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Attentional Bias Temporal Dynamics in Remitted Depression

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Abstract

Theory implicates attentional bias (AB) or dysregulated attentional processing of emotional information in the recurrence of major depressive episodes. However, empirical study of AB among remitted depressed patients is limited in scope and has yielded mixed findings. Mixed findings may be accounted for by how the field has conceptualized and thereby studied AB. We propose that a novel temporal dynamic process perspective on AB may help disambiguate extant findings and elucidate the nature of AB in remitted depression. We thus re-examined Dot Probe data among remitted depressed patients (RMD; N=328) and non-depressed controls (NDC; N=82) that previously yielded null effects when AB was quantified by means of the traditional aggregated mean bias score (Vrijssen et al., 2014). We re-analyzed data using a novel computational approach that extracts a series of bias estimations from trial-to-trial (Zvielli, Bernstein, & Koster, 2015). Key features of these dynamic process signals revealed moderate to excellent reliability relative to the traditional aggregated mean bias scores. These features of AB dynamics, specifically temporal variability in AB including AB towards and away from emotional stimuli, were significantly elevated among RMDs relative to NDCs. Moreover, among RMDs, a greater number of past depressive episodes were associated with elevation in these features of AB dynamics. Effects were not accounted for by residual depressive symptoms or social anxiety symptoms. Findings indicate that dysregulation in attentional processing of emotional information reflected in AB dynamics may be key to depression vulnerability.

General Scientific Summary

We found that the temporal dynamics of biased attentional processing of emotional information were significantly more elevated among remitted depressed patients than among healthy controls; and that among remitted depressed patients, a greater number of past depressive episodes were associated with elevations in these temporal dynamics. Findings indicate that dysregulation in attentional processing of emotional information reflected in attentional bias dynamics may be related to depression vulnerability.

Key Words: attentional bias; dynamics; depression; major depressive disorder; remitted depression; variability

Attentional Bias Temporal Dynamics in Remitted Depression

Depression is a highly burdensome disorder, associated with tremendous individual suffering. Seminal to the episodic course of this disorder, repeated depressive episodes are associated with elevated risk for future depressive episode onset. Relapse rates are estimated to be between 50-80% (Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2013; Pettit, Lewinsohn, & Joiner Jr., 2006; Ramana et al., 1995), with many patients experiencing more than one episode (Boland, Keller, Gotlib, & Hammen, 2002). Recurrence, which may occur even despite initial treatment responding, has been construed as the key challenge for improving depression treatment efficacy (Richards, 2011; Williams et al., 2014).

A growing body of research is thus focused on identifying malleable causal risk factors for relapse among individuals who have remitted from depression (RMD) and are therefore at elevated risk for developing future episodes (De Raedt & Koster, 2010; Farb, Irving, Anderson, & Segal, 2015; Teasdale, 1988). Major theories of depression have implicated dysfunctional attentional processing of emotional information or *attentional bias* (AB) as a core cognitive risk factor for depression and relapse risk (De Raedt & Koster, 2010; Farb et al., 2015). Depression may be characterized by difficulties to disengage attention from negative information (Bradley, Mogg, & Lee, 1997; Gotlib, Krasnoperova, Yue, & Joormann, 2004; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005). Importantly, in individuals at-risk for depression, AB to negative information is indeed associated with the persistence of sad mood (Clasen, Wells, Ellis, & Beevers, 2013; Sanchez, Vazquez, Marker, LeMoult, & Joormann, 2013). There also is some evidence for prospective effects of AB on risk for developing depressive symptoms (Beevers & Carver, 2003; Woody, Owens, Burkhouse, & Gibb, 2015). Therefore, AB may be a key mechanisms linked to risk for relapse among RMDs.

