



# Manipulating Attention to Nonemotional Distractors Influences State Anxiety: A Proof-of-Concept Study in Low- and High-Anxious College Students

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Anxious individuals have difficulty inhibiting attention to salient, but nonemotional, distracting stimuli. The exact nature of this relationship remains unclear, however. In the present study, we tested the hypothesis that increasing attention to salient, but nonemotional, distracting stimuli would lead to increases in state anxiety by manipulating attentional strategies during a visual search task. We randomly assigned students low and high in trait anxiety to either a 1-session singleton detection training group or a feature search group. Singleton detection training increases distraction by salient, nonemotional stimuli whereas feature search training protects attention against distracting stimuli. Findings revealed that singleton detection training not only increased distraction by salient, nonemotional stimuli but also increased state anxiety. Moreover, this increase in state anxiety was most pronounced among high trait-anxious individuals. In contrast, feature search training protected attention against distracting stimuli and against increases in state anxiety, particularly in the high trait-anxious individuals. Together, the current findings provide initial support for the notion that distraction by salient, nonemotional stimuli can increase state anxiety levels. Furthermore, these

results suggest that individuals already vulnerable to experience anxiety are most likely to be affected by distraction by salient, nonemotional stimuli, and that training anxious individuals to focus on specific shape features may be a viable attention modification intervention.

*Keywords:* anxiety; attention; attention training; attentional capture; search strategies

ANXIOUS INDIVIDUALS ARE KNOWN to preferentially attend to threatening stimuli (Bar-Haim et al., 2007); however, they also demonstrate broader attentional deficits that manifest across a range of nonemotional cognitive tasks. In fact, such attentional problems represent core diagnostic features of many anxiety disorders in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013). Numerous behavioral and neuroscientific studies have confirmed the robust relationship between anxiety and difficulties inhibiting distracting information even in the absence of threat (Berggren & Derakshan, 2013; Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007). To account for these broad attentional impairments, Attentional Control Theory (ACT; Eysenck et al., 2007) posits that anxiety is characterized by increased influence of the bottom-up stimulus-driven attention system that tracks salient and threatening stimuli and decreased influence of the volitional, top-down control system that sets and tracks goals

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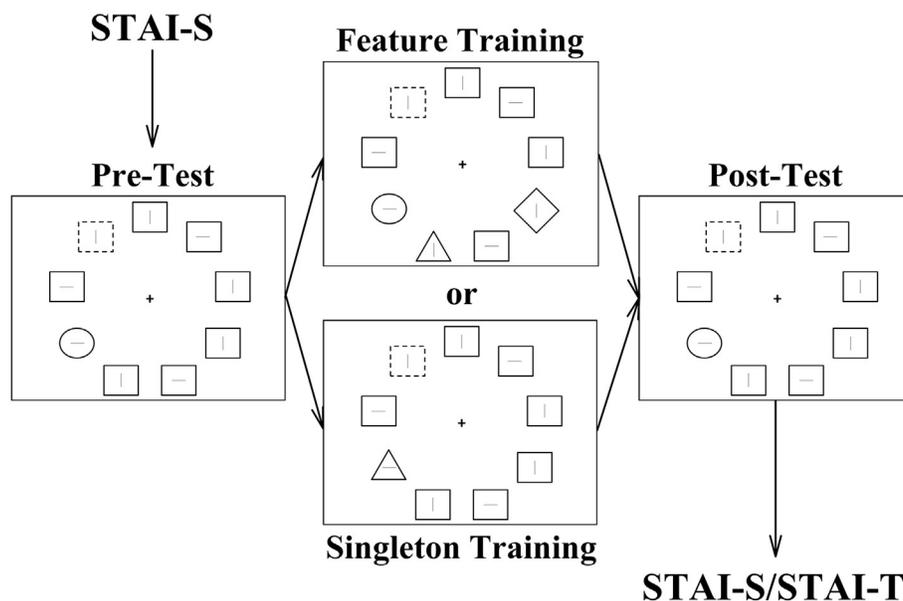
(Corbetta & Shulman, 2002; Posner & Petersen, 1990). Thus, ACT suggests that this imbalance between salience- and goal-driven attention is at the root of impaired attentional control in anxiety and impacts performance on a variety of attentional tasks—both with and without affective stimuli.

