the stimulus was falsely categorised by the

participant, a red “X” appeared signalling that a mistake was made. The participants needed to correct their mistake first by pressing the right key to continue with the test.

The PO-IAT measured the time it took participants to respond to each stimulus, in which the differences in response time indicated the strength of implicit associations quantified by the d-score. When computing the d-score, the average response times of block six and seven (Me/Negativity + Others/Positivity) was subtracted from block three and four (Me/Positivity + Others/ Negativity). Afterwards, values were individually standardised by dividing them by the standard deviations of response times of blocks three and four collectively, and blocks six and seven collectively. The resulting mean value of the two quotients was considered the index value or d-score (indicating the strength of the implicit association).

Therefore, a positive d-score indicated that the participant had a stronger association between themselves and positive concepts (shorter reaction times in block 3/4), while a negative d-score indicated a stronger association between themselves and negative concepts (shorter reaction times in block 6/7). The range of values for the d-score is not limited, which means that it can be less than -1 or greater than +1, depending on how much the response times differ. A d-score of zero indicated no stronger implicit association with either of the two concepts being tested (Nosek et al., 2005).

Costantini et al. (2019) reported that the split-half correlation of the PO-IAT that was corrected by the Spearman-Brown formula had a reliability score of .86, indicating strong internal consistency. In order to calculate split-half reliability, the Spearman-Brown formula translates the split-half correlation score into an estimate of the reliability for the entire test (Thompson, 2023). This reliability test was performed in the present study as well and showed a reliability score of .51.

CBM Training in the TIIM Application

In order to conduct the CBM training, the TIIM application was used. The TIIM (Twente Intervention Interaction Machine) application is a tool created by the Behavioural, Management and Social Sciences (BMS) Lab at the University of Twente (The BMS Lab, 2023). It is a free mobile app available on both the IOS App Store and the Android Play Store, although with restricted access. TIIM allows students, researchers and teachers at the University of Twente to design surveys, long-term studies, or interventions. In this study, the app was used to conduct the CBM training via the response latency platform of the TIIM application. As the response latency platform is a relatively new development, there is not much research on its effectiveness yet. However, previous studies by Wächtler (2019) and Pieterse and Bode (2018) found significant results when using the TIIM application for interventions aimed at reducing a fatigue bias. Furthermore, Wolbers et al. (2021) mentioned that it is a very convenient and inexpensive training tool, as participants can use the TIIM app at any time and place and because very little mental effort and literacy are required for the use of this mobile CBM training app. This suggests that the platform might be an effective tool for conducting CBM.

Twice a day for three days, the participants were asked to complete the CBM training to potentially strengthen the self-concept implicit PO. In the app, participants were asked to swipe certain words that appeared in the middle of the screen either down on the screen, to the category “Me/Positivity”, or upwards on the screen, towards “Others/Negativity”. Furthermore, a zooming function was incorporated. When words were swiped down towards “Me/Positivity”, the word on the screen became larger, stimulating a sensation of approach. Similarly, when the words were swiped away towards “Others/Negativity”, the words became smaller, generating a feeling of avoidance (Wiers et al., 2010). The words that appeared in the middle of the screen were the same stimuli that were used in the IAT (see Appendix C), and each word was presented five times, in a randomised order. When a

participant swiped the word to the wrong category, the category label turned red and the participant was asked to swipe again until they categorised it correctly. When they did swipe the words into the correct category, the category label turned green and a positive chime confirmed their choice. Besides the training sessions, the app included a welcome message and brief daily instructions. The participants received notifications from the app as a reminder to complete their training sessions.

Procedure

The questionnaires included in the research but not relevant to this thesis were: the Patient Health Questionnaire – 9 (PHQ-9), the Life Orientation Test-Revised (LOT-R) and the Perceived Stress Scale (PSS).

At the start of the study, the participants received a link to the SoSci website with information about the study and the informed consent form. This included a brief introduction to the purpose of the study and the procedure. Participants were informed that the effect of the CBM training and PO levels were measured, along with other aspects of mental well-being. Besides that, it was stated in the form that participation was entirely voluntary, withdrawal was possible at any time during the study, and the researchers could be contacted for further information or when experiencing problems. After giving consent, participants filled in demographic information which included age, gender, nationality and current (for students) or highest achieved education level (see Appendix D). Lastly, they filled in their email address to receive information about the next steps of the study. This email address was solely used for research purposes and not stored in the dataset or given to third parties.

The first 30 participants that signed up for the study were assigned to the intervention group and received an email with the link to start the pretests. The rest of the participants were assigned to the control group and received another link to the pretests. Both groups

filled in the pretests on the SoSci website, consisting of the PSS-10, STAI, LOT-R, PHQ-9 scales, and the PO-IAT test.

After completing the pretests, the intervention group received instructions for downloading the TIIM App. After they downloaded the TIIM App and created an account, participants were assigned to the CBM training. Then, the participants could complete the first session, and the second session two hours after completing the first session of the day (see Table 1). The sessions could be done at any location and participants received a notification on their phone when the next session was available. If a session was not yet completed, participants received a reminder on their phones three and six hours after the session got available. After three days, the intervention and the control group received an email to complete the posttests, which were identical to the pretests. If not completed, they received a reminder email to complete the posttests after one day.

Table 1

Overview of Sessions in the TIIM App

Session number	Days of the CBM training	Availability
Session 1	Day 1	Directly after filling in the pretests
Session 2	Day 1	2 hours after completing session 1
Session 3	Day 2	1 day after the start of the intervention
Session 4	Day 2	2 hours after completing session 3
Session 5	Day 3	2 days after the start of the intervention
Session 6	Day 3	2 hours after completing session 5

Data Analysis

To conduct the statistical analysis, RStudio version 4.3.0 was used. Prior to starting the analysis, the dataset was inspected and cleaned. Irrelevant measures, such as those regarding the PSS, LOT-R, and PHQ-9 were removed. Additionally, four participants who did not complete the PO-IAT pretest were removed from the dataset (n = 50). Any participants who had missing values in the posttest were retained in the dataset, and their missing values were imputed with the means of those measures based on the group and measurement time, which is a method that can be used to avoid decreasing the sample size (Grace-Martin, 2020). For the STAI posttest measurement, there were missing values from 12 participants, and for the PO-IAT posttest, there were 14 missing values that were imputed with the mean. Furthermore, descriptive statistics were calculated for the PO-IAT pre- and posttest per treatment condition, as well as for the STAI pre- and posttest for both groups.