Yet, empirical evidence of AB among RMDs is limited in several ways. First, few studies have directly tested AB for emotional stimuli among RMDs and initial studies examined small samples. Furthermore, findings so far are mixed. In some of these studies selective covert attention (behavioral reaction time data) to negative information was observed among RMDs, consistent with theory (Joormann & Gotlib, 2007). Partly consistent with theory, Sears and colleagues (2011) found that RMDs (N=15) oriented their overt attention (eye-tracking data) to depression-related stimuli more than NDCs (N=38), although they did not orient their attention differently to positive stimuli; RMDs did however express fewer fixations and shorter overall fixation time on positive stimuli compared to NDCs. Yet, RMDs did not make more fixations or express longer overall fixation time on depression-related stimuli than NDCs (Sears, Newman, Ference, & Thomas, 2011). However, other eye-tracking research reported that current depression (N=21), but not RMD (N=21), was associated with a loss of elaborative overt attentional processing of positive stimuli that characterizes healthy controls (N=21) (Isaac, Vrijzen, Rinck, Speckens, & Becker, 2014). Moreover, Vrijzen and colleagues studied AB in a large RMD sample (N=337) and non-depressed healthy controls (NDC; N=83). To potentiate the capacity to detect associations between AB and depression vulnerability, they measured covert AB to happy and sad faces following a sad mood induction designed to activate depressogenic cognitive processing (Teasdale & Barnard, 1995). Despite a well-powered design, Vrijzen et al found that neither AB to happy nor to sad faces discriminated between RMDs and NDCs. Furthermore, they found no association between AB and number of past depressive episodes among the RMDs.

We propose that mixed findings may be, at least in part, accounted for by how the field has conceptualized and thereby studied AB broadly and in depression specifically. We hypothesize that a novel dynamic process perspective on AB may help disambiguate these extant

findings and help elucidate the nature and role(s) of AB in depression vulnerability (Zvielli et al., 2015). Historically, AB has been quantified by means of aggregated means of response time differences between trial types or conditions (i.e., incongruent - congruent trials). Instead, Zvielli et al. (2015) proposed that AB may be better understood as a dynamic process expressed in fluctuating, phasic bursts, towards and/or away from motivationally-relevant stimuli from moment-to-moment. Accordingly, they introduced a novel computational procedure – Trial Level Bias Scores (TL-BS) – to estimate AB concurrent with its repeated, real-time expression from trial-to-trial in the Dot Probe and related cognitive-experimental task used to measure AB. This yields a series of repeated estimations of AB, towards and/or away from target stimuli, from trial-to-trial over time, per individual – rather than only a single aggregated mean static estimate of AB (Yuval, Zvielli, & Bernstein, in press); and thereby permits computation of indices that reflect key features of observed AB temporal dynamics including within-subject AB towards, away, and temporal variability of attentional allocation. These indices of AB show considerably better reliability than traditional aggregated mean bias scores (Amir, Zvielli, & Bernstein, in press; Davis et al., in press; Rodebaugh et al., in press). Recent studies have demonstrated convergent, incremental, known-group criterion, and predictive validity of the dynamic features of the temporal dynamics of AB, in multiple tasks (e.g., dot probe task, spatial cueing task) for spider phobia, addiction behavior (e.g., smoking rate), social anxiety, PTSD risk (prospective-longitudinal prediction of PTSD symptom development), as well as PTSD symptom severity and trauma-related behavioral avoidance in highly traumatized refugees (e.g., Bardeen, Tull, Daniel, Evenden, & Stevens, in press; Davis et al., in press; Schäfer et al., in press; Yuval et al., in press; Zvielli et al., 2015; see also Iacoviello et al., 2014; Naim et al., 2015 for related work on attention bias variability in PTSD). These findings are furthermore noteworthy in light of recent studies demonstrating that the same conceptual and methodological problems observed for aggregated

mean estimates of covert attentional bias are evident for overt indices of AB (i.e., eye-tracking measurement; Amir et al., in press; Waechter, Nelson, Wright, Hyatt, & Oakman, 2014). Indeed, in anxious adults, Amir et al (in press) found that traditional aggregated mean covert and overt AB scores demonstrated (seemingly) no association and poor psychometrics; whereas the real-time, dynamic expressions of overt and covert attentional processes were significantly coupled from trial-to-trial, and voluntary inhibition of overt attention de-coupled their connection.

Thus, if indeed traditional aggregated mean bias scores collapse across within-subject temporal variability – i.e., across fluctuating AB towards to away from negative/positive emotional stimuli as they unfold from moment-to-moment in time – then it is not surprising that aggregated means will yield mixed results and sometimes null effects in remitted depression. Accordingly, modeling AB as a dynamic process in time may help to disambiguate extant mixed findings regarding AB and depression vulnerability among RMDs. We therefore re-analyzed the Dot Probe task data reported in Vrijnsen et al. (2014). We first tested the reliability of the novel indices of AB dynamics. We next tested whether RMDs would express greater attentional dysregulation – greater attentional fluctuations towards *and* away from emotional stimuli (sad and happy faces) – than NDCs. Moreover, in line with extant AB literature in depression, we expected greater attentional dysregulation with respect to negatively- relative to positively-valenced stimuli; although other work suggests that attentional dysregulation may also be expected with respect to positively-valenced stimuli in depression (e.g Epstein et al., 2006; Heller et al., 2009; Shestiyuk, Deldin, Brand, & Deveney, 2005). Moreover, we tested whether number of past depressive episodes among RMDs was related to greater attentional dysregulation.

