

Attention Bias Dynamics and Symptom Severity During and Following CBT for Social Anxiety
Disorder

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Abstract

Objective: Threat-related attention bias figures prominently in contemporary accounts of the maintenance of anxiety disorders, yet longitudinal intervention research relating attention bias to anxiety symptom severity is limited. Capitalizing on recent advances in the conceptualization and measurement of attention bias, we aimed to examine the relation between attention bias, indexed using trial-level bias scores (TLBS) to quantify temporal dynamics reflecting dysregulation of attentional processing of threat (as opposed to aggregated mean bias scores) and social anxiety symptom severity over the course of cognitive behavior therapy (CBT) and one-month follow-up.

Method: Adults with social anxiety disorder (N=39) assigned to either yohimbine- or placebo-augmented CBT completed measures of attention bias and social anxiety symptom severity weekly throughout CBT (5 sessions) and at one-week and one-month post-treatment.

Results: TLBS scores of key features of attention bias temporal dynamics showed stronger psychometric properties than mean aggregated scores and highly inter-related, in line with within-subject temporal variability fluctuating in time between attentional over-engagement and strategic avoidance from threat. Attention bias toward threat and temporal variability in attention bias (i.e., attentional dysregulation), but not attention bias away from threat, significantly reduced over the course of CBT. Cross lag analyses revealed no evidence of a causal relation between reductions in attentional dysregulation leading to symptom severity reduction, or vice versa. Observed relations did not vary as a function of time.

Conclusions: We found no evidence for attentional dysregulation as a causal mechanism for symptom reduction in CBT for social anxiety disorders. Implications for future research are discussed.

Public health significance: This study suggests that attentional dysregulation may not be a mechanism for change in cognitive behavioral therapy, an effective treatment for social anxiety disorder. Though data is still preliminary, our finding that cognitive behavioral therapy did not lead to changes in attentional avoidance leaves open the possibility that targeting attentional avoidance alongside cognitive behavioral therapy may enhance its efficacy.

Keywords: attention bias, cognitive behavioral therapy, social anxiety disorder

Attention Bias Dynamics and Symptom Severity During and Following CBT for Social Anxiety Disorder

Cognitive-behavioral theories implicate attention bias in the etiology and maintenance of social anxiety disorder (Clark & Wells, 1995; Hirsch & Clark, 2004; Morrison & Heimberg, 2013; Rapee & Heimberg, 1997). Attention bias has been conceptualized as dysregulation in attentional processing of emotional stimuli (Cisler, Bacon, & Williams, 2009; Mogg, Bradley, Williams, & Mathews, 1993), characterized by facilitated attention toward and/or difficulty disengaging attention from threatening cues (Amir, Elias, Klumpp, & Przeworski, 2003; Koster, Crombez, Verschuere, & Houwer, 2006; Mogg & Bradley, 1998). Attention bias is thereby thought to drive a variety of maladaptive processes implicated in social anxiety disorder (e.g., misinterpretation of threat; Clark & Wells, 1995; Heinrichs & Hofmann, 2001; Morrison & Heimberg, 2013).

There is a growing body of research focused on the role of attention bias in social anxiety disorder (for review, see Heeren, Reese, McNally, & Philippot, 2012; Van Bockstaele et al., 2014). Cross-sectional research has shown some support for the hypothesized association between attention bias and social anxiety disorder. Specifically, performance on tasks adapted to measure attention bias (e.g., the Stroop, dot-probe, and spatial cueing paradigms) has, with some mixed evidence, generally tended to discriminate between socially anxious and non-anxious individuals. Yet, relatively little research has focused on how attention bias relates to social anxiety disorder symptoms over the course of cognitive behavior therapy (CBT), which aims to directly target factors related to attention bias (e.g., cognitive appraisal, avoidance; Clark & Wells, 1995; Hofmann, 2007). Pishyar and colleagues (2008) used a composite measure of both attentional avoidance and hypervigilance and found that, relative to those assigned to a waitlist

control condition, individuals receiving CBT evidenced reductions in both social anxiety symptoms and attention toward threat. Barry et al. (2015) demonstrated that difficulty with disengagement from threatening cues, but not facilitated engagement toward threatening cues, predicted CBT response in a mixed anxiety disorder sample that included individuals suffering from social anxiety disorder.

Building upon extant research, we subjected adults with social anxiety disorder to a repeated assessment schedule of attention bias and social anxiety disorder symptom severity during and following a brief exposure-based CBT program. In addition to examining the change in attention bias that occurs with CBT, we modeled the data such that we could make inferences with respect to directionality and causality – i.e., determine whether attention bias changes during CBT precede and lead to social anxiety reduction, whether social anxiety reductions during CBT precede and lead to reduction in attention bias, or both.