To test the first two hypotheses, two-way Analyses of Variance (ANOVA) were performed. Before performing the ANOVA, several assumptions were checked. However, it is important to note that even if assumptions were violated in this research, the analyses were still conducted. First, the data was checked for outliers, however, these outliers were not removed from the dataset. Additionally, The Shapiro-Wilk test was conducted to inspect the normal distribution of the data. Furthermore, Levene's test was used to test the assumption of homogeneity of variance, and Box's M-test tested the assumption of homogeneity of covariances. In the case of violations, a non-parametric test, the Kruskal-Wallis rank sum test, was included.

For the second hypothesis, a mediation analysis was conducted. Before conducting the analysis, assumptions were once again tested. The data were checked for outliers, normality was tested with the Shapiro-Wilk test, and linearity was inspected with plots. Furthermore, the Durbin-Watson test was used to check the independence of residuals.

Post hoc, a moderation analysis was performed. In order to do so, a median split was performed to divide the sample into "low baseline anxiety" and "high baseline anxiety". Then, it was calculated to what extent the anxiety scores changed per baseline anxiety group and per treatment condition. The assumptions that were checked for the moderation analysis were the assumption of normality, linearity and homoscedasticity. For all of the analyses, a *p* value of < .05 was considered to be statistically significant, and a *p* value of < .10 was considered marginally significant.

Results

Descriptive Statistics

First, descriptive statistics were gathered, which are presented in Table 2. It can be noted that for the control group, both the d-scores of the PO-IAT and the STAI scores remained rather unchanged between the pre- and posttest measurements. For the experimental group, there is an increase in d-scores and a very slight decrease in STAI scores.

Table 2

Means, Standard Errors, Minimum and Maximum Values, Standard Deviations and Confidence Intervals of the PO-IAT and STAI by Time and Group

	Control group (n = 22)					Experimental Group (n = 28)				
Test	M (SE)	Min.	Max.	SD	95% CI	M (SE)	Min.	Max.	SD	95% CI
d-Score Pretest	0.47 (0.09)	-0.30	1.19	0.40	[0.30, 0.65]	0.56 (0.07)	-0.20	1.09	0.35	[0.43, 0.70]
d-Score Posttest	0.49 (0.05)	0.12	0.99	0.23	[0.39, 0.59]	0.81 (0.04)	0.111	1.24	0.24	[0.72, 0.90]
STAI Score Pretest	40.5 (2.95)	23	67	13.9	[34.3, 46.6]	41.6 (2.20)	22	65	11.6	[37.1, 46.1]
STAI Score Posttest	40.6 (2.38)	21	60	11.1	[35.7, 45.6]	40.2 (1.84)	23	64	9.73	[36.4, 43.9]

Note. CI = Confidence Interval.

Furthermore, the STAI scores were grouped based on the distribution of low, moderate and high scores, as suggested by Skapinakis (2014), which was mentioned in the method section. The STAI scores are grouped by treatment group and measurement time (see Table 3).

Table 3

Distribution of STAI Scores per Treatment and Measurement

STAI Category	Experimental Group (n = 28)				Control Group (n = 22)			
	Pretest		Posttest		Pretest		Posttest	
	n	%	n	%	n	%	n	%
Low	11	39.3	12	42.9	12	54.6	8	36.4
Moderate	16	57.1	15	53.6	8	36.4	13	59.1
Severe	1	3.6	1	3.6	2	9.1	1	4.6

RQ1: What is the effect of CBM training with the TIIM app on PO bias?

In order to test the first hypothesis, an ANOVA test was conducted. Beforehand, assumptions were checked. The analysis showed that there were eight outliers in the data, six of these were in the experimental group and two in the control group. One of these outliers appeared to be extreme according to the analysis. Other than that, no assumptions were violated. The Kruskal-Wallis rank sum test was included and showed that the groups showed different distributions.

A two-way mixed ANOVA test was conducted to investigate whether there was an increase in PO-IAT scores for the intervention group after they completed the CBM training,

compared to the control group (see Table 4). The analysis showed that the treatment condition had a significant main effect on the d-scores (p = .00152). Additionally, the time factor had a significant main effect on the d-scores as well (p = .02). However, the interaction effect between "Treatment" and "Time" was only marginally significant (p = .07).

Table 4

Two-Way Mixed ANOVA Examining the Effects of Treatment and Time on d-Scores

Effect	DF	Sum Sq	Mean Sq	F	Pr(>F)
Treatment	1	1.03	1.03	10.66	.002
Time	1	0.54	0.54	5.53	.02
Treatment : Time	1	0.33	0.33	3.46	.07

Note. DF = degrees of freedom, Sum Sq = Sum of squares, Mean Sq = Mean Square, F = F-value, Pr(>F) = p-value.

As there were two significant effects found in the ANOVA, post hoc tests were conducted to gain more information about the effects of treatment and time.

For the PO-IAT pretest, the effect of the treatment condition was not significant (p = .41). However, for the posttest measurement, there is a highly significant positive effect of treatment ($p < 0.001$) (see Table 5), with d-scores being significantly higher in the experimental group than in the control group (see Table 2).

Table 5

Post Hoc Between-Subject Test of Simple Effects of Treatment on d-Scores at Pretest and Posttest

Measurement	Effect	DFn	DFd	F	p	p < .05	ges	p.adj
PO-IAT pretest	Treatment	1	48	0.69	.41		0.01	.82
PO-IAT posttest	Treatment	1	48	23.2	<.001	*	0.33	<.001

Note. DFn = Degrees of Freedom Numerator, DFd = Degrees of Freedom denominator, ges = generalised eta squared, *p < .05 = significant main effect

As for the effect of time (see Table 6), it was significant for the experimental group (p = .001). This shows that for the experimental group, there was a significant difference in scores between the pre- and posttest, as the mean d-scores had increased significantly compared to the pretest (see Table 2). For the control group, however, the effect of time did not appear to be significant (p = .86). Thus, for the control group, there was no significant difference between the two time measurements.