Method

Participants

A total of 337 adults who experienced one or more depressive episodes in the past and were in remission at time of testing, as well as 83 never-depressed individuals took part in the study (see Table 1 for descriptive statistics). $N=328$ remitted depressed participants and $N=82$ never-depressed control participants completed the Dot Probe task. RMDs were included if they met the criteria of the DSM-IV (American Psychiatric Association, 1994) for a previous depressive episode that was currently in remission, and were ruled-out if they met diagnostic criteria for a current depressive episode. The NDCs did not have a current or previous diagnosis of depression. Please see online supplement and Vrijzen et al., (2014) for further details regarding the sample.

Procedure

Depression Assessment and Study Eligibility. Trained professionals interviewed eligible participants with the Structured Clinical Interview for the DSM-IV Axis-I disorders (SCID-I; First, 2014) under the supervision of an experienced psychiatrist with specific expertise in depressive disorders. The SCID-I has demonstrated good test-retest reliability (Zanarini et al., 2000) and inter-rater reliability (Lobbestael, Leurgans, & Arntz, 2011; Zanarini et al., 2000). In addition to RMD status, number of past episodes was assessed during the diagnostic interview. Degree of current (residual) depressive symptomatology was measured using the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996), and social anxiety symptomatology using the Liebowitz Social Anxiety Scale (Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992).

Mood Induction. The mood induction entailed a validated, 6-min sad scene from the movie “Sophie’s Choice” (Fitzgerald et al., 2011). Participants were instructed to allow the film to influence their mood as much as possible.

Attentional Bias Measurement. The Dot Probe task was based on previous work on AB in depression (Joormann & Gotlib, 2007). Participants were requested to respond as quickly and

accurately as possible to a probe replacing one of two pictures presented together for 1000ms (one emotional and the other neutral). The task was composed 240 trials in total, split into 4 blocks of 60 trials divided by brief breaks. Please see Vrijssen et al (2014) and online supplement for additional details.

Results

Sample Descriptive Statistics

Sample descriptive data are presented in Table 1. See Vrijssen et al (2014) for additional details.

Attentional Bias Computation

See online supplement for data preparation procedure. First, a traditional aggregated mean bias score was computed, per stimulus type (i.e., sad or happy faces), by subtracting the mean response time of congruent trials (CT) from incongruent trials (IT). A positive score indicates bias towards, and a negative score indicates bias away from the emotional face. Second, computation of AB as a process at the trial-level (TL-BS) was done, per stimulus type (i.e., sad or happy faces), by matching each IT with its most proximate CT (no more than 5 trials away) and vice-versa, and then subtracting the RTs from one another (IT - CT; Zvielli et al., 2015). The derived series of difference scores per person was used to quantify parameters of AB dynamics – each reflecting a key feature of AB dynamics: Mean TL-BS_{TOWARDS}; Mean TL-BS_{AWAY}; Peak TL-BS_{TOWARDS}; Peak TL-BS_{AWAY}; and TL-BS Variability (see online supplement for further details).

Split-Half Reliability of Attentional Bias Indices

See Table 1 in the online supplement for split-half reliability of traditional bias scores and TL-BS parameters. In summary, traditional bias scores showed poor reliability (<.23). In contrast, the TL-BS parameters showed much improved reliability (.58 to .90).

Attentional Bias and Group Status

In order to simplify results, and due to the high correlation between Mean and Peak AB parameters ($r = .83$ to $.87$), in subsequent analyses we report only Mean TL-BS_{TOWARDS}, Mean TL-BS_{AWAY} and TL-BS Variability. Peak TL-BS positive and negative indices demonstrate an identical pattern of results as those reported herein for Mean TL-BS_{TOWARDS} and Mean TL-BS_{AWAY}, respectively.