We have recently argued (Moser, Becker, & Moran, 2012; Moran & Moser, 2015) that the ideal way to assess the imbalance between salience- and goal-driven attention in anxiety is through the use of the “additional singleton paradigm” (Theeuwes, 1991, 1992). In this task, participants are presented with a circular array consisting of simple shapes (see Figure 1 for an example array). On each trial, the participant is presented with an array containing one unique “singleton” shape (e.g., a circle; Figure 1), which serves as the target, and a homogeneous set of nontarget shapes (e.g., squares; Figure 1). The participant’s task is to locate the unique target shape and identify whether the line segment contained within it is oriented vertically or horizontally. Color is irrelevant to the task; however, on half of the trials one of the nontarget shapes is presented in a different color (e.g., one square is displayed in red while the rest are displayed in green; Figure 1), making it a physically salient color singleton or distractor (Theeuwes, 1991, 1992). In this way, the additional singleton paradigm simultaneously pits bottom-up

salience-driven attention against top-down goal-driven attention for the initial selection of attention. The primary finding across individuals is that response times to the target are longer when the color singleton is present than when the color singleton is absent (for a review see Theeuwes, 2010). Theeuwes argued that the slowed response times result from the automatic selection of the color singleton by the bottom-up salience-driven system that occurs before the target can be selected by the top-down goal-driven system.

Using the additional singleton task, we have shown that the distracting effects of the color singleton are exaggerated in trait-anxious undergraduates, suggesting that they are more susceptible to distraction by nonaffective physical salience than nonanxious individuals (Moran & Moser, 2015; Moser et al., 2012). This effect has also been replicated in a sample of patients diagnosed with posttraumatic stress disorder (PTSD; Esterman et al., 2013). Together, these results provide strong support for ACT’s central claim that anxiety is associated with increased influence of the salience-driven attention system and decreased influence of the goal-driven attention system, resulting in preferential processing of salient stimuli—even those that are not threatening—and impaired task performance.

The exact nature of the relationship between this attention to nonemotional color singletons/distractors



**FIGURE 1** A schematic representation of the experimental procedure. Dashed-line objects represent the color singleton distractor. All participants first completed the state-anxiety questionnaire and the pretest phase. Participants were then randomly assigned to a singleton- or feature-mode training phase. Participants were always asked to report the orientation of the line segment in the target shape (determined by group assignment). Following training, participants completed the posttest phase and completed the state- and trait-anxiety questionnaires (see method for a description of tasks).

and anxiety remains unclear because existing studies have been cross-sectional and correlational. ACT is likewise ambiguous as to whether such impairments in attentional control are predicted to be causes or consequences of anxiety, although most of the research to date has focused on attentional control impairments as consequences of anxiety. Attention to threat, on the other hand, has been suggested to play a causal role in the development and maintenance of anxiety (for a review see MacLeod & Mathews, 2012). In a classic study by MacLeod and colleagues (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; and later replicated by Grafton, Mackintosh, Vujic, & MacLeod, 2014), participants were either trained to attend to threatening words or neutral words using a probe detection task and then completed a stressful cognitive task involving solving difficult anagrams. MacLeod et al. found that individuals trained to attend to threatening words reported more anxiety following the stressful anagram task. Thus, inducing attention to threat had a causal influence on subsequent anxiety. Since this discovery, clinical researchers have devoted a significant amount of effort to reverse engineering this effect—i.e., showing that training anxious individuals and patients to preferentially attend to neutral stimuli or away from negative stimuli leads to significant decreases in reported anxiety symptoms and diagnoses (for a review see Hallion & Ruscio, 2011). The primary aim of the current study was to conduct an initial test of whether manipulating attention to nonemotional color distractors could, too, lead to an increase in anxiety.

We reasoned that manipulating attention to nonemotional color distractors would influence anxiety levels for four reasons. First, several theories, including ACT (Eysenck et al., 2007; Gray, 2001; Gray, Braver, & Raichle, 2002; Pessoa, 2013; Shackman et al., 2011), suggest that anxiety increases the influence of a common (bottom-up) attentional system for processing salient stimuli, regardless of affective content. Recently, we provided initial support for the psychometric unity of affective and nonaffective attentional biases and their common association with anxiety using a latent variable approach (Moran & Moser, 2014). Specifically, we found that attentional biases to negative affective stimuli and salient but nonaffective stimuli formed one unified “attentional bias” factor. Moreover, this generic attentional bias factor was significantly associated with anxiety—i.e., greater attentional bias to threat and nonaffective salience was associated with greater anxiety symptoms. We found no evidence for unique associations between affective and nonaffective attentional biases and anxiety. Thus,

it appears that negative and nonaffective attentional biases can be thought of as reflecting one, rather than two, attentional bias. We therefore reasoned that if this is the case, and manipulating negative attentional bias influences anxiety, then manipulating nonaffective attentional bias should likewise affect anxiety levels.