Table 6

Post Hoc Within-Subject Test of Simple Effects of Time on d-Scores

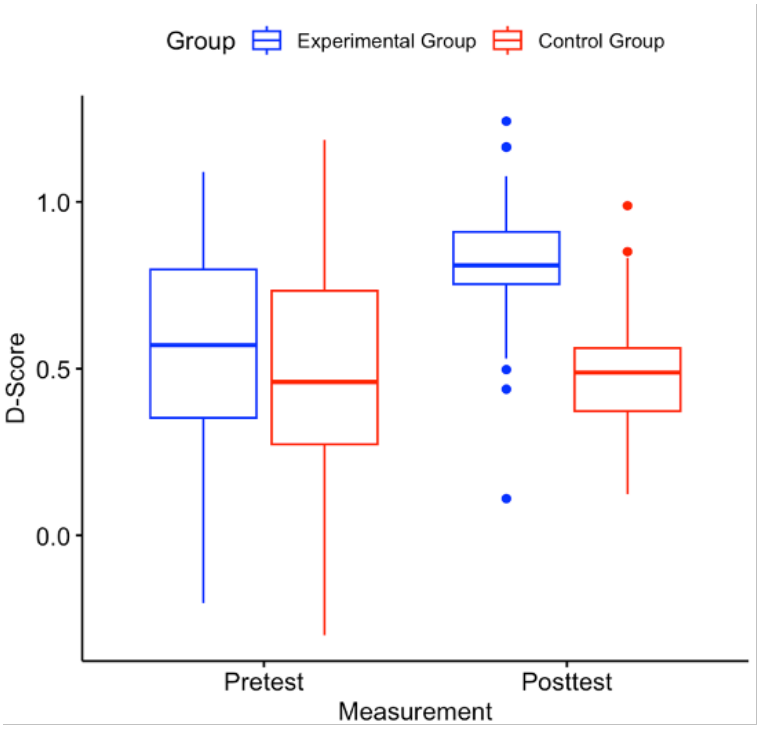
Treatment	Effect	DFn	DFd	F	p	p < .05	ges	p.adj
Experimental	Time	1	27	13.4	.001	*	0.15	.002
Control	Time	1	21	0.03	.86		0.00	1

Note. DFn = Degrees of Freedom Numerator, DFd = Degrees of Freedom Denominator, ges = generalised eta squared, *p < .05 = significant main effect.

Based on these findings, Hypothesis 1, stating that the experimental group would show an increase in d-scores after the intervention compared to the control group, can be partially accepted, as the interaction effect only had marginal significance. To visualise these results, a box plot was created illustrating the d-scores for the two groups at both time measurements (see Figure 1).

Figure 1

Box Plot of d-Scores of the PO-IAT per Time Measurement for the Experimental and Control Group



RQ2: What is the effect of CBM training with the TIIM app on anxiety?

Hypothesis 2 assumed that state anxiety scores would decrease between the pre- and posttest measurements for the experimental group after the CBM training, compared to the control group. For this hypothesis, a similar approach was taken as for Hypothesis 1. Before conducting a two-way ANOVA, assumptions were checked. It was found that the data

included two outliers, one in the experimental group and one in the control group, but neither of these outliers was extreme. Other than that, no assumptions were violated.

Following the testing of the assumptions, the two-way mixed ANOVA test was conducted to see whether the STAI scores decreased for the intervention group after they completed the CBM training in the TIIM app (see Table 7). The ANOVA indicated that the main effect of the treatment variable was not significant (p = .89). Furthermore, the main effect of time turned out not to be statistically significant either (p = .75). Lastly, the interaction effect between treatment and time also showed no statistical significance (p = .72).

Table 7

Two-Way Mixed ANOVA Examining the Effects of Treatment and Time on STAI Scores

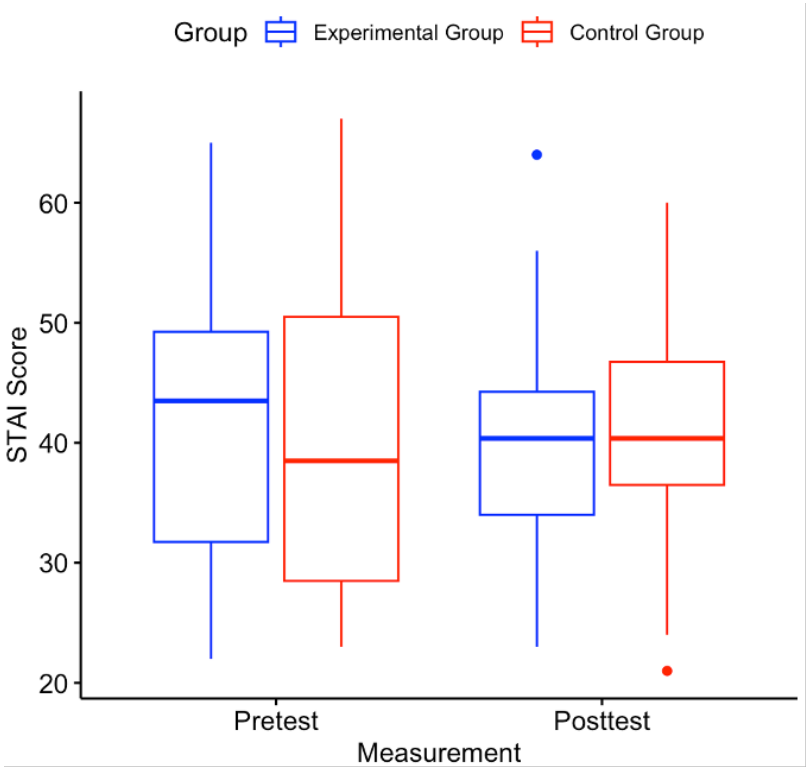
Effect	DF	Sum Sq	Mean Sq	F	Pr(>F)
Treatment	1	3	2.66	0.02	.88
Time	1	13	13.38	0.10	.75
Treatment : Time	1	17	16.73	0.13	.72

Note. DF = degrees of freedom, Sum Sq = Sum of squares, Mean Sq = Mean Square, Pr(>F) = p value.

Thus, there were no significant effects of the treatment variable on the STAI scores, nor were there significant effects of the time variable or the interaction between these two variables on the STAI scores. The means for the STAI scores remained rather unchanged (see Table 2). Therefore, Hypothesis 2 was rejected. The STAI scores for the experimental group and control group at both time measurements were visualised in a box plot (see Figure 2).

Figure 2

Box Plot of STAI Scores per Time Measurement for the Experimental and Control Group



RQ3: Does a change in PO-IAT scores mediate the effect of the CBM training in the TIIM app on anxiety?

To test Hypothesis 3, a mediation analysis was needed. However, as there was no simple main effect found in Hypothesis 2, it could already be assumed that there would be no significant mediator effect. Still, the analysis was run. To keep it brief, tables describing details of the analyses run were not included in this text, but are to be found in the appendix (see Appendix E).

To start, assumptions for a meditation analysis were checked. The analysis showed that there were no influential outliers in the data. Furthermore, the assumptions for normality and independence of residuals were met. However, the assumption for linearity was violated.