See Figure 1. First, Table 2 presents the main effects of a series of four ANOVAs with group status (between-subject factor) and stimulus valence (i.e., sad/happy; within-subject factor) for each AB index (dependant variable). As expected, group status was significantly associated with each of the TL-BS parameters, such that RMDs showed significantly higher levels on all features of AB temporal dynamics compared to NDCs. As reported previously (Vrijssen et al., 2014), we did not find a similar between-group effect for traditional aggregated mean bias scores. In addition, none of the group X stimulus valence interactions were significant ($F_{(1,408)} = .14 - .89, n.s$).

Attentional Bias and Number of Past Depressive Episodes

As predicted, a greater number of depressive episodes predicted elevated levels of all TL-BS parameters (see Table 3 and Figure 1). Depressive episode history was not similarly related to traditional bias scores (Table 3; Vrijssen et al., 2014). In addition, number of depressive episodes did not interact with stimulus valence ($F_{(1,326)} = 0.16$ to $3.57, n.s$).

Analyses Ruling Out Alternative Explanations of Findings

Residual Depressive Symptoms and Social Anxiety among RMDs. We next attempted to rule-out that current residual depressive symptoms or social anxiety alternatively explain observed findings. To do so, we excluded all participants with current (residual) depressive symptoms (i.e., excluded if BDI-II total score ≥ 14) as well as current social anxiety symptoms

(i.e., excluded if LSAS total score ≥ 30 ; Mennin et al., 2002) and conducted the same set of analyses reported above among the remaining RMDs ($N = 166$) and NDCs ($N = 75$). We found that TL-BS parameters again discriminated between RMDs and NDCs ($F_{(1,239)} = 9.98 - 11.66, p < .01, \eta_p^2 = .040 - .047$). Moreover, a greater number of depressive episodes was again associated with elevated levels of each TL-BS parameter ($F_{(1,164)} = 12.48 - 16.92, p < .01, \eta_p^2 = .071 - .094$).

Medication Use among RMDs. To rule-out that medication status among RMDs ($n=176$ non-medicated vs. $n=151$ medicated) alternatively explains observed between- and within-group effects, we tested an additional ANOVA, with three levels of the between-subjects factor: (non-medicated) NDCs, non-medicated RMDs, and medicated RMDs. These groups were included as a between-subject variable instead of the earlier group (RMD/NDC) variable in the ANOVA described above. As expected, a main effect for group on each AB parameter ($F_{(2,175)} = 8.79 - 9.91, p < .01, \eta_p^2 = .041 - .047$) was explained by a significant difference between NDCs and non-medicated RMDs ($\text{Mean}_{\text{diff}} = 17.51 - 22.07, p < .01$), as well as by a significant difference between NDCs and medicated RMDs ($\text{Mean}_{\text{diff}} = 21.40 - 25.33, p < .01$); no difference was observed between medicated and non-medicated RMDs ($\text{Mean}_{\text{diff}} = 2.50 - 5.64, p > .49$), as revealed by a Post-Hoc Tukey analysis. Furthermore, among RMDs, medication status did not interact with number of depressive episodes to predict levels of any of the TL-BS parameters ($F_{(1,323)} = 0.73 - 1.16, p > .28$).

Controlling for General Reaction Time Variability. We re-ran ANOVAs described above, while controlling for mean and SD of RT on neutral trials. We used the 12 neutral trials from the practice block – because no neutral trials were included in the experimental blocks (Joormann & Gotlib, 2007). Group status remained significantly associated with parameters of AB temporal dynamics above and beyond mean RT on neutral trials ($F_{(1,407)} = 9.96 - 12.33, p < .01, \eta_p^2 = .024 - .029$) as well as above and beyond SD of RT on neutral trials ($F_{(1,407)} = 15.30 -$

18.04, $p < .01$, $\eta_p^2 = .036 - .040$). A similar incremental association, above and beyond mean RT of neutral trials, was observed between number of depressive episodes and parameters of AB temporal dynamics among RMDs ($F_{(1,326)} = 5.90 - 6.25$, $p < .02$, $\eta_p^2 = .018 - .019$); although the magnitude of the Mean TL-BS_{AWAY} fell slightly ($F_{(1,326)} = 3.02$, $p = .08$, $\eta_p^2 = .009$). All incremental effects remained significant after controlling for SD of neutral trials RT ($F_{(1,326)} = 5.25 - 8.99$, $p < .01$, $\eta_p^2 = .016 - .030$).

