

INTRODUCTION

- A compelling body of research has identified selective attention to threat, or the threat bias, as a causal mechanism in anxiety (Hakamata et al., 2010). Threat bias is implicated across anxiety disorders and predicts a persistent course of anxiety from childhood to adulthood (Bar-Haim et al., 2007).
- Attention bias modification (ABM) techniques can train attention away from threat, resulting in clinically significant reductions in anxiety and stress reactivity in adults and children (Bar-Haim, 2010). However, several characteristics of ABM may limit treatment acceptability and compliance, particularly in youth, including the repetitive and "boring" nature of the task.
- Given that anxiety- and stress-related disorders frequently have onset in adolescence and early adulthood, a crucial goal of clinical research is to **optimize the translational potential of ABM by creating highly accessible, portable, engaging versions of the ABM protocol**. In the two studies presented, we tested the initial feasibility, efficacy, and "dosage" effects of a mobile application (for iOS devices such as iPhones), or "app", that takes the core components of the gold-standard ABM protocol (the dot probe task) but puts them in the context of an appealing game.
- The app incorporates video game-like features such as points, animated characters and sound effects, but in which, like traditional ABM, attention is systematically redirected away from threat-relevant stimuli (angry faces).
- Additionally, two versions of the app were used (a high and low dosage version) to examine how exposure time affected threat bias, trait anxiety, and stress reactivity in highly anxious young adults.

HYPOTHESES

- Hypothesis 1:** The ABM relative to control condition will result in reduced threat bias measured via an independent threat bias task (dot probe).
- Hypothesis 2:** Subjective and observed anxious behavior will be reduced among participants in the ABM versus control condition.
- Hypothesis 3:** Changes in threat bias will moderate the ameliorating effect of the ABM condition on subjective anxiety and stress reactivity: that is, those in the ABM **condition who also show reductions in threat bias** will evidence the lowest levels of subjective anxiety and stress reactivity.

METHOD

Participants

Study 1 "High Dosage": 38 participants with elevated STAI trait anxiety (11 Male/27 Female aged 17-50 ($M = 22.34$, $SD = 6.91$) participated in the study. $N_s = 20$ teens, 12 in their 20's, six 30 or above.

Study 2 "Low Dosage": 40 participants with elevated STAI trait anxiety (28 Female/12 Male; ages 17-38 ($M = 20.23$, $SD = 4.08$) participated in the study. $N_s = 25$ teens, 12 in their 20's, two 30 or above.

Threat Bias

The baseline and post-app threat bias was measured using the Dot Probe Task (see also Bar-Haim, 2010). Stimuli were images of angry (threat) and neutral (non-threat) faces from the NimStim Stimulus Set (Tottenham et al., 2002).

In this task, participants viewed two images of faces for 500 ms. These faces were either paired threat & non-threat or paired non-threat & non-threat. On each trial, one of the face cues was randomly replaced by an arrow (probe). Participants were asked to identify the direction of the arrow and reaction times were collected.

Three bias scores (attentional threat bias, vigilance, and disengagement) were calculated using differences in reaction times between trial types.

Mobile Application (App)

Participants were randomly assigned to either an ABM version or placebo control version of the app. For every trial, two cartoon characters (sprites), one showing an angry expression and one showing a neutral/positive expression, appeared simultaneously on the screen for 500 ms.

Both sprites then "burrowed" into the grass field. In the ABM version, a trail of grass appeared in the location of the non-threat character for every trial, whereas in the placebo version, a trail appears randomly in the location of the angry or neutral sprite. The participant is instructed to follow the grass trail by swiping with their finger as quickly and accurately as possible.

Sound effects notify the participant of errors and provide feedback on reaction time. In Study 1 ($N = 38$) we used a "high dosage" version of the app (16 rounds lasting ~40 minutes) and in Study 2 ($N = 35$) we used a "low dosage" version of the app (12 rounds ~20 minutes of game play with 20 minutes of breaks).

State Trait Anxiety Inventory

Measures of state and trait anxiety (Spielberger, 1983) were obtained at baseline. State anxiety was assessed a second time after playing the app.



Figure 1: Examples of the app game-play.