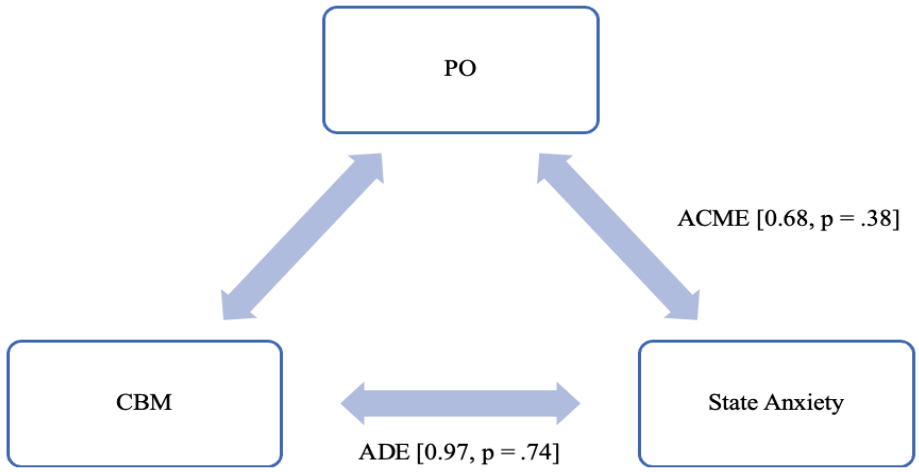
Then, it was investigated whether the treatment variable would be a predictor of the change in d-scores. The mediation analysis showed that the treatment variable was indeed a significant predictor of the change in d-score (p = .04). Thus, the absence or presence of CBM training had an effect on the change in the d-score (see Table D1).

Next, the relation between the treatment and the change in d-score on the change in STAI scores was investigated. This analysis showed that neither the treatment (p = .76) nor the change in d-scores (p = .46) was a significant predictor of the change in anxiety (see Table D2).

Lastly, a mediation analysis was conducted to research the effect of the mediator variable "change in d-score" on the relationship between the treatment and the change in anxiety (see Table D3, see Figure 3). The results suggest that the indirect effect (ACME) was not statistically significant (p = .38). Furthermore, the average direct effect (ADE) of the treatment variable on the change in anxiety scores was not significant either (p = .74). The total effect of the group variable on the change in anxiety, including the indirect effect and direct effect, was not statistically significant either (p = .54).

Figure 3

Mediation Model of the Effect of PO on the Relationship Between CBM and State Anxiety



Note. ACME = Average Causal Mediation Effect, ADE = Average Direct Effect

In conclusion, the mediation analysis was not of any statistical significance and it showed that a change in PO was not a significant mediator in the relation between the training and the change in anxiety. Therefore, the third hypothesis was rejected.

Additional Findings

After conducting these analyses, it was decided to include a moderation analysis to examine whether the baseline anxiety of participants had an effect on how much the intervention would change their scores. To do so, the sample was divided using a median split, indicating high or low baseline anxiety. To inspect whether there was a difference in how much the anxiety scores changed after the intervention, the "Change in Anxiety" scores were analysed per treatment group, separated by low baseline anxiety and high baseline anxiety (see Table 8). These results suggest that in general, the groups who had high baseline anxiety showed a decrease in anxiety scores between the measurements, whereas the groups who started with low anxiety tended to show an increase in anxiety scores.

Table 8

Descriptive Statistics of the Change in Anxiety Scores per Treatment Group, Divided by High and Low Baseline Anxiety Scores

Treatment	Baseline Anxiety	Mean	SD	Median	Min.	Max.
Experimental	High	-5.57	10.8	-5.5	-24.6	21
	Low	4.03	9.62	2.5	-11	22
Control	High	-4.96	9.75	-6	-19	10
	Low	3.76	6.79	1.37	-5	16.4

Note. Mean = the mean score with which the group increased or decreased in anxiety scores. Min. = the highest value with which the anxiety scores reduced between pre- and posttest. Max. = the highest value with which the anxiety scores increased between pre- and posttest.

Assumptions were checked, and it turned out that the assumptions for linearity and homoscedasticity were violated, but the assumption for normality was met. The moderation analysis showed that the main effects of treatment (p = .54) were not statistically significant, although baseline anxiety (p = .001) showed some significance, which arguably could be due to the fact that this moderator variable is directly based on the dependent variable. However, the interaction between these two variables was not significant (p = .87), indicating that the effect of the training on the change in anxiety scores did not depend on the baseline anxiety (see Table 9). Thus, although the mean scores of the change in anxiety suggested a trend, this interaction was not significant.

Table 9

Analysis of Variance for Moderation Analysis

	Sum of squares	Mean Square	F	p-value
Group	33.50	33.47	0.38	.54
Baseline Anxiety Group	1034.00	1034.03	11.65	.001
Group : Baseline Group	2.40	2.36	0.03	.87

Discussion

The purpose of this study was to investigate the effect of CBM training in the TIIM app on self-concept PO bias and state anxiety, along with the potential mediator effect of PO bias on the relationship between the training and state anxiety. In order to conduct this study, a new CBM training was developed, based on the PO-IAT by Costantini et al. (2019). A nonclinical sample was studied that consisted of 50 students, 28 of which were assigned to

the intervention group that followed the CBM training for three days with two sessions a day, and 22 of which were part of a control group.

One of the main findings of this study was that a brief mobile CBM training seems to be able to improve the implicit self-concept PO bias. The data analysis suggested that the interaction effect between time and treatment in the relationship between the CBM training and PO was marginally significant. As the interaction effect requires greater statistical power and is therefore more difficult to detect, it is quite remarkable that a marginally significant effect was found. However, this training effect of CBM on PO did not lead to a reduction of state anxiety. As there was no significant change in the STAI scores between the treatment groups or over time, it was not unusual that the mediation analysis did not show any significant effects either. Lastly, a moderation analysis was performed post hoc to investigate whether baseline anxiety moderated the effect of the training on state anxiety. However, it appeared that the baseline anxiety did not have a moderating effect on the relationship between CBM training and state anxiety scores.

Although multiple hypotheses had to be rejected, this research showed positive results regarding the improvement of the self-concept PO bias after using the CBM training. The simple main effects and the marginally significant interaction effect indicate a possibility of a training effect of the CBM on PO scores. In line with other studies such as those by MacLeod and Mathews (2012) and Beard (2011), this research indicated that CBM can prove to be an effective method for changing cognitive biases.