Discussion

The present study re-examined Dot Probe data in a large sample of RMDs and NDCs that previously yielded non-significant associations between the traditional aggregated mean index of AB and group status, and between traditional mean AB and number of past depressive episodes (Vrijzen et al., 2014). We re-analyzed these data by means of TL-BS, a computational approach that extracts a signal-like series of bias estimations from trial-to-trial in time (Zvielli et al., 2015). Key features of subject-level dynamic process signals of AB revealed moderate to excellent reliability relative to poor reliability of the traditional aggregated mean bias scores (Rodebaugh et al., in press; Waechter & Stolz, 2015). We found that elevations in key features of the temporal dynamics of AB were significantly elevated among RMDs compared to NDCs; and, among RMDs, related to greater number of past depressive episodes (see Figure 1; Amir et al., in press; Waechter et al., 2014). Thus, paradoxically, the greater the dysregulation in attentional processing of emotion, and thus the greater the temporal dynamics towards *and* away from emotional information within an individual, the more likely that aggregated mean bias scores will obfuscate the nature of AB and its role in depression specifically and perhaps psychopathology vulnerability more broadly (e.g., Zvielli et al., 2015). Accordingly, observed findings may help explain why studies have reported mixed and sometimes null associations between aggregated

mean bias scores and remitted depression (Isaac et al., 2014; Peckham, McHugh, & Otto, 2010; Vrijzen et al., 2014).

Three key alternative accounts of the observed findings and their interpretation were empirically tested and ruled-out. First, effects of AB dynamics were maintained when RMDs with elevated symptoms of depression and social anxiety were omitted from analyses. Second, medication use among RMDs, which could also potentially influence observed effects of AB dynamics, did not do so. Finally, general performance artifacts of slowed RT (Lemelin et al., 1996) and elevated RT variability (Kaiser et al., 2008) – previously observed among depressed individuals compared to non-depressed – did not account for the observed findings.

With regard to the nature of observed attentional dysregulation in remitted depression, the current findings could be due to stronger but less efficient regulatory efforts to control attention for emotional information. Indeed, attentional dyscontrol may potentiate (non)effortful dynamic shifts between hypervigilance, over-engagement, and avoidance in response to the emotionally evocative effects of repeated stimulus exposure (Bishop, 2008; Desimone & Duncan, 1995; Eysenck, Derakshan, Santos, & Calvo, 2007; Gross, 2015; Ochsner & Gross, 2005). Indeed, such cognitive impairments increase with multiple episodes of depression (Vanderhasselt & De Raedt, 2009). Research is needed to elucidate the mechanisms of AB in depression and related conditions.

The present findings may have clinical implications for AB modification and depression relapse risk. Specifically, future work may directly test whether emerging cognitive bias modification methods capable of targeting the real-time, individual expression of AB dynamics from moment-to-moment (Bernstein & Zvielli, 2014; Schnyer et al., 2015; Zvielli, Amir, Goldstein, & Bernstein, 2016) may be used to target attentional dysregulation and thereby improve depression treatment relapse prevention outcomes. Moreover, future efforts to target AB

dynamics may also help to provide further experimental evidence of the causal or etiological role(s) of AB dynamics in depression relapse risk (Koster & Bernstein, 2015; Zvolensky, Schmidt, Bernstein, & Keough, 2006).

The study has a number of limitations. First, trials were intermixed (Happy and Sad faces) with only a short block of neutral trials prior to presentation of emotion trials, and no neutral trials buffering between the emotion trials. Future investigations of AB dynamics may begin to examine these types of methodological issues by assigning emotional valence to separate blocks of trials, including a substantial block of neutral trials to better isolate the emotional effect from an impairment in general executive functions; as well as by testing specific sequences of trials on observed temporal dynamics (Egner, Ely, & Grinband, 2010). Second, it is difficult to rule out that other processes, and not temporal variability in spatial attention, may in part account for temporal variability in RT captured by the TL-BS scores. Indeed, although the TL-BS computation is based on difference scores in time, and thus is one reasonable means to quantify spatial attentional expression at the trial-level, other non-attentional processes may also influence observed temporal variability in RT (e.g., freezing). Accordingly, future research is needed to isolate key *sources of variability* in RT or eye movements in response to emotional stimuli, including spatial attention. Indeed, developing the methodological and computational capacity to *isolate* the temporal dynamics of biased or dysregulated spatial attentional processing of emotional information from measured performance variability in time (e.g., RT, eye movement) is a critical goal of future research. Third, and relatedly, the high inter-correlations between the TLBS parameters in these data demonstrate that the phenomenon of dysregulation in attentional processing of emotional information or “bias” in these data may be best captured by the shared variance between these various components of the TLBS signal. In light of this pattern of within-subject variability observed in these data, meaningfully testing unique incremental effects of each

candidate parameter with respect to depression outcomes was not possible (Miller & Chapman, 2001). Future research may be designed to advance understanding of unique patterns and components of attentional dysregulation linked to depression and relapse risk. Finally, number of past episodes was assessed retrospectively and recall biases could potentially affect participants' report. Moreover, observed effects of AB for remitted depression were small in magnitude. Prospective and experimental studies on depression relapse risk are needed to assess whether AB dynamics have a significant functional role in depression vulnerability.