Second, the associations between anxiety and negative and nonaffective attentional biases might exist because all three draw on the same neurophysiologic mechanisms, namely, activity of the right prefrontal and posterior parietal cortices (PFC and PPC, respectively). Indeed, research from a variety of areas indicates that the right PFC and PPC are involved in anxious arousal, negative emotion processing and general vigilance (Compton et al., 2003; Corbetta & Shulman, 2002; Engels et al., 2007; Shackman et al., 2006, 2011). Thus, manipulating a nonaffective attentional bias should influence anxiety because it would modulate the same neural mechanisms involved in producing anxious states.

Third, research has already set a precedent for the influence of nonemotional attentional states on negative emotion processing. Most germane to the present investigation, Gable and Harmon-Jones (2012) induced two different attentional states using the Navon (1977) local vs. global letters task in which participants are either asked to identify a small letter making up a larger letter (e.g., little “T”s that form the shape of a larger “H”) or to identify the larger letter (e.g., the larger “H”), respectively. Local processing narrows attention whereas global processing broadens attention. Gable and Harmon-Jones found that inducing a narrowed attentional focus enhanced the subsequent early attentional processing of negative pictures compared to inducing a broadened attentional state. Previous research had shown that negative emotional states narrow attentional focus (Gable & Harmon-Jones). Thus, inducing an attentional state that was previously shown to be associated with negative emotional states increased negative emotion processing.

Finally, recent findings also indicate that nonemotional working memory performance predicts later increases in anxiety (Bredemeier & Berenbaum, 2013). Bredemeier and Berenbaum found that poorer performance on a standard working memory task predicted increases in worry symptoms 2 months later, even after accounting for baseline worry. Importantly, poor working memory performance relates to worse attentional control, which may make it difficult for anxious individuals to suppress negative thoughts (Crowe et al., 2007) and divert attention away from negative information (e.g.,

Derryberry & Reed, 2002). Thus, if poor working memory capacity is predictive of later anxiety symptoms and associated with worse attentional control, perhaps inducing changes in attentional control would also have influences on later anxiety.

Together, the research and theory reviewed above provide sufficient evidence to suggest that manipulations of nonemotional attentional control might have influences on anxiety. To test our prediction, we applied theory and methodology from cognitive science concerning the effects of attentional search strategies on distractor processing (Bacon & Egeth, 1994; Folk, Remington, & Johnston, 1992; Leber & Egeth, 2006a, 2006b). Following from earlier observations by Pashler (1988), Bacon and Egeth (1994) proposed that Theeuwes' original findings in the additional singleton task were the result of individuals adopting a "singleton detection mode," which involves prioritizing the most salient information. Because participants in Theeuwes' task are asked to search for a uniquely shaped singleton embedded among homogeneous nontarget shapes, a singleton detection mode would be optimal. While in this mode, participants also become more susceptible to other types of singletons such as irrelevant color distractors. However, Bacon and Egeth argued that different search modes would be optimal under different conditions. Specifically, when a task involves searching for a specific target shape (e.g., a circle) embedded in an array of heterogeneous nontarget shapes (e.g., triangles, squares and diamonds)—rather than for a uniquely shaped singleton among homogeneous nontarget shapes—one would adopt what they referred to as a "feature search mode" that prioritizes a target's defining feature(s). Critically, while searching for a specific target shape, search parameters are tuned for a particular feature and individuals are thus less susceptible to interference from distractors that do not share the relevant feature.

Most important to the current study, Leber and Egeth (2006a) extended Bacon and Egeth's (1994) work by randomly assigning participants to either a one-session singleton detection training involving searching for a uniquely shaped singleton among homogeneous nontarget shapes—i.e., the standard additional singleton paradigm—or a feature search training that involved searching for a specific target shape in the heterogeneous arrays described above. Consistent with Bacon and Egeth (1994), Leber and Egeth (2006a) confirmed that singleton detection training led to a significantly larger distractor cost—i.e., more slowing of reaction time in the presence of a color singleton—compared to feature search training, in a post-test session wherein all participants were exposed to the standard additional singleton paradigm (for similar results, see

also Cosman & Vecera, 2013; Leber & Egeth, 2006b; Leber, Kawahara, & Gabari, 2009). Thus, manipulating search strategy through brief attentional training induced the predicted behavioral effects with respect to distractor processing. In the current study, we made use of this search strategy training paradigm to test the prediction that manipulating attention to nonemotional distractors has a causal impact on anxiety.