Strengths and Limitations

A novelty in the current study was the use of this specific CBM for PO, which was newly developed for the purpose of this research. As these first results indicate a positive effect of the CBM, future research could look into this CBM training more to further investigate its effectiveness and implementation possibilities. PO in itself is a relatively new

construct, and the results of this study greatly add to the existing research on PO. Furthermore, the design of this study was novel as it targeted a self-concept bias in the context of PO, while the majority of research on CBM focuses on attentional biases or interpretive biases, especially if anxiety is being researched as well, as the cognitive bias being targeted usually is directly related to the object of fear. Addressing these types of biases with CBM seems to be effective in most previously conducted research (MacLeod & Mathews, 2012). A strength of the current study is that it used a type of bias, the self-concept bias, that is much less researched in the field of CBM, compared to attentional or interpretation biases. Therefore, the current study filled a gap in research on CBM and provided positive results for the use of a self-concept bias. Additionally, a strength of this study was that it used mobile CBM training via the TIIM application, while the IAT was conducted using a PC. This likely limited the possibility that any effects found in the IAT posttest were simply caused by a training effect of repeatedly using the same platform.

However, no effects were found in the mediation analysis with PO as a mediator between the training and state anxiety. As a large amount of research suggested that an increase in PO could lead to a decrease in anxiety, these results can be seen as somewhat surprising, and it is essential to further investigate why the increase in PO did not lead to any changes in state anxiety scores. One possible explanation is that PO perhaps merely has an indirect effect on anxiety and that this effect needs longer than three days to manifest itself. The relationship between the two concepts could be mediated by, for instance, self-efficacy, community support, or coping strategies (Carver et al., 2010; Kupcewicz et al., 2022). Thus, there could be concepts at play that were not able to be captured in the current study. Therefore, future research should focus on the relationship between PO and state anxiety and analyse what factors could be mediators or moderators, to gain a better understanding of whether increasing PO could reduce feelings of anxiety. Additionally, it could be useful to

increase the duration of the intervention, as this would allow more time for the effect of the CBM on PO to translate to an effect on anxiety.

Besides a lack of effects found in the mediation analysis, there was no significant moderation effect found either. Although the descriptive statistics regarding the change in anxiety score per baseline anxiety group did suggest a trend, namely that those starting with higher baseline anxiety would show a bigger decrease in anxiety after the intervention, this effect was not significant. One possible explanation for this is that the sample size was too small. As there were only 50 participants in this study, splitting them up into four groups, namely high or low baseline anxiety in the experimental group and high or low baseline anxiety in the control group, leads to four very small samples, which makes it hard to find significant results. Therefore, it would have been better to have a bigger sample.

Additionally, in order to investigate the effects of PO and the CBM training on anxiety, state anxiety was examined in this study. On a positive note, the baseline anxiety found in this study had approximately the same means for state anxiety scores as those found in healthy Italian students by Franzoi et al. (2020). This shows that the sample in the present study did not differ much from non-clinical samples analysed in other studies in terms of STAI scores and that the results from this study are likely generalisable to the population of healthy students (Moran, 2021). Still, it could be debated whether state anxiety was the right measure for anxiety in this study. According to Spielberger et al. (1983), state anxiety is influenced by environmental and situational factors. Therefore, it remains uncertain whether the intervention could have had a big effect on the state anxiety scores, or if the personal circumstances of the participants mostly dictated the answers on the STAI questionnaires. Nonetheless, a strength of this study is that it included a control group. Using this type of study design, it was possible to partially account for these personal circumstances, as both groups would have had personal circumstances that affected their STAI scores. In order to

further investigate what the effects of the CBM training are on state anxiety, longer and more frequent testing of state anxiety through experience sampling could be useful, as the intervention may not have immediate effects on state anxiety, but effects could possibly be found in the long run. Additionally, future research could look into different measures of anxiety, or include measures such as trait anxiety, as this seems to be a predictor of state anxiety (Peng & Huang, 2014).

One of the major limitations of this study is the use of a new CBM training, which focuses on increasing the self-concept PO bias using approximately the same stimuli as the PO-IAT by Costantini et al. (2019). As this CBM training was newly developed for the purpose of this study, there is not yet any evidence of the effectiveness of this training. The research operated under the assumption that the PO-IAT developed by Costantini et al. (2019) was a good measure for PO, although there is no sufficient evidence to support this assumption. Costantini et al. (2019) mentioned a Spearman-Brown split-half reliability score of .86 for the PO-IAT, showing good internal consistency. However, this has not been sufficiently confirmed by other studies, and in the present study, a Spearman-Brown split-half reliability score of .51 was found, which is much lower than what the creators of the PO-IAT stated, suggesting that the test might not be as reliable as previously thought. As for validity, Costantini et al. (2019) mentioned that the IAT showed good convergent validity, and it could be stated that the PO-IAT showed sensitivity to change, as the scores changed significantly after the CBM training. However, as the original PO-IAT was created in Italian and this study used an English version of this scale, it is possible that the translation affected the validity. Additionally, for most of the stimuli, the English translations as suggested by Costantini et al. (2019) were used, but for two of the stimuli, the translation was slightly adjusted. Namely, “self-assured” was changed into “confident”, and “cheerful” was modified to “satisfied”. As the current research did not include a measure for explicit PO, there is currently no option to

examine the construct validity of the English PO-IAT used in this study. Therefore, it is not certain that the factors of PO, namely life satisfaction, self-esteem and optimism, are truly captured by the IAT. Nosek (2007) described explicit and implicit constructs to be "related, but distinct" (p. 66), with correlations between implicit and explicit constructs ranging from weakly positive to strongly positive, with a median of .48. Therefore, no predictions can currently be made for how well the implicit measures reflect the explicit measures of PO, nor would it necessarily be a fault in the IAT if the constructs are not strongly related, as it might be the case that explicit and implicit attitudes simply differ (Nosek, 2007). Nevertheless, for future research, it would be useful to include not only the PO-IAT and the new CBM training for PO but also an explicit measure of PO, to examine whether the results of the IAT are in line with explicit PO scores. Furthermore, it was assumed that using the stimuli from this IAT, even if it did prove to be valid and reliable, would create an effective CBM training. However, this is not certain, and as this was a newly developed CBM, more research using this CBM training needs to be done.

Other limitations of this study are the use of ANOVA despite certain assumptions being violated, and the choice to keep outliers in the data analysis instead of removing them. Using ANOVA even when assumptions are violated can lead to untrustworthy results. However, research has suggested that the ANOVA assumptions may be too restrictive (Taskinen et al., 2008). Additionally, as this was preliminary research, it was more or less a risk that was willingly taken, with the hope that future research in this field will do more robust testing. As for outliers, they can impact the results as well, for example in terms of the means found. The analysis showed that there were eight outliers in the PO-IAT posttest, one of which was extreme, and there were two outliers in the STAI posttest. However, outliers were retained in the dataset in order to provide a complete picture of the sample, and since the topic is quite novel, it is unsure what true outlier scores are.