We also capitalized on emerging theory and findings positing that dysregulation in attentional processing of threat in social anxiety disorder may be better reflected by a dynamic process over time instead of static perspective on attention bias (Zvielli, Bernstein, & Koster, 2015). Specifically, Zvielli et al. (2015) proposed that attention bias is a dynamic process expressed in fluctuating, phasic bursts toward and away from motivationally relevant stimuli over time. Accordingly, they introduced a novel computational procedure, Trial-Level Bias Scores (TLBS), that yields a series of repeated estimations of attention bias, toward and/or away, from trial-to-trial over time, per individual – rather than only a single aggregated mean static estimate of attention bias that collapses across time. Traditionally, bias is inferred from aggregated mean/median differences in reaction time (RT) between trial types in which emotional stimuli may interfere with (slow) *or* enhance (speed) attentional processing. Zvielli et al. found that key

features of the temporal dynamics of attention bias (e.g., mean and temporal variability in attention bias toward and away from motivationally-relevant stimuli) demonstrated higher split-half reliability as well as incremental predictive validity above and beyond conventional aggregated mean bias scores in discriminating between phobics and healthy controls. More recently, Yuval et al. (in press) found that the temporal dynamics of attentional bias (towards, away, and variability) to trauma cues predicted levels of posttraumatic stress symptom severity in refugees at elevated risk for trauma-related mental health problems; and that temporal variability in bias well as attentional bias away but not towards trauma cues predicted behavioral avoidance of exposure to trauma stimuli; no effects were observed when bias was quantified traditionally. Schaefer et al (in press) found that, among German soldiers, bias dynamics to emotional information, at pre- and post-deployment, predicted higher levels of posttraumatic stress symptomatology after deployment as a function of number of traumatic experiences; conventional mean bias scores did not similarly prospectively predict posttraumatic stress at post-deployment. In anxious adults, Amir and colleagues (in press) found that not only were features of covert and overt bias dynamics correlated, but that the real-time, dynamic expressions of overt and covert attentional processes were significantly coupled from trial-to-trial; again, conventional covert and overt bias scores were not associated. In related work, attention bias variability was examined with respect to PTSD (Iacoviello et al., 2014; Naim et al., 2015), providing further evidence for the utility of a dynamic process perspective on attention bias in psychopathology. Accordingly, in so far as this conceptual and computational approach better represents the nature of attentional dysregulation in the processing of threat theorized to be important in the maintenance of social anxiety disorder, this perspective may be key to help to elucidate the role(s) of attention bias in therapeutic change over the course of CBT for social

anxiety. This study will be the first to model attention bias as a dynamic process measured repeatedly over the course of CBT, allowing us to examine temporal relations between dysregulation in attentional processing of threat and symptom change.

We predicted that modeling attention bias as a dynamic process, rather than using the conventional computation, would yield more reliable indices of attention bias. This is important for modeling attention bias measured repeatedly at multiple points in time over the course of therapy. Next, we predicted that attention bias toward threat (i.e., hypervigilance), attention bias away from threat (i.e., avoidance), and temporal variability in attention bias (i.e., attention dysregulation) would each decrease over time. Furthermore, we expected that greater regulation of attentional processing of threat (reduced attention bias dynamics) would lead to reduced social anxiety symptom severity, *and* that reduced symptom severity would lead to greater attentional regulation. Thus, we predicted that (dys)regulated attentional processing of threat and social anxiety symptom severity would be reciprocally related. Finally, we examined whether these bias-anxiety relations would vary as a function of time (i.e., testing the stationarity assumption, or the often incorrect assumption that relations do not vary over the course of treatment).

Method

Design

The parent clinical trial, approved by the Institutional Review Board at Southern Methodist University, for this secondary analysis involved the random assignment of 40 adults with social anxiety disorder to a 5-session CBT protocol augmented with either Yohimbine hydrochloride, an alpha2-adrenergic receptor agonist, or pill placebo administered acutely 1-hour prior to sessions 2-5 (Smits et al., 2014). In this study, social anxiety symptoms declined significantly for participants in both conditions, with individuals receiving yohimbine-augmented CBT evidencing a faster rate of symptom decline than those receiving placebo-augmented CBT.

Symptom severity and attention bias were assessed at baseline, before each weekly session, and at both one week and one month post-treatment. Prior to the session onset, symptom severity was assessed and was immediately followed by the attention bias task (and pill administration at weeks 2-5). Because we aimed to examine the relation between attention bias and symptom severity during and following CBT, we only used data from sessions 1 (immediately before the start of CBT) to 5, post-treatment and follow-up (e.g., 7 total data points).

Participants

Of the 40 individuals participating in the study, 39 individuals completed attention bias assessment during at least one of the seven assessments (i.e., one participant did not complete any attention bias assessments due to early dropout). Informed consent was obtained from all participants at Southern Methodist University. Participants had a DSM-IV diagnosis of social anxiety disorder, as diagnosed by the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID; First, Spitzer, Gibbon, & Williams, 1998) and evidenced no psychiatric and medical comorbidities that interfered with the safety of participating in the study (see Smits et al., 2014 for list of study entry criteria). Sample characteristics (from baseline and the first attention bias assessment task at week 1) are reported in Table 1.

Insert Table 1 about here

CBT

Treatment consisted of a 5-week CBT protocol for social anxiety disorder (Hofmann, 2004), which has been employed in previous and ongoing studies examining pharmacological augmentation of CBT for social anxiety disorder (Guastella et al., 2008; Hofmann et al., 2006; Hofmann, Otto, Pollack, & Smits, 2015). The first session consists of psychoeducation about

social anxiety disorder and rationale for exposure therapy, while sessions 2-5 consist of public speaking exposure exercises.

