COGNITION AND EMOTION, 2017
http://dx.doi.org/10.1080/02699931.2017.1307808

BRIEF ARTICLE

Combined behavioural markers of cognitive biases are associated with anhedonia

Taban Salem[a], E. Samuel Winer[a] and Michael R. Nadorff[a,b]

[a]Department of Psychology, Mississippi State University, Mississippi State, MS, USA; [b]Menninger Department of Psychiatry and Behavioral Sciences, Baylor College of Medicine, Houston, TX, USA

ABSTRACT

Biases towards negative information, as well as away from positive information, are associated with psychopathology. Examining biases in multiple processes has been theorised to be more predictive than examining bias in any process alone. Anhedonia is a core symptom of psychopathology and predictive of future psychopathological symptoms. Finding that combined biases are associated with anhedonia would advance knowledge of the nature of emotional processing biases and the value of objective performance-based measures for identifying early risk markers. Participants ($N = 139$) completed tasks that assess latency bias (dot probe) and biased recognition (two-alternative forced-choice) of emotional information, as well as an anhedonia measure. An index was computed for each task's performance reflecting biased processing of positive and negative words. Only combined biases on both tasks were associated with anhedonia. Attentional bias was positively associated with anhedonia, but only when recognition bias for emotional words was high. Thus, assessing biases in multiple domains increased sensitivity to uncover relationships between emotional processing biases and anhedonic symptoms.

ARTICLE HISTORY
Received 4 December 2015
Revised 7 February 2017
Accepted 16 February 2017

KEYWORDS
Dot probe; accuracy; latency; attentional bias; anhedonia

The combined cognitive bias hypothesis (Everaert, Koster, & Derakshan, 2012) argues that emotional information-processing biases in different domains (e.g. attention, memory, and interpretation) interact to magnify emotion dysregulation and psychopathological symptoms. Initial evidence supports this hypothesis (Ellis, Beevers, & Wells, 2011; Everaert, Duyck, & Koster, 2014; Everaert, Tierens, Uzieblo, & Koster, 2013; Koster, De Raedt, Leyman, & De Lissnyder, 2010; Wells, Beevers, Robison, & Ellis, 2010). For example, in a study by Wells et al. (2010) the relationship between depressive symptoms and recognition memory for angry faces was mediated by breadth of attention while viewing the faces; Koster et al. (2010) found that among dysphoric individuals, attentional bias towards negative information might produce increased processing of negative cues at the time of encoding, which in turn could give rise to enhanced memory for negative information; and Everaert et al. (2013) found that a significant indirect effect of attentional bias on memory bias was mediated by interpretation bias.

However, because combined bias research is in its early stages, several empirical issues remain to be addressed. To our knowledge, no studies to date have investigated interactions among biases based on briefly presented stimuli and opposing emotional valences. The latter issue is particularly crucial, given that cognitive biases either enhancing the processing of negative information or limiting the processing of positive information both uniquely contribute to the onset and maintenance of depressive symptoms (Kircanski & Gotlib, 2015; Winer & Salem, 2016). How combined biases relate to specific depressive symptoms is also currently unknown. In previous combined bias studies, depressive symptoms were combined into sum scores (Ellis et al., 2011; Everaert et al., 2014). However, a growing body of evidence suggests that

CONTACT Taban Salem tms469@msstate.edu

depression is not a single syndrome (Fried & Nesse, 2015) but rather a network of distinct but interrelated symptoms (Bringmann, Lemmens, Huibers, Borsboom, & Tuerlinckx, 2015). It is thus possible that specific symptoms are differentially related to biases, and therefore studies exploring various cognitive task and emotional valence combinations in relation to individual depressive symptoms are needed.

The present study

One aim of the present study is to examine combined biases in relation to anhedonia, or the loss of interest in and/or pleasure from previously enjoyable experiences. Increases in anhedonic symptoms present an important target for research, because *loss* of interest and/or pleasure may be specifically associated with depressed states and suicidality in clinical and non-clinical samples (Winer, Drapeau, Veilleux, & Nadorff, 2016; Winer, Nadorff, et al., 2014). Indeed, in a recent network analysis of depressive symptoms over time, loss of pleasure was the strongest predictor of increases in other depressive symptoms over the next week (Bringmann et al., 2015). Disturbances in positive affect also predict an increase in broader depressive symptoms over longer periods of time (Raes, Smets, Nelis, & Schoofs, 2012); thus, anhedonia appears to be a strong candidate variable for research in populations with mild overall symptoms, as biases related to anhedonia may together predict worsening psychopathology.