We first expected to replicate Leber and Egeth (2006a, 2006b) by showing that individuals trained in singleton detection mode would demonstrate a robust slowing of reaction time in the presence of the color singleton distractor—hereafter referred to as "distractor cost"—whereas individuals trained in feature search mode would demonstrate a significantly smaller distractor cost in the posttraining additional singleton paradigm. Of critical importance to the current investigation, we also reasoned that if distraction by nonemotional color singletons observed in anxiety plays a causal role, then training individuals to adopt the singleton detection mode should lead to increases in anxiety. This logic follows directly from that which has been delineated in the negative attention bias literature (MacLeod & Mathews, 2012). Namely, if an anxiety-related attention bias has a causal influence, then inducing it will have a measureable impact on anxiety. Conversely, training individuals to adopt the feature search mode should protect against this increase in anxiety, which parallels the prediction and findings observed when individuals are trained to avoid negative stimuli in standard probe detection tasks (Grafton et al., 2014; MacLeod et al., 2002). Finally, we included participants reporting both average-to-low levels of trait anxiety and those reporting elevated levels of trait anxiety to examine the potential moderating effect of anxiety vulnerability on the attentional training effects. Previous research by MacLeod and colleagues (Grafton et al., 2014; MacLeod et al., 2002) examined negative attention bias training preselected participants displaying moderate-to-high levels of anxiety to avoid potential ceiling or floor effects on attention bias and stress reactivity. However, to our knowledge, no studies have directly tested whether level of anxiety impacts the effectiveness of attention training in modulating attention or anxiety. Here, we sought to directly test this possibility in the context of nonemotional attention training.

## Method

### PARTICIPANTS

Sixty-two undergraduates (46 female) participated in the current study for partial credit in psychology courses. Prior to attending the lab session, all

participants completed the trait version of the State-Trait Anxiety Inventory (STAI-T; Spielberger & Gorsuch, 1983) online as part of a mass screening. Twenty-nine participants scoring at or below the 50th percentile of scores were recruited to represent individuals with average-to-low levels of anxiety (hereafter referred to as low trait-anxious participants; LTA). Thirty-three participants scoring in the upper 20th percentile of scores were recruited to represent individuals with high anxiety levels (hereafter referred to as high trait-anxious participants; HTA). Across both anxiety groups, 29 participants were randomly assigned to the singleton detection group and 33 were randomly assigned to the feature search group.

#### STIMULI AND MATERIALS

Stimuli and procedures were similar to those used in our previous work (Leber & Egeth, 2006a; Moser et al., 2012; Moran & Moser, 2015). Participants were presented with search arrays consisting of 9 geometric shapes equally spaced along an imaginary circle ( $11^\circ$  radius). Stimuli were presented against a black background on a 19-inch LCD monitor. Shape stimuli consisted of unfilled diamonds (length of side:  $4.5^\circ \times 4.5^\circ$  of visual angle), squares (diamonds rotated  $45^\circ$ ), circles (diameter:  $3.4^\circ$  of visual angle) and equilateral triangles facing upwards (length of side:  $5^\circ$  of visual angle). The outlines of all stimuli were colored green except for the color singleton which was colored red. Gray line segments ( $1.5^\circ$  long;  $.2^\circ$  thick) were centered in each shape. Line segments were randomly selected to be horizontally or vertically oriented. E-Prime (Psychology Software Tools, Sharpsburg, PA) was used to control stimulus timing and record responses.

The STAI-State (STAI-S; Spielberger & Gorsuch, 1983) was used to assess participants' current anxiety both prior to and immediately following the experiment to test the primary hypothesis of the current study. The STAI-T was also administered at the completion of study procedures, including after completion of the STAI-S, to confirm the status of the LTA and HTA groups. Each scale consists of 20 items rated on a Likert scale ranging from 1 (*almost never*) to 4 (*almost always*).

#### PROCEDURE

See Figure 1 for a visual depiction of the overall procedures of the current study. In the laboratory, participants were first given a description of the study procedures and completed a consent form. Participants were naïve to the design of the experiment and the purpose of the training manipulation. Participants then completed the STAI-S. They then completed the pretest phase,

the training phase, and the posttest phase. Finally, participants completed the STAI-S again and the STAI-T. The entire session lasted approximately 90 minutes.