Trier Social Stress Test (TSST)

Following the app training and threat bias assessment, the TSST was administered (Kirschbaum et al., 1993). The TSST includes both a social-evaluative threat (giving a speech for 3 minutes after 3 minutes of preparation) and a lack of control task (3 minute arithmetic task). Both tasks were video-recorded and completed in front of two researchers.

Stress Reactivity: Anxious Behaviors.

Behaviors were coded during each of the three-minute social stressor in 10 second epochs. Behaviors consisted of flight behaviors: looking down/away from the judge; closing the eyes; drawing the chin in toward the chest; crouching; being still or freezing (Troisi, 1999). Additionally, nervous speech (e.g. "umm" or "hmm") and expressions of frustration (e.g. "Oh my goodness!" or groaning) were coded. The final score was the sum of all instances (coded yes/no) across all behaviors.

Stress Reactivity: Self-Reported Mood.

Self-reported mood was recorded before and after the TSST using the 65-item Profile of Mood States (POMS; McNair et al., 2003). Participants are instructed to indicate on a five-point scale how well each adjective describes their current mood (not at all to extremely). The POMS measures six different mood states (e.g., tension/anxiety, depression/dejection) which is summed to create a single negative mood score.

RESULTS Study 1: "High Dosage"

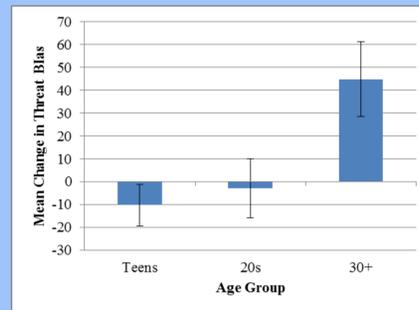
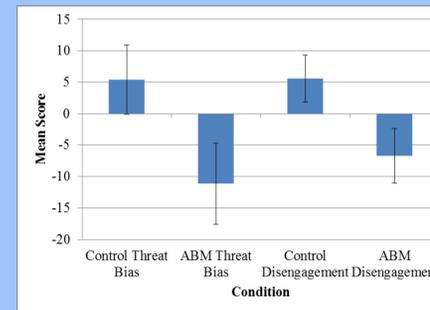
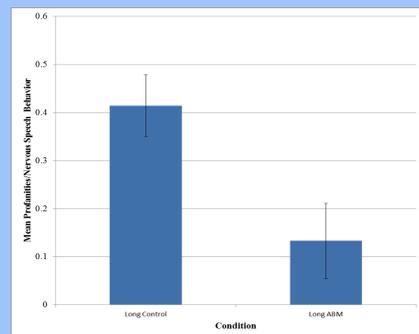


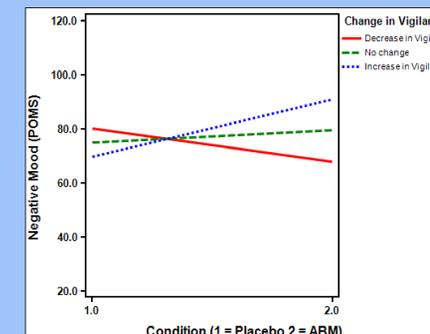
Figure 2: Change in threat bias (Post Bias- Pre Bias) predicted by age group. Participants aged 30 and above showed overall smaller reductions in threat bias after app play, regardless of condition, $F(2,36) = 4.82$, $p = .017$.



Hypothesis 1: Threat Bias
 As predicted, participants in the ABM condition experienced decreases in disengagement, $F(1,30) = 4.57$, $p = .04$, and threat bias, $F(1,30) = 3.83$, $p = .06$.



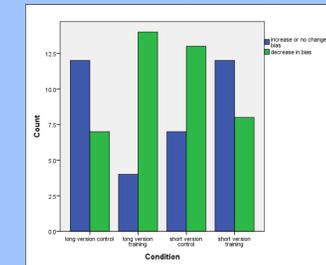
Hypothesis 2: State Anxiety and Stress Reactivity
 As predicted, there was a significant effect of training condition on behavior during the TSST: those in the ABM versus control condition showed reduced profanities/nervous speech, $F(1,26) = 7.45$, $p = .011$ (Note these values were transformed using a log10 transformation). Changes in state anxiety and mood after the TSST did not differ for the training group relative to controls.