A second aim of the present study is to examine combined biases via a novel combination of emotional information-processing tasks: the emotional dot-probe (DP; MacLeod, Mathews, & Tata, 1986), which assesses attentional bias, and the two-alternative forced-choice (2AFC; Snodgrass & Shevrin, 2006), which assesses emotional word recognition. The 2AFC and DP tasks likely assess related but distinct cognitive biases associated with emotion dysregulation and psychopathology, and both allow for the assessment of positive and negative emotional biases.

Recent research indicates that attentional biases as measured by the DP task may be inconsistent, occurring in short bursts (Zvielli, Vrijsen, Koster, & Bernstein, 2016) or only for some valenced stimuli. Thus, emotional processing biases on the DP task alone may not be a strong or sensitive predictor of recent anhedonia, especially in a population with low overall symptom severity. Similarly, processing biases for unconsciously presented emotional stimuli have been found to be associated with depressive symptoms in some cases (Bradley, Mogg, & Millar, 1996), but such effects alone are not consistent predictors of depressive symptoms (Teachman, Joormann, Steinman, & Gotlib, 2012). Although biased processing in a single domain (e.g. just in attention, or just in recognition of unconsciously presented stimuli) might be a meaningful indicator of underlying depressive schemas, it is reasonable to ask whether processing biases in the same direction across two domains might be stronger evidence of depressive schemas operating at an automatic level, and thus might be predictive of recent increases in anhedonia. Thus, the present study is aimed at investigating a possible interaction between two methods of assessing biased processing of emotional information – that is, whether or not these two sources of information interact to yield a more sensitive indicator of depressive symptoms than either method alone – and not necessarily an interaction between the biases themselves, although the latter is not precluded by the present study or hypotheses.

In the present study, we expected that integration of DP and 2AFC bias indices would produce the strongest association between task performance and self-reported anhedonic symptoms, such that there would be an increase in the strength of the positive relationship between DP bias and anhedonic symptoms as 2AFC bias increased.

Method

Rationale for examining the DP and 2AFC

The DP task is one of the most widely used paradigms in attentional bias research. Participants respond to an attentional probe that replaces either a neutral or a valenced stimulus by pressing a key to indicate the probe's type or location. Shorter response times (RTs) for probes that replace emotional, compared to neutral, cues indicate that a participant was attending to the location of the emotional cue when the probe appeared, whereas shorter RTs for probes that replace neutral cues indicate a tendency to avoid emotional cues.

A large-scale recent meta-analysis of DP findings and symptoms of psychopathology found evidence of biases towards negative information and away from positive information by depressed participants (Winer & Salem, 2016). While the DP task on average yields small-to-medium effect sizes for emotional attentional biases with depressed individuals, not all DP studies have produced similar findings (Winer & Salem, 2016); however, these limitations are not specific to the DP task. A 2010 meta-analysis on cognitive biases and depressive symptoms evidenced small-to-medium overall effect when collapsing across several attentional bias tasks (Phillips, Hine, & Thorsteinsson, 2010), with effect sizes for the DP task as large as or larger than the overall mean (Phillips et al., 2010). Thus, the DP task appears to be a good representation of attentional bias tasks on the whole.

A possible accompaniment to the DP task is a recognition task based on a two-alternative forced-choice identification paradigm (2AFC; Snodgrass & Shevrin, 2006; Winer, Cervone, Newman, & Snodgrass, 2011). In this task, a single stimulus word (e.g. "hope") is presented briefly (7–8 ms) before being replaced by a mask to limit awareness. Participants are then presented with two word choices – the target word and a distractor – and instructed to select the one that was previously shown. Because the 2AFC's primary dependent variable is accuracy, general interference due to the presence of emotional information can be ruled out. Thus, differential performance for positive and negative words on the 2AFC suggests evidence of inhibition or facilitation more strongly than does performance on the latency-based DP.

Participants

Data from the 2AFC and the DP were collected from 152 undergraduate student volunteers enrolled in psychology courses at a large Southern university. Participants were recruited online and awarded course credit for participation.

The first 142 participants were not preselected. To increase statistical power (McClelland & Judd, 1993), the last 10 participants were recruited from volunteers who had given a response of 2 ("I have lost most of my interest in other people or things") to BDI-II Item 12 (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) on a broader set of online prescreening measures.

Measures

DP task

Latency bias was assessed using the DP. The task was presented on 140-Hz CRT monitors equipped with AMD Radeon HD 7470 or 6450 graphics cards with 4 GB RAM. The stimulus sequence, timing, stimulus randomisation, and data logging was controlled by E-Prime 2.0 software.