In summary, the present findings support the idea that dysregulation in attentional processing of emotional information may play a role in remitted depression and risk for relapse. This sets the stage to elucidate the mechanisms (e.g., emotion regulatory processes) linking AB temporal dynamics to depression vulnerability, and to test experimental methods to modify AB dynamics in an effort to promote stable remission.

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Table 1

Sample Descriptive Data

| | Remitted Depressed Patients (RMD) <i>N</i> =328 | | Never-Depressed Controls (NDC) <i>N</i> =82 | |
|-------------------------------|---|---------------|---|---------------|
| | Range | Mean / % (SD) | Range | Mean / % (SD) |
| Age (years) | 19–72 | 47.74 (11.99) | 18–63 | 42.94 (11.10) |
| Sex (% female) | – | 66.5 | – | 67.1 |
| Medication use (% medicated) | – | 46 | – | – |
| Depression symptomatology | 0–46 | 14.36 (9.87) | 0–20 | 3.59 (4.55) |
| Social Anxiety symptomatology | 0–58 | 19.46 (12.82) | 0–32 | 9.68 (7.13) |
| # Depressive Episodes | 1–10 | 3.53 (1.87) | – | – |

Table 2

Split-Half Reliability for Traditional Aggregated Mean Bias Score and TL-BS Parameters

| Stimuli (Faces) | | Traditional Mean BS | Mean TL-BS _{TOWARDS} | Mean TL-BS _{AWAY} | Peak TL-BS _{TOWARDS} | Peak TL-BS _{AWAY} | TL-BS Variability |
|-----------------|-------------|---------------------|-------------------------------|----------------------------|-------------------------------|----------------------------|-------------------|
| | ALL (N=410) | 0.12 | 0.80 | 0.80 | 0.70 | 0.72 | 0.87 |
| Sad | NDC (N=82) | 0.23 | 0.75 | 0.70 | 0.70 | 0.59 | 0.87 |
| | RMD (N=328) | 0.10 | 0.80 | 0.80 | 0.69 | 0.72 | 0.87 |
| | ALL (N=411) | 0.21 | 0.80 | 0.80 | 0.68 | 0.78 | 0.87 |
| Happy | NDC (N=82) | 0.10 | 0.72 | 0.87 | 0.58 | 0.84 | 0.90 |
| | RMD (N=328) | 0.23 | 0.80 | 0.78 | 0.67 | 0.76 | 0.86 |

Note. NDC = non-depressed controls. RMD = remitted depressed patients. All values are Spearman-Brown prophecy corrected.

Table 3

Zero Order Correlations for Traditional Aggregated Mean Bias Score, TL-BS Parameters, Depression and Social Anxiety