Assessment

Liebowitz Social Anxiety Scale – Self-Report (LSAS-SR). The LSAS-SR (Fresco et al., 2001) is a self-report measure of social anxiety disorder severity commonly used in treatment studies. The self-report version of the LSAS has sound psychometric properties, which are comparable to those of the clinician-rated version (Fresco et al., 2001).

Attention Bias. We employed a modified version of the Posner spatial cueing paradigm (Posner, Snyder, & Davidson, 1980), which has been previously used to assess attention bias in social anxiety disorder (Amir et al., 2003; Amir, Weber, Beard, Bomyea, & Taylor, 2008; Julian, Beard, Schmidt, Powers, & Smits, 2012). In this task, a word that is either socially positive (e.g. “delighted”), socially negative/threatening (e.g. “embarrassed”), or neutral (e.g. “dishwasher”) is presented on the computer screen. After 600 milliseconds, the word disappears and an asterisk appears in either the same location or the location opposite the word. There are 288 trials, of which 192 are valid (i.e., the word validly predicts the location of the target), 48 are invalid (i.e., the word does not predict the location of the target), and 48 are uncued (i.e., no word is presented at all). The participant must select either the left button on the keyboard if the asterisk appears on the left side of the screen, or the right button on the keyboard if the asterisk appears on the right side of the screen.

Conventional Approach: Aggregated Mean Bias Score. The conventional approach to attention bias calculation involves comparing average invalid and valid trial reaction times within threat and neutral trials separately, then comparing performance depending on valence (for more information on this calculation, see Koster, De Raedt, Goeleven, Franck, & Crombez,

2005). Accordingly, we first calculated a threat index (i.e., subtracted average valid threat RTs from average invalid threat RTs) and a neutral index (i.e., subtracted average valid neutral RTs from average invalid neutral RTs), and then subtracted the neutral index from the threat index to compute an attention bias score.

Dynamic Process Approach: Trial-Level Bias Score. As noted, this study is the first to utilize TLBS in the spatial cueing task; accordingly, this computation required some adaptations. The overall number of invalid trials in the task (16%; Amir et al., 2003) precludes the computation of TLBS by matching valid and invalid trials as is done when congruency is fully counterbalanced (Zvielli et al., 2015). Therefore, we performed the TLBS computation by matching each threat trial with the most proximate neutral trial (e.g., Zvielli, Amir, Goldstein, & Bernstein, 2015; valid threat trial RT was subtracted from valid neutral trial RT and invalid neutral trial RT was subtracted from invalid threat trial RT). This was done in order to (1) optimize TLBS ability to capture any temporal dynamic in attention bias, regardless if it is linked to hypervigilance or disengagement (i.e., valid/invalid); and (2) to maximize the number of potential matches in time, thus providing maximal temporal resolution of the attention bias estimation (Zvielli et al., 2015). We then used this TLBS signal-like sequence of RT differences to compute three subject-level variables (i.e., TLBS parameters) that indicate the overall direction and magnitude of bias toward and away, separately, as well as the variability in attention bias toward and away over time. First, $TLBS_{\text{toward}}$ is the mean of a participant's positive TLBS scores (i.e., faster RTs in response to valid threat than valid neutral trials or slower RTs in response to invalid threat than invalid neutral trials), indexing level of attention bias toward threat (wherein higher means reflect greater attention bias toward threat). $TLBS_{\text{away}}$ is the mean of negative TLBS scores (i.e., slower RTs in response to valid threat than valid neutral trials or

faster RTs in response to invalid threat than invalid neutral trials), indexing level of attention bias away from threat (wherein lower means reflect greater attention bias away from threat).

TLBS_{variability} is the temporal stability/variability in the expression of attention bias toward and/or away from threat over time (i.e., sum of the distances between sequential TLBS scores divided by the number of TLBS scores), wherein higher means reflect greater variability in attention bias.

Data Analysis

Data Cleaning. Following the data cleaning procedures utilized in previous trials (Amir et al., 2008; Julian et al., 2012), response latencies for inaccurate trials (i.e., when the participant pressed the button corresponding to the incorrect location of a probe) were deleted and not used in the analyses. Accordingly, 2.97% of trial data were eliminated due to incorrect responses. Additionally, sessions with an overall accuracy of less than 90% (5.06% of trial data) were removed from the analysis due to potential inattention or random guessing. Also in line with these procedures, response latencies of less than 200 ms or greater than 1,500 ms were removed and not used in the analyses (2.08% of trial data). Outliers were then removed on an individual, session level basis, with outliers defined as reaction times more than three standard deviations outside of the individual's mean reaction time for a particular session (1.29% of trial data).

Psychometric Properties. We utilized data from the baseline and week 1 assessment (both before treatment and drug administration) to estimate retest reliability for the conventional attention bias index and TLBS attention bias indices in the sample. Following procedures delineated by Price et al. (2014), we calculated the Intraclass Correlation Coefficient (ICC) using a 2-way random effects model and the 'absolute' agreement definition. We calculated both single measure ICC scores (i.e., the reliability for a single assessment point per individual) and average

measures ICC scores (i.e., the reliability for assessments averaged across individuals; analogous to the internal consistency index, α).