Additionally, the sample showed some missing values in the posttest measurement. For the STAI, 12 values were missing, and for the PO-IAT, 14 values were missing. It was decided to impute these missing values with the means of those values per group. However, some literature criticises this method of imputing missing values (Farhangfar, 2008). Therefore, the results of some of the analyses must be handled with caution, as it is possible the effects were underestimated by imputing missing values with the means (Grace-Martin, 2020).

Implications for Future Research

In general, the current study serves as a good basis for future research on the use of CBM in the improvement of PO. However, future research on this topic could benefit from avoiding certain limitations of this study. Firstly, it is suggested to increase the length of the CBM intervention, as it is possible that the effects of an increase in PO need longer than three days to translate into a change in state anxiety scores. Secondly, it is recommended to aim for a bigger sample size, especially if one wants to investigate the moderator effect of baseline anxiety. Thirdly, it could be useful to use ESM for the state anxiety scores, as it is a construct that consists of transitory feelings, and simply one pretest and one posttest measurement might not provide enough insight into one's usual state anxiety levels and the effect of the training. Lastly, the relationship between PO and state anxiety could be investigated further, to clarify whether there are mediating or moderating variables at play.

Conclusion

In conclusion, although there was no mediation or moderation effect, there were simple main effects found in the analysis. It was found that the CBM training in the TIIM app did increase participants' d-scores, indicating a higher Positive Orientation. This research on PO using CBM training was novel, which is why these findings are valuable and pose interesting possibilities for future research and the use of CBM in the context of PO.

Moreover, this study was one of the first to include a control group when researching the TIIM app, therefore adding valuable insights to the research on this particular platform. Future research would do well to test this intervention further, to review its implications for future use. Additionally, future research could focus more on the relationship between PO and state anxiety, and perhaps use a longer intervention with a bigger sample size to investigate potential mediators or moderators. In sum, this research provided a good basis for further research on the use of CBM on PO, as well as a first version of a new CBM training specifically for PO.

References

Asendorpf, J. B., Banse, R., & Mücke, D. (2002). Double dissociation between implicit and explicit personality self-concept: The case of shy behavior. *Journal of Personality and Social Psychology*, *83*(2), 380–393. https://doi.org/10.1037/0022-3514.83.2.380

Back, M. D., Schmukle, S. C., & Egloff, B. (2009). Predicting actual behavior from the explicit and implicit self-concept of personality. *Journal of Personality and Social Psychology*, *97*(3), 533–548. https://doi.org/10.1037/a0016229

Bandelow, B., & Michaelis, S. (2015). Epidemiology of anxiety disorders in the 21st century. *Dialogues in Clinical Neuroscience*, *17*(3), 327–335. https://doi.org/10.31887/dcns.2015.17.3/bbandelow

Baxter, A. J., Vos, T., Scott, K. M., Norman, R. E., Flaxman, A. D., Blore, J. D., & Whiteford, H. (2014). The regional distribution of anxiety disorders: implications for the Global Burden of Disease Study, 2010. *International Journal of Methods in Psychiatric Research*, *23*(4), 422–438. https://doi.org/10.1002/mpr.1444

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

Caprara, G. V., Steca, P., Alessandri, G., Abela, J. R. Z., & McWhinnie, C. M. (2010). Positive orientation: explorations on what is common to life satisfaction, self-esteem, and optimism. *Epidemiologia E Psichiatria Sociale*, *19*(1), 63–71. https://doi.org/10.1017/s1121189x00001615

Carver, C. S., Scheier, M. F., & Segerstrom, S. C. (2010). Optimism. *Clinical Psychology Review*, *30*(7), 879–889. https://doi.org/10.1016/j.cpr.2010.01.006

Connolly, A. (2020). *The impact of anxiety on college students' academic lives*. JMU Scholarly Commons. https://commons.lib.jmu.edu/honors202029/103

Costantini, G., Perugini, M., Dentale, F., Barbaranelli, C., Alessandri, G., Vecchione, M., & Caprara, G. V. (2019). Assessing Positive Orientation With the Implicit Association Test. *European Journal of Psychological Assessment*, *35*(1), 109–116. https://doi.org/10.1027/1015-5759/a000362

De Cássia Lopes Chaves, E., Iunes, D. H., De Castro Moura, C., Carvalho, L. C., Silva, A. M., & De Carvalho, E. C. (2015). Anxiety and spirituality in university students: a cross-sectional study. *Revista Brasileira De Enfermagem*, *68*(3), 504–509. https://doi.org/10.1590/0034-7167.2015680318i

Eisenberg, D. (2019). Countering the Troubling Increase in Mental Health Symptoms Among U.S. College Students. *Journal of Adolescent Health*, *65*(5), 573–574. https://doi.org/10.1016/j.jadohealth.2019.08.003

Farhangfar, A., Kurgan, L., & Dy, J. G. (2008). Impact of imputation of missing values on classification error for discrete data. *Pattern Recognition*, *41*(12), 3692–3705. https://doi.org/10.1016/j.patcog.2008.05.019

Franzoi, I. G., Sauta, M. G., & Granieri, A. (2020). State and Trait Anxiety Among University Students: A Moderated Mediation Model of Negative Affectivity, Alexithymia, and Housing Conditions. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01255

Gladwin, T. E., Wiers, C. E., & Wiers, R. W. (2016). Cognitive neuroscience of cognitive retraining for addiction medicine. *Elsevier eBooks*, 323–344. https://doi.org/10.1016/bs.pbr.2015.07.021

Grace-Martin, K. (2020). Missing Data: Two Big Problems with Mean Imputation. *The Analysis Factor*. https://www.theanalysisfactor.com/mean-imputation/

Greenwald, A. G., McGhee, D. E., & Schwartz, J. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464–1480. https://doi.org/10.1037/0022-3514.74.6.1464

Jenkins, P., Ducker, I., Gooding, R. A., James, M. L., & Rutter-Eley, E. (2021). Anxiety and depression in a sample of UK college students: a study of prevalence, comorbidity, and quality of life. *Journal of American College Health*, *69*(8), 813–819. https://doi.org/10.1080/07448481.2019.1709474

Kupcewicz, E., Mikla, M., Kadučáková, H., Grochans, E., Valcarcel, M. D. R., & Cybulska, A. M. (2022). Correlation between Positive Orientation and Control of Anger, Anxiety and Depression in Nursing Students in Poland, Spain and Slovakia during the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *19*(4), 2482. https://doi.org/10.3390/ijerph19042482

Leiner, D. J. (2016). SoSci Survey (Version 3.4.10) [Computer software]. Available at https://www.soscisurvey.de