#### All Phases

Regardless of group assignment, all participants completed three experimental phases: the pretest phase, the training phase, and the posttest phase. Across all groups and all phases, each trial began with the presentation of a search array which remained present until a response was given. The location of targets, nontargets, and color singleton distractors were randomized on each trial. Participants were required to locate the target shape (defined at the beginning of each phase) and use the keyboard to report the orientation of the line segment contained within the target shape. Participants responded using the "a" and "l" keys, which were covered by blank, white stickers. Stimulus-response mappings were counterbalanced across participants. A red color singleton distractor was present on half of trials. Participants were instructed not to pay attention to color, but rather to focus on finding the target shape. A feedback tone was presented when the participant responded incorrectly. The search array was followed by a variable duration intertrial interval (1200–1600 ms), which consisted of a white fixation cross presented at the center of the screen. Each of the three phases consisted of 432 trials for a total of 1,296 trials. Participants completed 24 practice trials prior to each phase.

#### Pre/Posttest Phases

The pre- and posttest sessions were identical. Participants were required to locate the target shape (always a circle) among homogeneous nontargets (always squares) and use the keyboard to report the orientation of the line segment contained within the target shape.

#### Training Phase

The training phase varied as a function of group assignment. Participants in the singleton detection group searched for a unique shape (either a circle, diamond, or triangle—each presented on one third of trials) among homogeneous nontargets (always squares). Participants in the feature search group searched for a consistent target (always a circle) among heterogeneous nontargets consisting of a diamond, a triangle, and 6 squares.

#### DATA PROCESSING AND ANALYSES

Initially, reaction times (RTs) across all trials were trimmed for outliers such that trials were removed if their RTs were greater than 3000 ms or less than

250 ms (Moser et al., 2012). Accuracy analyses included all trials that remained after this trimming procedure. For RT analyses, only correct trials were included.

The primary dependent variable for behavioral analyses was color singleton distractor cost on RT—as in past studies (Leber & Egeth, 2006a)—calculated as the difference between RTs on distractor present trials and RTs on distractor absent trials. RT was the focus because it is robustly related to anxiety and is reliably modulated by search training whereas accuracy is not (Esterman et al., 2013; Moran & Moser, 2015; Moser et al., 2012), findings consonant with ACT, which focuses on performance efficiency (i.e., RT) rather than performance effectiveness (i.e., accuracy). However, distractor cost on accuracy was also calculated as the difference between accuracy on distractor present trials and accuracy on distractor absent trials, in order to ensure that differences in accuracy did not confound RT effects.

We first examined the effect of training on the posttest RT distractor cost as a manipulation check to ensure that we replicated Leber and Egeth (2006a) in that singleton detection training should result in a larger distractor cost than feature search training. We then examined whether anxiety vulnerability—i.e., LTA vs. HTA group status—moderated training effects on RT. To test the primary hypotheses of the study, we examined the effect of training group on change in state anxiety,

Table 1  
Descriptive Statistics for Self-Report and Behavioral Measures Across Training and Anxiety Groups

Variable	Singleton Group	Feature Group
<b>LTA Group</b>		
N	14	15
STAI-T	31.71 (4.65)	31.33 (7.38)
STAI-S Pre	26.14 (4.13)	28.60 (4.60)
STAI-S Post	30.64 (9.21)	32.40 (7.49)
$\Delta$ STAI-S	4.5 (9.69)	3.80 (6.33)
Accuracy Cost Pre (%)	-.81 (1.58)	.79 (1.93)
RT Cost Pre (ms)	25.40 (35.70)	26.30 (35.75)
Accuracy Cost Post (%)	-.54 (2.07)	-.43 (1.45)
RT Cost Post (ms)	19.34 (16.21)	2.03 (15.97)
<b>HTA Group</b>		
N	15	18
STAI-T	57.29 (9.34)	53.00 (7.81)
STAI-S Pre	34.17 (7.59)	40.61 (10.79)
STAI-S Post	42.83 (10.55)	38.78 (11.12)
$\Delta$ STAI-S	8.67 (10.13)	-1.83 (6.54)
Accuracy Cost Pre (%)	-.27 (2.02)	-.64 (1.89)
RT Cost Pre (ms)	38.62 (51.42)	27.86 (35.78)
Accuracy Cost Post (%)	-.14 (1.10)	.11 (1.39)
RT Cost Post (ms)	21.38 (28.12)	7.70 (23.78)

Note. LTA = Low trait anxious; HTA = High trait anxious.

as measured by the STAI-S, from pre- to posttraining and whether anxiety vulnerability—i.e., LTA vs. HTA group status—moderated training effects. Differences in degrees of freedom reflect missing data points for certain analyses.