Hypothesis Testing. Data were analyzed using multilevel modeling (MLM). We used maximum likelihood estimation and robust standard errors for the variances of the regression coefficients. The repeated assessments of the outcomes, attention bias, and social anxiety symptom severity were nested within subjects.

To investigate the changes in attention bias over time, we modeled time from assessment one (prior to the first CBT session) to the follow-up assessment. In addition, we added a term to allow attention bias at follow-up to be freely estimated in order to reflect potential differences between the treatment (session 1 through post-treatment) and follow-up (post-treatment to one month follow-up) sessions. Initial symptom severity (at baseline, one week pre-treatment) and the interaction of initial symptom severity with time were included as covariates in all analyses. Though not a primary focus of the current study (but rather a consequence of the secondary nature of this analysis), treatment condition was added as a level-two moderator of all the predictors in the models to explore (i.e., no *a priori* hypothesis) whether any of the relationships were different for yohimbine (YOH) vs. placebo (PBO).

In order to test whether changes in symptom severity caused subsequent changes in attentional dysregulation (or vice versa), we employed within-subjects cross-lag panel analyses (see Table 3; for other examples of this type of quasi-causal analysis, see Meuret, Rosenfield, Seidel, Bhaskara, & Hofmann, 2010; Smits, Rosenfield, McDonald, & Telch, 2006; Tschacher & Ramseyer, 2009). In these analyses, LSAS at a time point (t) was entered as a predictor of attentional dysregulation at the next time point ($t+1$), controlling for attentional dysregulation at

the previous time point (and vice versa for attentional dysregulation changes predicting symptom changes).

Given that recent research (Hamaker, Kuiper, & Grasman, 2015) shows that one must disaggregate the effects of time varying predictors (TVPs) to obtain accurate, unbiased estimates of their effects on outcome, we disaggregated each (TVP) into the person's mean across all assessments (TVP_{mean} ; the between-person component) and their deviation from their mean at each session (TVP_{dev} ; the within-person component): $TVP_{\text{dev}} = TVP_{\text{raw}} - TVP_{\text{mean}}$. Accordingly, in these analyses, significant TVP_{mean} effects can be interpreted merely as between-subjects covariation between the predictor and the outcome (i.e., people with higher average levels of $TLBS_{\text{variability}}$ might have greater symptoms) whereas significant lagged TVP_{dev} effects can be interpreted as reflecting quasi-casual effects of the predictor on the outcome (Hamaker et al., 2015). Given the study aims to identify quasi-causal relations, we limit our reporting to TVP_{dev} effects, although TVP_{mean} effects were included in all analyses (as was necessary to accurately assess the TVP effects; Hamaker et al., 2015). To further strengthen causal inference, we also controlled for the growth curve for each variable in these analyses, as this helps rule out the possibility that the predictor and outcome are related merely because they are both changing over time (Wang & Maxwell, 2015).

Finally, we repeated the analysis with Time as a moderator to test the stationarity assumption that the relations do not vary over the course of treatment (Maxwell & Cole, 2007; Smits et al., 2012).

Power analyses (PinT 2.12; Snijders & Bosker, 1993) indicated that we had sufficient power ($> .80$) to detect a medium effect size ($d=.50$) for our least powerful test (those involving treatment condition differences or the mean levels of TVPs). Furthermore, the tests involving the

repeated measures over time (those involving the change in the attention bias indices over time, and those involving the cross lag effects between deviations in attentional dysregulation and LSAS) were more powerful and able to detect effect sizes as small as $d=.36$ with power $>.80$. Effect sizes were calculated using the t to d conversion.

Results

Psychometric Properties of Attention Bias Indices

See Table 2 for correlations between attention bias measures and social anxiety symptom severity at week 1. Using scores from a baseline assessment (not shown in Table 2) and week 1 (both pre-treatment), internal consistency and retest reliability indices were significant for each of the three TLBS measures: TLBS_{toward} (ICC-single measure=.44, ICC-average measures=.61, $p=.005$), TLBS_{away} (ICC-single measure=.46, ICC-average measures=.63, $p=.003$), and TLBS_{variability} (ICC-single measure=.53, ICC-average measures=.69, $p=.001$). Internal consistency and retest indices were not significant for the attention bias index computed using the conventional aggregated mean bias score approach (ICC-single measure=.05, ICC-average measures=.10, $p=.379$). We thus only retained the TLBS indices of attention bias in all subsequent analyses.

Correlations between the attention bias indices and social anxiety symptoms (LSAS) at baseline are displayed in Table 2. None of the attention bias scores were significantly related to LSAS. However, the three TLBS indices were very highly correlated with one another. Higher TLBS_{toward} (i.e., increased bias toward threat) was strongly related to lower TLBS_{away} (i.e., increased bias away from threat; $r=-.75$), and higher TLBS_{variability} (i.e., increased attentional dysregulation) was strongly related to both higher TLBS_{toward} ($r=.87$) and lower TLBS_{away} ($r=-.96$). This is in line with strong symmetry of within-subject variability toward *and* away from

threat, such that those exhibiting more bias towards threat also subsequently exhibit more bias away from threat, repeatedly in time.