Leung, C. J., Yiend, J., Trotta, A., & Lee, T. M. (2022). The Combined Cognitive Bias Hypothesis in Anxiety: A Systematic Review and Meta-analysis. *Journal of Anxiety Disorders*, *89*, 102575. https://doi.org/10.1016/j.janxdis.2022.102575

Lindgren, K. P., Neighbors, C., Gasser, M. L., Ramirez, J. J., & Cvencek, D. (2017). A review of implicit and explicit substance self-concept as a predictor of alcohol and tobacco use and misuse. *American Journal of Drug and Alcohol Abuse*, *43*(3), 237–246. https://doi.org/10.1080/00952990.2016.1229324

MacLeod, C., & Mathews, A. (2012). Cognitive Bias Modification Approaches to Anxiety. *Annual Review of Clinical Psychology*, *8*(1), 189–217. https://doi.org/10.1146/annurev-clinpsy-032511-143052

Mascarenhas, D., & Smith, N. C. (2011). Developing the performance brain. *Elsevier eBooks*, 245–267. https://doi.org/10.1016/b978-0-443-06734-1.00017-1

Mohamad, N. E., Sidik, S. M., Akhtari-Zavare, M., & Gani, N. A. (2021). The prevalence risk of anxiety and its associated factors among university students in Malaysia: a national cross-sectional study. *BMC Public Health*, *21*(1). https://doi.org/10.1186/s12889-021-10440-5

Moran, M. (2021). What is a Representative Sample? *Statistics Solutions*. https://www.statisticssolutions.com/what-is-a-representative-sample/

Murray, A., Marenus, M. W., Cahuas, A., Friedman, K. B., Ottensoser, H., Kumaravel, V., Sanowski, J., & Chen, W. (2022). The Impact of Web-Based Physical Activity Interventions on Depression and Anxiety Among College Students: Randomized Experimental Trial. *JMIR Formative Research*, *6*(4), e31839. https://doi.org/10.2196/31839

Nieto, I., & Vázquez, C. (2021). 'Relearning how to think': A brief online intervention to modify biased interpretations in emotional disorders—study protocol for a randomised controlled trial. *Trials*, *22*(1). https://doi.org/10.1186/s13063-021-05459-3

Nosek, B. A., Greenwald, A. G., & Banaji, M. R. (2005). Understanding and using the Implicit Association Test: II. Method variables and construct validity. *Personality and Social Psychology Bulletin*, *31*(2), 166-180.

Nosek, B. A. (2007). Implicit–Explicit Relations. *Current Directions in Psychological Science*, *16*(2), 65–69. https://doi.org/10.1111/j.1467-8721.2007.00477.x

Peng, H., & Huang, T. (2014). An Examination of College Students' State Anxiety to Trait Anxiety, Problem Solving Status and Spirituality. *International Journal of Academic Research and Reflection*, *2*(4), 64–80.

Pieterse, M. E., & Bode, C. (2018, August 21-25). Cognitive bias modification to relieve fatigue symptoms: preliminary results from a self-identity fatigue IAT [Conference session]. In Psychology, Health & Technology. Paper presented at the 32nd EHPS Conference, Galway, Ireland.

Quek, T. T. C., Tam, W. W., Tran, B. X., Zhang, M., Zhang, Z., Ho, C. S., & Ho, R. C. (2019). The Global Prevalence of Anxiety Among Medical Students: A Meta-Analysis. *International Journal of Environmental Research and Public Health*, *16*(15), 2735. https://doi.org/10.3390/ijerph16152735

Saviola, F., Pappaianni, E., Monti, A., Grecucci, A., Jovicich, J., & De Pisapia, N. (2020). Trait and state anxiety are mapped differently in the human brain. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-68008-z

Seligman, M. E. P., Walker, E. F., and Rosenhan, D. L. (2000). Abnormal Psychology, 4th Edn. New York: W.W. Norton & Company, Inc.

Skapinakis, P. (2014). Spielberger State-Trait Anxiety Inventory. *Springer eBooks*, 6261–6264. https://doi.org/10.1007/978-94-007-0753-5_2825

Spielberger, C. D., Goruch, R., Lushene, R., Vagg, P., & Jacobs, G. (1983). Manual for the state-trait inventory STAI (form Y). *Mind Garden, Palo Alto, CA, USA*.

Spielberger, C. D., & Sydeman, S. J. (1994). State-Trait Anxiety Inventory and State-Trait Anger Expression Inventory. In M. E. Maruish (Ed.), *The use of psychological testing for treatment planning and outcome assessment* (pp. 292–321). Lawrence Erlbaum Associates, Inc.

Sydeman, S. J. (2018). State-Trait Anxiety Inventory. *Springer eBooks*, 1–3. https://doi.org/10.1007/978-3-319-28099-8_950-1

Taskinen, A., Sirviö, H., & Bruen, M. (2008). Statistical analysis of the effects on overland flow of spatial variability in soil hydraulic conductivity / Analyse statistique des effets

de la variabilité spatiale de la conductivité hydraulique du sol sur l'écoulement de surface. *Hydrological Sciences Journal-journal Des Sciences Hydrologiques*. https://doi.org/10.1623/hysj.53.2.387

The BMS Lab. (2023, March 27). *Twente Intervention and Interaction Machine (TIIM) - BMS LAB — Where Technology Meets Life*. BMS LAB — Where Technology Meets Life. https://bmslab.utwente.nl/equipment-facilities-and-services/software-of-the-lab/twente-intervention-interaction-machine-tiim/

Thompson, N. (2023). What is the Spearman-Brown Formula? - Psychometric analytics. *Assessment Systems*. https://assess.com/spearman-brown-prediction-formula/

van der Velden, P. G., van Bakel, H. J., & Das, M. (2022). Mental health problems among Dutch adolescents of the general population before and 9 months after the COVID-19 outbreak: A longitudinal cohort study. *Psychiatry Research-neuroimaging*, *311*, 114528. https://doi.org/10.1016/j.psychres.2022.114528

Wächtler, M. W. (2019). *Testing Cognitive Bias Modification with the IVY Training App on Fatigue Self-Concept in Explicit and Implicit Vitality* [Bachelor Thesis]. University of Twente.