Hypothesis 3: Effects of Condition on Anxiety/Stress will be Moderated by Changes in Threat Bias
 As predicted, changes in vigilance interacted with condition ($\beta = -0.48$, $t(33) = -1.88$, $p = .069$, $\Delta R^2 = .08$) such that those in the ABM condition showed reduced negative mood after the TSST, but only if they also showed decreased vigilance following ABM (only the decrease vigilance line was significant at $t(33) = 1.90$, $p = .034$, 1-tailed).

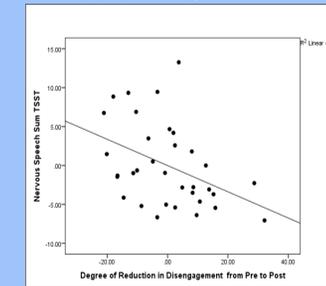
RESULTS Study 2: "Low Dosage"

In contrast to Study 1, changes in threat bias did not differ across the different age groups.



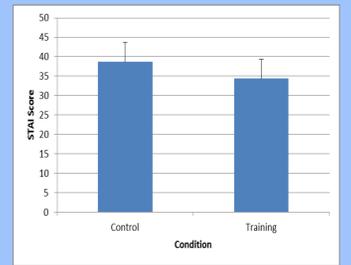
Hypothesis 1: Threat Bias

Counter to predictions, participants in the ABM versus placebo condition showed increases in threat bias, $F(1,32) = 5.53$, $p = .02$ and disengagement, $F(1,32) = 13.19$, $p = .001$.



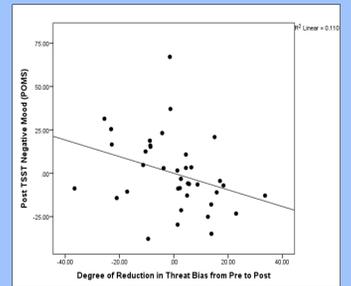
Hypothesis 3: Effects of Condition on Anxiety/Stress will be Moderated by Changes in Threat Bias

Regardless of condition, reductions in threat bias were associated with lower negative mood after the TSST ($\beta = -.06$, $p = -.38$, $p = .06$) and improved disengagement was associated with less nervous speech expressed during the TSST ($\beta = -.69$, $p = .02$).



Hypothesis 2: State Anxiety and Stress Reactivity

As predicted, state anxiety was reduced post ABM for the training group, $F(1,32) = 4.62$, $p = .03$, relative to controls. No significant effects emerged for stress reactivity as measured via self-report of mood or anxiety-related behaviors observed during the TSST.



DISCUSSION

These findings provide preliminary evidence that this novel mobile application reduces threat bias, state anxiety and stress reactivity. The efficacy of this gamified version of ABM emerged in domains similar to those of traditional ABM. **Efficacy after a single session of play suggests potential for this app to function as a "cognitive vaccine" for acute stress.**

In Study 1 (high dosage), the ABM condition reduced threat bias and anxious behavior during the TSST. Subjective mood was influenced in interaction with changes in vigilance: the ABM condition resulted in reduced negative mood during the stressor, but only for those participants showing decreases in vigilance after app play.

In Study 2 (low dosage), however, the ABM condition appeared to *increase* threat bias, but successfully reduced subjective state anxiety.

At the same time, in Study 2, regardless of condition, participants showing decreases in threat bias showed reduced stress reactivity (anxious behavior and negative mood during the stressor).

Taken together, these results represent an important step towards evaluating the efficacy of ABM in a gamified mobile format and providing initial insights into "dosage" effects of a single session. However, the degree to which changes in threat bias can account for reductions in anxiety and stress reactivity remains unclear.

Future research should examine both acceptability (willingness to use the app and adherence to treatment) and efficacy of long-term app use. Moreover, further research should examine the longevity of effects, optimal number of trials and sessions in a multi-session study, and efficacy in a clinical setting.

Future developments to the application might include reinforcements (such as in-game awards) for following a regular training schedule. Given evidence here that a single session can affect positive change, the mobile format will also allow instant access so that training can be completed anywhere (e.g., before attending a stressful event) with a low barrier to entry (a device with Apple iOS) and in a format which is unobtrusive.

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