Insert Table 2 about here

Change in Attention Bias and Social Anxiety Symptoms Over the Course of CBT

Bias Toward Threat: TLBS_{toward}. Consistent with our prediction, there was a significant decrease in TLBS_{toward} over the course of treatment (session 1 to post-treatment), $b=-1.84$, $p=.011$, $d=.99$, and no significant change in TLBS_{toward} over the follow-up period, $b=4.04$, $p=.309$, suggesting that changes were maintained during follow-up period. No treatment condition (yohimbine vs. placebo) effects were observed, suggesting that these changes were seen in participants irrespective of treatment assignment.

Bias Away from Threat: TLBS_{away}. Consistent with our prediction, TLBS_{away} tended to decrease over the course of treatment, $b=1.33$, $p=.082$, although that decrease failed to reach conventional levels of significance. TLBS_{away} did not change significantly over the follow-up period, $b=-3.57$, $p=.154$. No treatment condition effects were observed.

Temporal Variability in Bias: TLBS_{variability}. Consistent with our prediction, there was a significant decrease in TLBS_{variability} over the course of treatment, $b=-2.76$, $p=.001$, $d=1.62$, which tended to revert toward baseline levels during follow-up, $b=7.01$, $p=.061$. No treatment condition effects were observed.

As previously reported (Smits et al., 2014), the slope of change in social anxiety symptoms was significant for participants in both treatment conditions, but those assigned to

yohimbine-augmented CBT (YOH) demonstrated a significantly faster rate of improvement than those assigned to placebo-augmented CBT (PBO).

Relation between Attentional dysregulation and Social Anxiety Symptom Severity over Time

Given 1) the extremely high correlations among the three TLBS parameters or high *within-subject* symmetry between the magnitude of attentional bias towards and away from threat, 2) the fact that the changes in the TLBS measures over the course of the study mimicked those correlations (reductions in for TLBS_{toward} and TLBS_{variability}, and a trend toward reductions in TLBS_{away}), and 3) the conceptual and mathematical inter-relations between these parameters, we opted to perform cross lag analyses on only the TLBS_{variability} parameter.

As can be seen in Figure 1, autocorrelations for TLBS_{variability}, $b=0.34$, $p<.001$, and LSAS, $b=0.57$, $p<.001$, were significant. However, contrary to our predictions, neither the TLBS_{variability} → LSAS nor the LSAS → TLBS_{variability} relations were significant.

Insert Figure 1 about here

Time as a Moderator of the Relation between Attention Bias and Symptom Severity over Time

Our previous cross lag analyses examined the relation between attentional dysregulation and social anxiety symptom severity across the full length of the study. Such analyses assume that these relations are stable across the length of the study (stationarity). It is possible that some of these relations may have been diminished because they varied over time (e.g., perhaps the relations were strong at the beginning of the study but weaker at the end of the study, or vice

versa). To test for stationarity, we added Time as a moderator of all the TLBS_{variability}/LSAS relations in the cross lag panel analysis, including each of the cross lag relations and each of the auto-correlation relations. None of the interactions between time and these attentional dysregulation/LSAS relations were significant, indicating that the relations did not change significantly over time.

Discussion

The present study is the first to report on the temporal and causal relations between threat-related attention bias and symptom severity during and following CBT for social anxiety disorder. Using an intense repeated assessment schedule over the course of CBT and a novel approach to quantify attention bias as a dynamic process in time (i.e., trial-level bias score; TLBS), the study yielded a number of findings. First, we found that TLBS parameters reflecting attention dysregulation as measured by the modified spatial cueing task demonstrate greatly improved psychometric properties as compared to aggregated mean bias scores. These results are consistent with earlier work using the modified dot probe task (Zvielli et al., 2015), suggesting that quantifying features of the temporal dynamics of attention bias provides a psychometrically stronger representation of the underlying phenomenon of attention dysregulation than aggregated mean scores. We did not find significant correlations between any of the attention bias indices and social anxiety symptom severity at baseline. These results comport well with previous research showing that, while attention bias distinguishes people with (social) anxiety disorder(s) from non-anxious individuals, attention bias does not vary significantly among anxious individuals with varying degrees of symptom severity (Bar-Haim et al., 2007).

Second, our results showed that attention bias toward threat, and variability in attending to threat, decreased significantly over the course of treatment, while attention bias away from

threat tended to decrease, although this latter tendency did not reach conventional levels of significance. These results are consistent with and extend those reported by Pishyar and colleagues (2008), who found that participants who received CBT, compared to those who did not, demonstrated reduced levels of attention bias toward social threat. Interestingly, Pishyar et al. also did not find that attention bias away from threat changed significantly with CBT for social anxiety. Though our findings similarly failed to support the hypothesis that CBT effectively modifies attention bias away from threat, we did observe evidence of attention bias away from threat prior to CBT in our sample, which was highly correlated with attention bias toward threat. Accordingly, it appears premature to rule out attention bias away from threat as an important attentional mechanism in social anxiety disorder.