## Results

Descriptive statistics for the behavioral and self-report measures are presented in Table 1. The singleton and feature groups did not differ with respect to sex for either the LTA (64.14% vs 60% female, respectively;  $\chi^2[1] = 0.06, p = .81$ ) or HTA groups (80% vs 88.89% female, respectively;  $\chi^2[1] = 0.50, p = .48$ ). Confirming group status, the HTA participants scored higher ( $M = 54.88, SD = 8.65$ ) than the LTA participants ( $M = 31.52, SD = 6.11$ ;  $t[59] = 12.07, p < .001$ ) across both training groups on the postexperiment STAI-T. Importantly, however, LTA and HTA participants were matched on STAI-T across training groups ( $ts < 1.42, ps > .16$ ; see Table 1). The two groups were also matched with respect to pretest RT and accuracy distractor costs ( $ts < 1$ ; see Table 1).

### EFFECTS OF TRAINING GROUP AND ANXIETY VULNERABILITY ON RT

We conducted a 2 (Search Training Group: Feature vs. Singleton)  $\times$  2 (Trait Anxiety Group: High vs. Low) ANOVA on posttraining RT distractor cost. Replicating Leber and Egeth (2006a), the significant effect of training group,  $F(1, 55) = 7.28, p = .009, \eta^2_p = .12$ , indicated that singleton detection training ( $M = 20.40, SD = 22.76$ ) produced a larger post-training RT distractor cost than feature search training ( $M = 5.22, SD = 20.62$ ; see Figure 2). Indeed, distractor cost was robust and significantly different from 0 following singleton detection training,  $t(26) = 4.66, p < .001$ , but not following feature

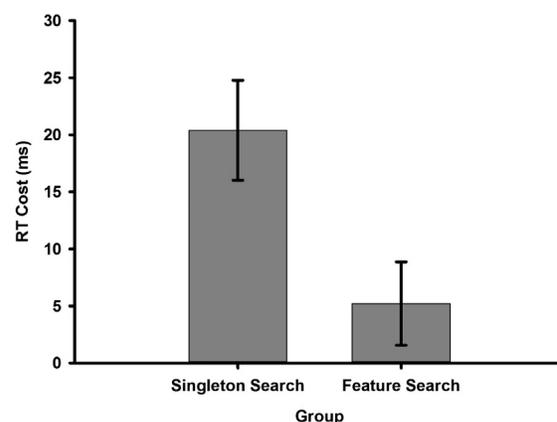


FIGURE 2 Posttest distractor cost (distractor-present RT minus distractor-absent RT) as a function of training group. Error bars represent  $\pm 1$  SEM.

search training,  $t(31) = 1.43, p = .16$ . Also consistent with Leber and Egeth, we found no effects of search training on accuracy ( $F_s < 1.40, p_s > .24$ ). Thus, it appears that the manipulation was successful insofar as the singleton detection group showed robust evidence of attentional capture by the salient color distractor, but the feature search group did not. Trait anxiety group, however, did not moderate the effect of training group on posttraining RT distractor cost ( $F < 1$  for the Training Group  $\times$  Trait Anxiety Group interaction), suggesting that attentional search training effects on RT were comparable across low and high levels of anxiety vulnerability. There was also no significant main effect of trait anxiety group ( $F < 1$ ).

#### EFFECTS OF TRAINING GROUP AND ANXIETY VULNERABILITY ON STATE ANXIETY

With respect to our primary hypotheses, we conducted a 2 (Time: Pre vs. Post Training)  $\times$  2 (Search Training Group: Feature vs. Singleton)  $\times$  2 (Trait Anxiety Group: High vs. Low) repeated measures ANOVA on STAI-S scores. The significant main effect of time,  $F(1, 55) = 12.50, p = .001, \eta^2_p = .19$ , indicated that state anxiety generally increased over the testing session. However, this main effect was qualified by a significant Time  $\times$  Search Training Group interaction,  $F(1, 55) = 6.85, p = .01, \eta^2_p = .11$ , which indicated that STAI-S scores increased from pre-to-post training in the singleton detection group but remained static from pre-to-post training in the feature search group. Critically, however, results revealed that this two-way interaction was further modified by a significant three-way interaction,  $F(1, 55) = 5.24, p = .03, \eta^2_p = .09$ , indicating that trait anxiety group moderated the effect of search training strategy on change in state anxiety from pre-to-post training (see Figure 3).