| | | NDC (N=82) | | | | | | | | | | |
|----------------|-----------------------------|----------------------------|--------------|-----------|-------------|--------|--------------|-----------|-------------|--------|-------|-------|
| | | Sad | | | | Happy | | | | | | |
| | | TB | Mean Towards | Mean Away | Variability | TB | Mean Towards | Mean Away | Variability | BDI-II | LSAS | |
| RMD (N=328) | Sad | TB | .22 | .23 | .07 | -.21 | .05 | -.14 | .20 | .17 | .07 | |
| | | Mean Towards | .20** | | -.75** | .93** | -.23 | .72** | -.83** | .81** | .13 | -.01 |
| | | Mean Away | .20** | -.82** | | -.89** | .05 | -.77** | .74** | -.77** | -.06 | -.01 |
| | | Variability | -.01 | .92** | -.93** | | -.17 | .78** | -.84** | .87** | .07 | -.04 |
| | Happy | TB | -.21** | -.02 | -.04 | .00 | | .08 | .35** | -.17 | -.03 | .00 |
| | | Mean Towards | -.03 | .81** | -.83** | .85** | .16** | | -.74** | .89** | .16 | -.06 |
| | | Mean Away | -.02 | -.82** | .83** | -.86** | .23** | -.80** | | -.90** | -.23* | -.01 |
| | | Variability | .00 | .87** | -.89** | .92** | -.04 | .91** | -.92** | | .16 | -.08 |
| | | BDI | .04 | .12 | -.07 | .09 | -.06 | .09 | -.13 | .13 | | .33** |
| | | LSAS | .05 | .15** | -.07 | .11 | -.04 | .12 | -.13 | .15** | .53** | |
| | | #Episodes | .07 | .18** | -.13 | .18** | -.01 | .20** | -.20** | .23** | .21** | .16** |
| | RMD [†] (N=166) | BDI-II < 14 & LSAS < 30 | BDI | .16 | -.06 | .11 | -.14 | -.08 | -.08 | .02 | -.09 | |
| LSAS | | | .17 | .06 | .06 | -.01 | -.13 | -.01 | -.03 | .03 | .12 | |
| #Episodes | | | .02 | .28** | -.24** | .26** | .02 | .29** | -.26** | .31** | -.02 | .08 |

Note. TB = Traditional Bias (aggregated mean). Shaded cells reflect zero order correlations for RMDs, non-shaded for NDCs. [†] = A subsample of RMDs was selected excluding participants with residual depressive symptoms and social anxiety symptoms. ** = $p < .01$.

Table 4

Descriptive Statistics by Stimuli Valence and Main Effects for Group on Attentional Bias

| | Stimuli (Faces) | RMD N=328 M(SD) | NDC N=82 M(SD) | $F_{(1,408)}$ | p | η_p^2 | M_{diff} | 95% CI | |
|-----------------------------------|--------------------|-----------------------|----------------------|---------------|-----|------------|------------|--------|--------|
| Traditional Mean BS | Sad | -3.13 (24.62) | 0.84 (19.39) | 2.59 | .11 | .006 | 2.93 | -0.56 | 6.51 |
| | Happy | -2.87 (24.33) | -0.98 (17.52) | | | | | | |
| Mean TL- BS _{TOWARDS} | Sad | 113.04 (51.14) | 91.29 (32.19) | 16.54 | .00 | .039 | 22.51 | 11.63 | 33.39 |
| | Happy | 111.76 (49.49) | 88.48 (31.43) | | | | | | |
| Mean TL- BS _{AWAY} | Sad | -112.90 (48.47) | -88.64 (32.16) | 18.30 | .00 | .043 | -23.41 | -34.18 | -12.65 |
| | Happy | -112.36 (49.64) | -89.79 (36.71) | | | | | | |
| TL-BS Variability | Sad | 95.30 (39.69) | 76.7 (27.64) | 19.17 | .00 | .045 | 19.50 | 10.75 | 28.26 |
| | Happy | 94.67 (38.10) | 74.26 (37.12) | | | | | | |

Note. None of the Group X Stimuli interactions were significant. BS = bias score.

Table 5

Associations Between Number of Depressive Episodes and AB among Remitted Depressed Patients

| | $F_{(1,326)}$ | p | η_p^2 | Stimuli (Faces) | B | p | 95% CI | |
|-----------------------------------|---------------|-----|------------|-----------------|-------|-----|--------|-------|
| Traditional Mean BS | .81 | .37 | .002 | Sad | 0.96 | .19 | -0.48 | 2.39 |
| | | | | Happy | -0.14 | .84 | -1.56 | 1.27 |
| Mean TL- BS _{TOWARDS} | 13.52 | .00 | .040 | Sad | 4.92 | .00 | 2.00 | 7.86 |
| | | | | Happy | 5.29 | .00 | 2.47 | 8.12 |
| Mean TL- BS _{AWAY} | 9.77 | .00 | .029 | Sad | -3.37 | .02 | -6.17 | -0.57 |
| | | | | Happy | -5.18 | .00 | -8.02 | -2.35 |
| TL-BS Variability | 14.30 | .00 | .042 | Sad | 3.72 | .00 | 1.44 | 6.00 |
| | | | | Happy | 4.62 | .00 | 2.46 | 6.78 |

Note. None of the Number of Depressive Episodes X Stimuli interactions were found significant.