Third, the findings from our cross lag analyses found no support for the hypothesis that improvement (i.e., reductions) in attentional dysregulation leads to symptom severity reduction, or vice versa, suggesting that these two change processes observed in response to CBT may occur independently. In some studies, null associations are best explained by low statistical power. However, in part because of the design (i.e., 8 repeated assessments), power to detect a longitudinal relation between attentional dysregulation and LSAS in our study was actually relatively good, with over .80 power to detect effect sizes as small as $d=.36$. This effect size is equivalent to $\eta^2=.031$. In other words, $d=.36$ is equivalent to accounting for about 3.1% of the variance, an effect size that Cohen (1988) considers within the “small effect size” range. Hence, despite the small sample size, we had sufficient power to detect relationships that were relatively small.

Fourth, by adding time as a moderator in our models, we were able to test the, often false, assumption inherent to most regression models of causation that the causal structure is constant

over time (Maxwell & Cole, 2003; Smits et al., 2012). Time did not emerge as a moderator, thus suggesting that relations between symptom reduction and the reduction between attentional dysregulation did not change during the course of CBT or follow-up.

These findings must be considered in the context of a number of limitations. First, although we had sufficient power to detect meaningful effects ($\eta^2 > .031$) as per Cohen (1988), we were underpowered to detect smaller effects if they existed. Second, our use of the spatial cueing task with verbal stimuli (though utilized as an assessment tool in previous work) may preclude direct comparison to literature utilizing the more common dot-probe task, or tasks using facial stimuli or stimuli that may most fundamentally capture feared stimuli in social anxiety (i.e., signs of negative evaluation). Third, we employed a standardized 5-session exposure-based CBT protocol. It is possible that changes in attention bias and their relations with social anxiety disorder severity observed in the current study would not generalize to protocols that employ more sessions or emphasize cognitive or a combination of cognitive and behavioral interventions. Fourth, because our design did not include a control condition for CBT, we cannot infer that observed findings are specific to CBT (as prescribed in the present protocol) or whether they simply speak to how attention bias and symptom severity change and relate to each other over time. Finally, we should note that we observed high correlations among the three TLBS parameters at baseline, which is not unexpected because the calculations are conceptually and mathematically inter-related components of the same process of emotional attention. Due to these very high intercorrelations, we chose to examine only one of the TLBS measures as it related to LSAS to avoid duplicate analyses. Given our small sample size, it was inadvisable to perform any traditional methods of combining data, such as latent variable SEM analysis or factor analysis, both of which require hundreds of subjects to establish reliable factors.

Despite these limitations, our findings provide new insight into the relation between a putative maintaining factor of social anxiety disorder and symptom severity over time. Notably, we observed no evidence suggesting that reduction in attentional dysregulation serves a key mediator of CBT efficacy. Though our analyses do not allow us to conclude that attention bias is not an important factor in either the maintenance and/or treatment of social anxiety disorder, our null findings leave open this possibility. The question remains whether, if specifically targeted/manipulated during CBT (e.g., via modification methods targeting attentional bias), attention bias might then serve as a mediator. Indeed, multiple candidate mediating processes may drive social anxiety, and change in some but not necessarily all such mediating processes may equifinally lead to reduced social anxiety symptoms.

Future work may also examine whether attentional dysregulation may mediate CBT outcomes in other types of anxiety disorders. Perhaps most importantly, our study adds to the growing body of evidence suggesting a dynamic process perspective, and quantification of key features of attention bias temporal dynamics via the TLBS approach may improve measurement of attention bias broadly, the capacity to model inter-relations of bias with respect to psychopathology, and to study (therapeutic) change in attention bias over repeated measurements in a more psychometrically sound manner. This approach, especially when complemented with research aiming to shed light on the mechanisms underlying temporal dynamics of attention bias, may be relevant in efforts to disambiguate the role of attention bias in various forms of psychopathology, such as social anxiety, as well as efforts to therapeutically target attention bias and putatively related psychopathology vulnerability.

References

- Amir, N., Elias, J., Klumpp, H., & Przeworski, A. (2003). Attentional bias to threat in social phobia: facilitated processing of threat or difficulty disengaging attention from threat? *Behaviour Research and Therapy*, *41*(11), 1325–1335. [http://doi.org/10.1016/S0005-7967\(03\)00039-1](http://doi.org/10.1016/S0005-7967(03)00039-1)
- Amir, N., Weber, G., Beard, C., Bomyea, J., & Taylor, C. T. (2008). The effect of a single-session attention modification program on response to a public-speaking challenge in socially anxious individuals. *Journal of Abnormal Psychology*, *117*(4), 860–868. <http://doi.org/10.1037/a0013445>
- Amir, I., Zvielli, A., & Bernstein, A. (in press). (De)coupling of overt and covert attentional bias to threat: Dynamic process perspective. *Emotion*.
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*(1), 1-24.
- Barry, T. J., Sewart, A. R., Arch, J. J., & Craske, M. G. (2015). Deficits in disengaging attention from threat predict improved response to cognitive behavioral therapy for anxiety. *Depression and Anxiety*, *32*(12), 892-899.
- Cisler, J. M., Bacon, A. K., & Williams, N. L. (2009). Phenomenological characteristics of attentional biases towards threat: A critical review. *Cognitive Therapy and Research*, *33*(2), 221–234.
- Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In *Social Phobia: Diagnosis, Assessment, and Treatment* (pp. 69–93). Guilford Press.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. (1998). *Structured Clinical Interview for DSM-IV Axis I Disorders: Patient Edition (February 1996 Final), SCID-I/P.*

Biometrics Research Department, New York State Psychiatric Institute.