Follow-up 2 (Time: Pre vs. Post Training)  $\times$  2 (Search Training Group: Feature vs. Singleton) ANOVAs in each trait anxiety group showed no Time  $\times$  Group interaction in the LTA group ( $F < 1$ ), suggesting that type of search strategy did not differentially impact state anxiety over time for LTA individuals. In contrast, there was a significant interaction between time and search training group in the HTA group,  $F(1, 28) = 11.98, p = .002, \eta^2_p = .30$  (see Figure 3). HTA individuals showed a significant increase in state anxiety from pre-to-post singleton detection training ( $M_{pre} = 34.17, SD = 7.59; M_{post} = 42.83, SD = 10.55; t[11] = 2.96, p = .01, d = .52$ ), but a nonsignificant decrease in state anxiety from pre-to-post feature search training ( $M_{pre} = 40.61, SD = 10.79; M_{post} = 38.78, SD = 11.12; t[17] = 1.19, p = .25, d = .22$ ).

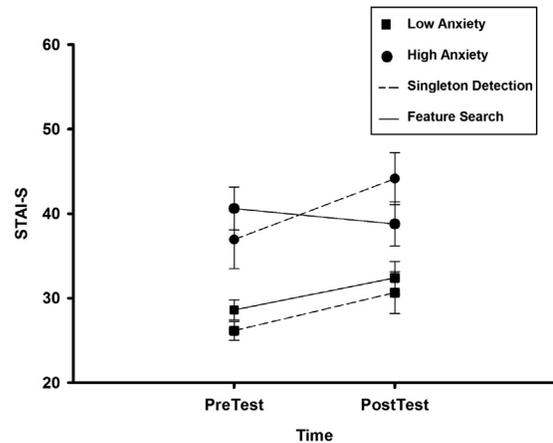


FIGURE 3 State anxiety (STAI-S) change from pre- to posttraining in the low and high trait anxious participants for the singleton detection and feature search training groups. Error bars represent  $\pm 1$  SEM.

The main effect of trait anxiety group was also significant,  $F(1, 55) = 22.68, p < .001, \eta^2_p = .29$ , confirming that HTA individuals reported higher state anxiety overall. No other significant effects emerged ( $F_s < 1$ ).

#### Discussion

The aim of the current study was to test the hypothesis that manipulating attention to salient, but nonemotional, distractors influences state anxiety. Results revealed that we were successful in producing the desired effect on RT distractor cost such that singleton detection training led to a larger RT distractor cost than feature search training. Moreover, these training effects on RT were not moderated by trait anxiety; singleton and feature training had comparable effects across low and high trait-anxious students. Importantly, results were consistent with our hypothesis in showing that singleton detection training led to an increase in state anxiety whereas feature search training protected against this increase, especially in high trait-anxious individuals. Although state anxiety tended to increase across the training session for most groups, the potentiating effect of singleton training and the protective effect of feature training were most robust in the high trait-anxious group (see Table 1 and Figure 3).

#### BASIC SCIENCE AND THEORETICAL IMPLICATIONS

The current findings provide additional support for the notion that attentional biases play a significant role in influencing levels of anxiety (MacLeod & Clarke, 2015; MacLeod & Mathews, 2012; Mathews & MacLeod, 2005; Van Bockstaele et al., 2014) and extend this conceptualization to include attentional processes involved in distraction by salient, nonemotional stimuli. In this way, our findings fit within the

broader research on cognitive functioning in anxiety (Eysenck et al., 2007; Sylvester et al., 2012) and suggest a causal, not just correlational, relationship between nonemotional attentional dysfunction and anxiety. Moreover, the current findings dovetail nicely with related research showing that working memory deficits prospectively predict increases in worry symptoms over time (Bredemeier & Berenbaum, 2013) and that narrowing attentional focus to non-emotional stimuli has causal effects on negative emotion processing (Gable & Harmon-Jones, 2012).

An important aspect of the current study was that we included both low and high anxious college students to test moderation of the search training effects by anxiety vulnerability. Although anxiety vulnerability did not moderate search training effects on RT distractor cost, it did moderate search training effects on state anxiety. The former result indicates that the effect of attentional search strategy training on RT distractor cost is robust across levels of anxiety vulnerability and replicates findings from previous research in unselected populations (e.g., Leber & Egeth, 2006a). However, manipulating attentional search strategy had a differential effect on state anxiety between low and high anxious individuals such that high anxious individuals' state anxiety was most differentially affected by singleton and feature search trainings. Specifically, singleton detection training increased state anxiety in the high anxious individuals whereas feature search training had no such effect.