Westerhof, G. J., & Keyes, C. L. (2010). Mental Illness and Mental Health: The Two Continua Model Across the Lifespan. *Journal of Adult Development*, *17*(2), 110–119. https://doi.org/10.1007/s10804-009-9082-y

Wiers, R. W., Rinck, M., Kordts, R., Houben, K., & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction*, *105*(2), 279–287. https://doi.org/10.1111/j.1360-0443.2009.02775.x

Wolbers, R. G. M., Bode, C., Siemerink, E. J. M., Siesling, S., & Pieterse, M. E. (2021). Cognitive Bias Modification Training to Improve Implicit Vitality in Patients With

Breast Cancer: App Design Using a Cocreation Approach. *JMIR Formative Research 2021*, *5*(3), e18325. https://doi.org/10.2196/18325

Yazdanshenas Ghazwin, M., Kavian, M., Ahmadloo, M., Jarchi, A., Javadi, S. G., Latifi, S., Tavakoli, S. a. H., & Ghajarzadeh, M. (2016). The Association between Life Satisfaction and the Extent of Depression, Anxiety and Stress among Iranian Nurses: A Multicenter Survey. *Iranian Journal of Psychiatry*, *11*(2), 120–127.

Young, K., Kashdan, T. B., & Macatee, R. J. (2015). Strength balance and implicit strength measurement: New considerations for research on strengths of character. *The Journal of Positive Psychology*, *10*(1), 17–24. https://doi.org/10.1080/17439760.2014.920406

Zenger, M., Brix, C., Borowski, J. B., Stolzenburg, J., & Hinz, A. (2010). The impact of optimism on anxiety, depression and quality of life in urogenital cancer patients. *Psycho-oncology*, *19*(8), 879–886. https://doi.org/10.1002/pon.1635

Appendix A

Informed Consent Form

Welcome.

You have been invited to participate in a study about the use of the mobile eHealth Application IVY as a tool to increase Positive Orientation in students. Positive orientation is the ability to have a positive view of yourself and your future. The purpose of this research is to gather insight into the current level of Positive Orientation of students and the effect of the IVY Application on Positive Orientation. Besides that, we are interested in the effect of the app on other aspects of mental well-being. The participants are distributed in two groups. Group 1 will be asked to answer the questionnaires twice, which will take approximately 90 minutes in total. Group 2 will be asked to answer questionnaires twice and additionally, use the IVY Application for 3 days in a row. This will take approximately 120 minutes in total. To inform you which group you are in, we will contact you by your given mail address. This study is conducted by the students Aishe Bingöl, Laureen Lhotak, Romy Nijhuis and Lytske Wijma from the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

This research has been reviewed and approved by the BMS Ethics Committee/domain Humanities & Social Sciences. There are minimal burdens and risks associated with participation in this study. Filling in the questionnaires is not likely to cause any psychological discomfort. However, participants might experience some technical difficulties. These difficulties are minimised by having performed pilot tests with different phones beforehand. Besides that, participants can contact the researchers when experiencing troubles with the app.

Your participation in this study is entirely voluntary and you are allowed to withdraw at any time during the process without any negative consequences, and without providing any reasons. Additionally, you are free to ask any questions. During your participation in this study, you may be asked questions that you may experience as (very) personal. You are free to refuse to answer any questions you do not feel comfortable answering.

The nature and purpose of this study, including the data collection, are for educational purposes only. In order to obtain a clear picture of the participant sample of this study, you will be asked certain questions about your demographic information. The data that is gathered will be handled anonymously and stored in a folder that only the researchers of this study can access. The data will be deleted after the final report is submitted.

Study contact details for further information:

Name Researcher	*E-mail*
Aishe Bingöl	a.bingol@student.utwente.nl
Laureen Lhotak	l.s.lhotak@student.utwente.nl
Romy Nijhuis	r.e.n.nijhuis@student.utwente.nl
Lytske Wijma	l.w.wijma@student.utwente.nl
Marcel Pieterse (supervisor)	m.e.pieterse@utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain

information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

- I hereby confirm that I am 18 years old or older and have read and understood the information. My participation in this study is voluntary.
- No, I do not consent and will not participate in the study.

Appendix B

State-Trait Anxiety Inventory Form Y-1

Read each statement and select the appropriate response to indicate how you feel right now, that is, at this very moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	**Somewhat**	**Moderately so**	**Very much so**
I feel calm	1	2	3	4
I feel secure	1	2	3	4
I am tense	1	2	3	4
I feel strained	1	2	3	4
I feel at ease	1	2	3	4
I feel upset	1	2	3	4
I am presently worrying over possible misfortunes	1	2	3	4
I feel satisfied	1	2	3	4
I feel frightened	1	2	3	4
I feel comfortable	1	2	3	4
I feel self-confident	1	2	3	4

I feel nervous	1	2	3	4
I am jittery	1	2	3	4
I feel indecisive	1	2	3	4
I am relaxed	1	2	3	4
I feel content	1	2	3	4
I am worried	1	2	3	4
I feel confused	1	2	3	4
I feel steady	1	2	3	4
I feel pleasant	1	2	3	4

Appendix C

List of Stimuli Used in the Experiment

List of Positive Stimuli for Category 'Positivity'

- High esteem
- Confident
- Happy
- Satisfied
- Positive
- Optimistic

List of Negative Stimuli for Category 'Negativity'

- Low esteem
- Insecure
- Unhappy
- Dissatisfied
- Negative
- Pessimistic

List of Pronouns for Category 'Me'

- I
- Me
- Myself
- Mine

List of Pronouns for Category 'Others'

- Others
- Them

- They
- Their

Appendix D

Demographics Questionnaire

What is your age? ___ years

What is your gender?

- Male
- Female
- Non-binary / third gender
- Prefer not to say

What is your nationality?

- Dutch
- German
- Other, namely…

Level of education

Choose what applies to you:

If you are still a student, please indicate the level of your current studies. If you are not currently a student, please indicate your highest achieved level of education.

- Secondary school
- Vocational Education (NL: MBO, DE: Ausbildung)
- University of Applied Sciences (NL: HBO, DE: Fachhochschule)
- University Bachelor degree
- University Master degree
- PhD

Appendix E

Mediation Analysis

Table D1

Analysis of the Effect of Treatment on the Change in d-Scores

	Estimate	SE	t	p
Intercept	0.48	0.17	2.88	.006
Treatment	-0.23	0.11	-2.12	.04

Table D2

Analysis of the Effect of Treatment and the Change in d-Score on the Change in STAI Scores

	Estimate	Std. Error	t-value	p-value
Intercept	-1.71	4.88	-0.35	.73
Treatment	0.97	3.09	0.31	.76
Change in d-score	-2.90	3.89	-0.75	.46

Table D3

Mediation Analysis Results

	Estimate	95% CI Lower	95% CI Upper	p-value
ACME	0.68	-0.69	3.08	.38
ADE	0.97	-5.15	6.48	.74
Total Effect	1.65	-4.58	6.69	.54

Prop. Mediated	0.41	-3.35	3.76	.64

Note. ACME = Average Causal Mediation Effect, ADE = Average Direct Effect, CI = Confidence Interval.