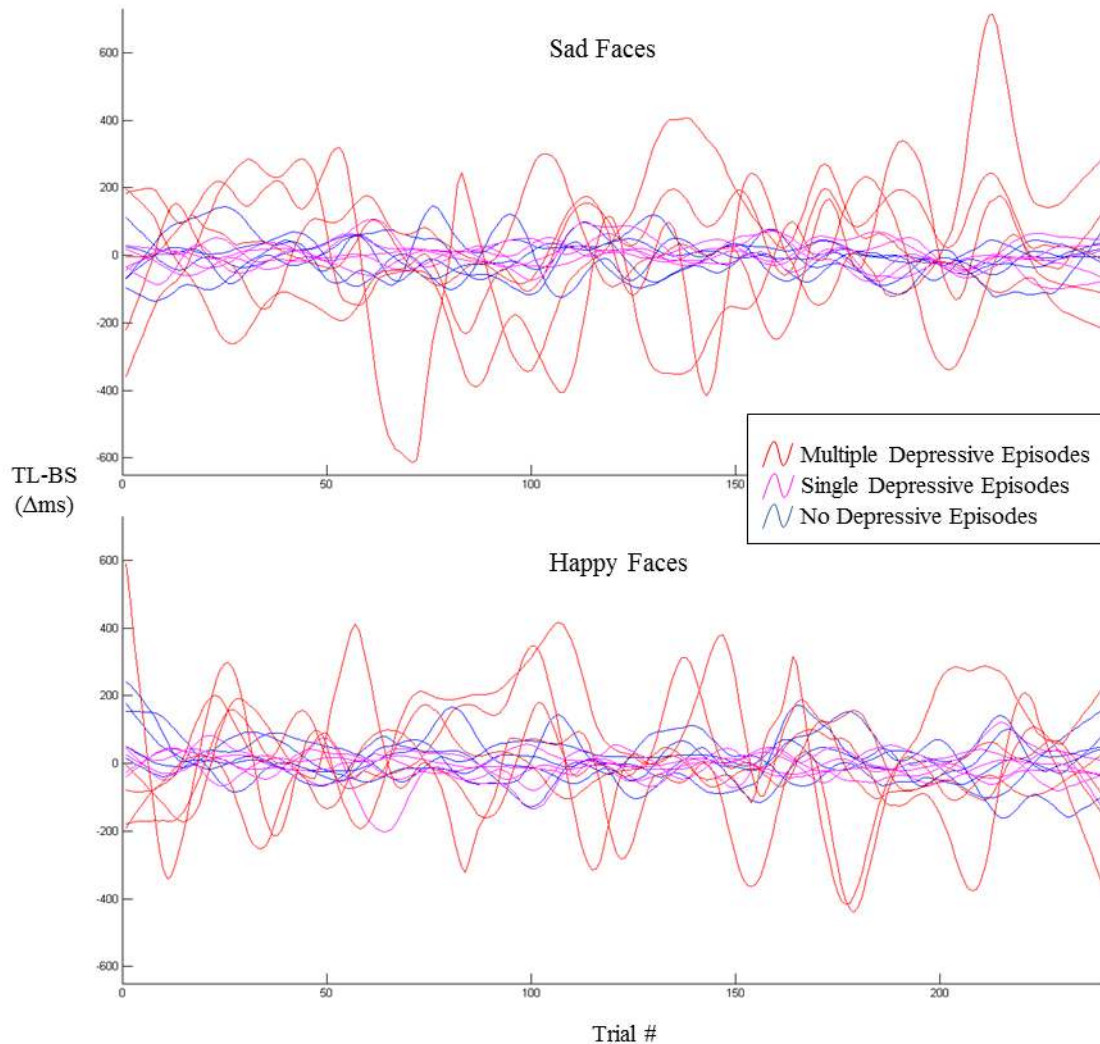


Figure 1. Attentional Bias Temporal Dynamics by Group Status and Number of Depressive Episodes

Note. **Multiple depressive episodes sub-group (RMD):** 5 RMD participants were randomly selected from the $n=83$ who demonstrated 6 or more past depressive episodes. **Single depressive episodes (RMD):** 5 RMD participants were randomly selected from the $n=60$ who demonstrated only 1 past depressive episode. **Non-depressed healthy controls (NDC):** 5 randomly selected NDC participants. **TL-BS:** Trial Level Bias Scores. For the purpose of visualization of the spaghetti plots only, TL-BS scores were interpolated to 240 data points and smoothed by a running mean with a 10-trial window size. All reported analyses in the text were performed on the full sample of RMDs and NDCs.