Previous research on negative attention bias modification has focused on either individuals showing moderate-to-high levels of anxiety (Grafton et al., 2014; MacLeod et al., 2002) or high anxious students and patients (e.g., Amir, Beard, Burns, & Bomyea, 2009; Heeren et al., 2012). What has not been established is whether a certain level of dispositional anxiety is necessary to reveal training effects on state anxiety. The current results suggest that, indeed, higher levels of anxiety vulnerability accentuate training effects on state anxiety in the context of nonemotional attention training. Our results are consistent with related research showing that rejection training reduces rejection bias in people with low, but not high, self-esteem (Dandeneau & Baldwin, 2004) and psychological distancing from negative experiences reduces emotional reactivity in people with high, but not low, levels of depression (Kross & Ayduk, 2009; Kross, Gard, Deldin, Clifton, & Ayduk, 2012). Together with the current results, extant research suggests that a higher degree of vulnerability to the trait of interest is important for revealing robust training effects. Future research on negative attention bias modification should also directly test the possible moderation by anxiety

vulnerability. It is possible that both negative attention bias and singleton detection search bias increase distress inasmuch as an individual has a preexisting vulnerability to anxiety, which would have important bearing on theoretical accounts of the causal role of attentional biases in anxiety.

A recent review of the research further suggests that greater investigation of the precise nature of the relationship between attentional biases and anxiety is necessary. Specifically, Van Bockstaele et al. (2014) provided evidence for a bidirectional influence such that negative attention bias can lead to anxiety and vice versa. Therefore, it will be important for future research to evaluate this bidirectional hypothesis with respect to attentional distraction by a perceptually salient singleton. Clearly, additional research will be needed to fully appreciate the role of attentional search strategies for nonemotional stimuli in the development, maintenance, and treatment of anxiety. One important next step would be to examine the association between RT distractor cost by a salient, nonemotional stimulus—as we have done previously (Moser et al., 2012; Moran & Moser, 2015)—and anxiety in a longitudinal design to understand the predictive value of singleton detection bias in the development of later anxiety. Future studies could also examine the effects of inducing a singleton detection mode on later anxiety responses to a stressful task as was done in the seminal work of Mathews and colleagues (2002) and later replicated by Grafton et al. (2014).

#### CLINICAL IMPLICATIONS

The primary motivation for conducting this study was to begin a line of research using nonemotional attention training that would parallel the negative attention bias modification literature on its way from establishing the causal role of negative attention bias in anxiety to demonstrating the power of negative attention bias modification in alleviating symptom burden in highly anxious individuals and patients. In demonstrating that attentional search strategy to nonemotional stimuli can modulate state anxiety in high anxious individuals, we have taken a first step toward our longer-term goal of using the current paradigm as an intervention for anxiety. This is an important step in light of research illuminating the limitations of negative attention bias modification procedures (Cristea, Kok, & Cuijpers, 2015; Fox, Mackintosh, & Holmes, 2014; Hallion & Ruscio, 2011; Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015; MacLeod & Clarke, 2015; Mogoșe, David, & Koster, 2014). Indeed, such reviews have revealed mixed and generally modest effects of negative attention bias modification interventions. Our study is thus in line with the recent remarks of MacLeod and

Clarke encouraging future research to rely less on the traditional dot probe approach and investigate other forms of attentional training procedures.

#### LIMITATIONS

Although findings from the current investigation are promising, there are a few caveats and limitations that should be mentioned. First, given the novelty of the current approach and findings, replication will be critical. Second—and related to the first point—our samples in each of the four groups were relatively small (<20 per group). Thus, larger scale studies will need to be conducted to attempt replication of the current findings with greater statistical power. The effects reported herein were generally moderate in size. Replication in larger samples would therefore provide more compelling evidence of the robustness of our findings and bolster the legitimacy of this novel approach. Third, we drew our participants from a college population and thus future studies should draw from community and patient populations to test whether the current findings generalize to other groups. Finally, the differential effects of singleton and feature training on state anxiety in the low and high trait-anxious groups might reflect greater awareness of deficits in attentional distraction and therefore a greater sensitivity to being equipped with a more effective strategy in the high trait-anxious individuals. Thus, our results might reflect this meta-cognitive process rather than direct modification of relationships between attention and emotion.

#### Conclusions

The current study represents a first step in evaluating the influence of attentional search strategies for nonemotional stimuli on anxiety. Findings were supportive of the hypothesis that adopting a singleton detection mode leads to increases in anxiety symptoms, especially in high trait-anxious individuals. There was also some evidence that adopting a feature search strategy protects against such increases or leads to slight reductions in anxiety among high trait-anxious individuals. Further examination of the causal role of search strategies in the development of later anxiety and the potential therapeutic effects of computerized feature search training in anxious patients are exciting new avenues for future research to explore.

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