Fresco, D. M., Coles, M. E., Heimberg, R. G., Liebowitz, M. R., Hami, S., Stein, M. B., & Goetz, D. (2001). The Liebowitz Social Anxiety Scale: A comparison of the psychometric properties of self-report and clinician-administered formats. *Psychological Medicine, 31*(6), 1025–1035. <http://doi.org/10.1017/S0033291701004056>

Guastella, A. J., Richardson, R., Lovibond, P. F., Rapee, R. M., Gaston, J. E., Mitchell, P., & Dadds, M. R. (2008). A randomized controlled trial of d-cycloserine enhancement of exposure therapy for social anxiety Disorder. *Biological Psychiatry, 63*(6), 544–549. <http://doi.org/10.1016/j.biopsych.2007.11.011>

Hamaker, E. L., Kuiper, R. M., & Grasman, R. P. (2015). A critique of the cross-lagged panel model. *Psychological Methods, 20*(1), 102–116. <http://doi.org/10.1037/a0038889>

Heeren, A., Reese, H. E., McNally, R. J., & Philippot, P. (2012). Attention training toward and away from threat in social phobia: Effects on subjective, behavioral, and physiological measures of anxiety. *Behaviour Research and Therapy, 50*(1), 30-39. <http://doi.org/10.1016/j.brat.2011.10.005>

Heinrichs, N., & Hofmann, S. G. (2001). Information processing in social phobia: A critical review. *Clinical Psychology Review, 21*(5), 751-770. [http://doi.org/10.1016/S0272-7358\(00\)00067-2](http://doi.org/10.1016/S0272-7358(00)00067-2)

Hirsch, C. R., & Clark, D. M. (2004). Information-processing bias in social phobia. *Clinical Psychology Review, 24*(7), 799–825. <http://doi.org/10.1016/j.cpr.2004.07.005>

- Hofmann, S. G. (2007). Enhancing exposure-based therapy from a translational research perspective. *Behaviour Research and Therapy*, *45*(9), 1987–2001.
<http://doi.org/10.1016/j.brat.2007.06.006>
- Hofmann, S. G., Meuret, A. E., Smits, J. A. J., Simon, N. M., Pollack, M. H., Eisenmenger, K., ... Otto, M. W. (2006). Augmentation of exposure therapy with d-cycloserine for social anxiety disorder. *Archives of General Psychiatry*, *63*(3), 298–304.
<http://doi.org/10.1001/archpsyc.63.3.298>
- Hofmann, S. G., Otto, M. W., Pollack, M. H., & Smits, J. A. J. (2015). D-cycloserine augmentation of cognitive behavioral therapy for anxiety disorders: An update. *Current Psychiatry Reports*, *17*(1), 532. <http://doi.org/10.1007/s11920-014-0532-2>
- Iacoviello, B. M., Wu, G., Alvarez, E., Huryk, K., Collins, K. A., Murrough, J. W., ... Charney, D. S. (2014). Cognitive-emotional training as an intervention for major depressive disorder. *Depression and Anxiety*, *31*(8), 699–706. <http://doi.org/10.1002/da.22266>
- Julian, K., Beard, C., Schmidt, N. B., Powers, M. B., & Smits, J. A. J. (2012). Attention training to reduce attention bias and social stressor reactivity: An attempt to replicate and extend previous findings. *Behaviour Research and Therapy*, *50*(5), 350–358.
<http://doi.org/10.1016/j.brat.2012.02.015>
- Koster, E. H. W., Crombez, G., Verschuere, B., & Houwer, J. D. (2006). Attention to threat in anxiety-prone individuals: Mechanisms underlying attentional bias. *Cognitive Therapy and Research*, *30*(5), 635–643. <http://doi.org/10.1007/s10608-006-9042-9>
- Koster, E. H. W., De Raedt, R., Goeleven, E., Franck, E., & Crombez, G. (2005). Mood-congruent attentional bias in dysphoria: Maintained attention to and impaired

disengagement from negative information. *Emotion*, 5(4), 446–455.

<http://doi.org/10.1037/1528-3542.5.4.446>

Kraemer, H. C., & Kupfer, D. J. (2006). Size of treatment effects and their importance to clinical research and practice. *Biological Psychiatry*, 59(11), 990-996.

Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*, 12(1), 23–44. <http://doi.org/10.1037/1082-989X.12.1.23>

Meuret, A. E., Rosenfield, D., Seidel, A., Bhaskara, L., & Hofmann, S. G. (2010). Respiratory and cognitive mediators of treatment change in panic disorder: Evidence for intervention specificity. *Journal of Consulting and Clinical Psychology*, 78(5), 691–704.

<http://doi.org/10.1037/a0019552>

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, 36(9), 809–848. [http://doi.org/10.1016/S0005-7967\(98\)00063-1](http://doi.org/10.1016/S0005-7967(98)00063-1)

Mogg, K., Bradley, B. P., Williams, R., & Mathews, A. (1993). Subliminal processing of emotional information in anxiety and depression. *Journal of Abnormal Psychology*, 102(2), 304–311. <http://doi.org/10.1037/0021-843X.102.2.304>

Morrison, A. S., & Heimberg, R. G. (2013). Social anxiety and social anxiety disorder. *Annual Review of Clinical Psychology*, 9(1), 249–274. <http://doi.org/10.1146/annurev-clinpsy-050212-185631>

Naim, R., Abend, R., Wald, I., Eldar, S., Levi, O., Fruchter, E., ... Bar-Haim, Y. (2015). Threat-related attention bias variability and posttraumatic stress. *American Journal of Psychiatry*, 172(12), 1242–1250. <http://doi.org/10.1176/appi.ajp.2015.14121579>

- National Institute for Clinical Excellence (2004). Clinical practice guideline no. 23. In *Depression: Management of Depression in Primary and Secondary Care*. London: National Institute for Clinical Excellence.
- Pishyar, R., Harris, L. M., & Menzies, R. G. (2008). Responsiveness of measures of attentional bias to clinical change in social phobia. *Cognition and Emotion*, 22(7), 1209–1227.
<http://doi.org/10.1080/02699930701686008>
- Posner, M. I., Snyder, C. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General*, 109(2), 160–174.
<http://doi.org/10.1037/0096-3445.109.2.160>
- Price, R. B., Kuckertz, J. M., Siegle, G. J., Ladouceur, C. D., Silk, J. S., Ryan, N. D., ... Amir, N. (2015). Empirical recommendations for improving the stability of the dot-probe task in clinical research. *Psychological Assessment*, 27(2), 365–376.
<http://doi.org/10.1037/pas0000036>
- Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, 35(8), 741–756. [http://doi.org/10.1016/S0005-7967\(97\)00022-3](http://doi.org/10.1016/S0005-7967(97)00022-3)
- Schäfer, J., Bernstein, A., Zvielli A., Höfler, M., Wittchen, H. U., & Schönfeld, S. (in press). Attentional bias dynamics predict posttraumatic stress symptoms: A prospective longitudinal study among soldiers. *Depression and Anxiety*.
- Smits, J. A. J., Julian, K., Rosenfield, D., & Powers, M. B. (2012). Threat reappraisal as a mediator of symptom change in cognitive-behavioral treatment of anxiety disorders: A systematic review. *Journal of Consulting and Clinical Psychology*, 80(4), 624.
<http://dx.doi.org/10.1037/a0028957>

- Smits, J. A. J., Rosenfield, D., Davis, M. L., Julian, K., Handelsman, P. R., Otto, M. W., ... Powers, M. B. (2014). Yohimbine enhancement of exposure therapy for social anxiety disorder: A randomized controlled trial. *Biological Psychiatry*, *75*(11), 840–846. <http://doi.org/10.1016/j.biopsych.2013.10.008>
- Smits, J. A. J., Rosenfield, D., McDonald, R., & Telch, M. J. (2006). Cognitive mechanisms of social anxiety reduction: An examination of specificity and temporality. *Journal of Consulting and Clinical Psychology*, *74*, 1203–1212. <http://doi.org/10.1037/0022-006X.74.6.1203>
- Snijders, T. A. B., & Bosker, R. J. (1993). Standard errors and sample sizes for two-level research. *Journal of Educational and Behavioral Statistics*, *237–259*.
- Tschacher, W., & Ramseyer, F. (2009). Modeling psychotherapy process by time-series panel analysis (TSPA). *Psychotherapy Research*, *19*(4-5), 469–481. <http://doi.org/10.1080/10503300802654496>
- Van Bockstaele, B., Verschuere, B., Tibboel, H., De Houwer, J., Crombez, G., & W, H. (2014). A review of current evidence for the causal impact of attentional bias on fear and anxiety. *Psychological Bulletin*, *140*(3), 682–721. <http://doi.org/10.1037/a0034834>
- Vogt, J., Lozo, L., Koster, E. H. W., & De Houwer, J. (2011). On the role of goal relevance in emotional attention: Disgust evokes early attention to cleanliness. *Cognition and Emotion*, *25*(3), 466–477. <http://doi.org/10.1080/02699931.2010.532613>
- Wang, L., & Maxwell, S. E. (2015). On disaggregating between-person and within-person effects with longitudinal data using multilevel models. *Psychological Methods*, *20*(1), 63–83. <http://doi.org/10.1037/met0000030>

Yuval, K., Zvielli, A., & Bernstein, A. (in press). Attentional bias dynamics and posttraumatic stress in survivors of violent conflict and atrocities: New directions in clinical psychological science of refugee mental health. *Clinical Psychological Science*.

Zvielli, A., Amir, I., Goldstein, P., & Bernstein, A. (2015). Targeting biased emotional attention to threat as a dynamic process in time attention feedback awareness and control training (A-FACT). *Clinical Psychological Science*. <http://doi.org/10.1177/2167702615588048>

Zvielli, A., Bernstein, A., & Koster, E. H. W. (2015). Temporal dynamics of attentional bias. *Clinical Psychological Science*, 3(5), 772-788. <http://doi.org/10.1177/2167702614551572>