Trial sequence. Each trial began with a word pair presented for 500 ms, with one word of neutral valence and one that was either positively or negatively valenced. The word pairs were presented at eye level in 18-point black Courier font against a white background, and each word was offset approximately 3.5 inches left or right from the centre of the screen. Next, both words disappeared and a dot probe appeared in the location previously occupied by one of the words. Participants were instructed to strike either the "s" or "k" keys to indicate the location of the probe as quickly as possible without making mistakes. Participants were given up to 10,000 ms to respond; after a response was given or 10,000 ms had elapsed there was an inter-trial interval of 1000 ms and the next trial began. The 500 ms stimulus duration was selected because it is brief enough to index early information processing, and because the majority of evidence for avoidance of positive information in the DP has been found at durations of 500 ms or longer (Winer & Salem, 2016).

Stimuli. Stimuli included 16 positive, 16 negative, and 16 neutral words, with all positive words rated above 7 and negative words below 3 on a bimodal 9-point valence scale, drawn from the Affective Norms for English Words (ANEW), a database maintained by the NIMH Center for Emotion and Attention (Bradley & Lang, 1999). In the DP, neutral words were presented twice as often as valenced words, because they always accompanied a valenced word. The mean valence was 7.94 for positive words, 5.06 for neutral words, and 2.29 for negative words. Words in each valence group were also matched for arousal (based on ANEW; mean of 5.77 for positive words, 3.64 for neutral words, and 6.16 for negative words) and length (mean of 4.56 characters for positive words, 5.00 for neutral words, and 4.50 for negative words). Word frequency was matched to minimise discrepancies between stimulus pairs. 2AFC: mean difference of 18.13 for negative (16.38 for positive) word pairs; DP: mean difference of 9.00 for negative–neutral pairs (15.88 for positive–neutral; Bradley & Lang, 1999).

Blocks. Participants completed two blocks of trials with 64 trials per block. Combinations of probe location and emotional word location were counterbalanced such that each emotional word appeared on the right and on the left, and the probe followed the emotional word on half of all trials. Trial order was randomised within each block.

Two-alternative forced-choice task

Identification accuracy was assessed using the computerised 2AFC task, which was presented on the same equipment with the same software as the DP.

Trial sequence. Each trial began with a fixation cross appearing in the centre of the computer screen. Participants focused on the fixation cross then pressed the spacebar to activate the trial, which began 136 ms later. A stimulus word (e.g. "hope") then appeared for 7.14 ms,[1] followed by a broken-letter mask (a jumble of letter fragments) presented for 50 ms; a fixation cross presented for 1000 ms; and two answer choices (e.g. "happy" and "hope") that remained onscreen until a response was given, at which point the fixation cross appeared marking the beginning of the next trial. All stimuli were presented in 18-point black Courier font and the masked stimuli were presented against a grey background. The fixation cross, mask, and answer choices were presented against a white background.

Stimuli. The same stimuli were used in the 2AFC task and the DP to allow for parallel examination of the relationship between the two tasks.

Blocks. Participants completed two blocks of trials, each of which consisted of two presentations the 48 stimulus words, presented in randomised order within each block, for a total of 192 trials from which positive and negative words were drawn for combined cognitive bias analyses.

Anhedonia

Recent changes in anhedonia were assessed using the Specific Loss of Interest and Pleasure Scale (SLIPS; for psychometric properties see Winer, Veilleux, & Ginger, 2014), a validated 23-item self-report measure of changes in the amount of pleasure and interest one feels in relation to social experiences. The SLIPS measures changes in anhedonic symptoms occurring within the past two weeks, independent of broader depressive symptoms. For each item, response options range from 0 to 3. The first response option (scored 0) indicates no loss of interest or pleasure (e.g. "I enjoy talking to people no less than before"), the second response option (scored 1) indicates some loss of interest or pleasure (e.g. "I enjoy talking to people less than I used to"), and the third response option (scored 2) indicates dramatic or total loss of interest or pleasure (e.g. "I hardly find enjoyment in talking to people anymore"). The final response option for each item (scored 3) indicates that the activity or situation has never been a source of interest or pleasure (e.g. "I never enjoyed talking to people"). When scoring the SLIPS, any items originally scored 3 are recoded as 0, ensuring that the final sum score for the measure only reflects increases in anhedonic symptoms (Winer, Veilleux, et al., 2014). In the present study, the SLIPS demonstrated adequate internal consistency, $\alpha = .86$.

Procedure

Following an informed consent procedure, seating was adjusted so that 2AFC and DP stimuli were presented at eye level for all participants. Participants were guided through the instructions and practice trials for the 2AFC task. The experimenter then left the room and participants completed two blocks of the 2AFC task, as described in the Measures section above. After the 2AFC task, the experimenter returned and guided participants through the instructions and practice trials for the DP. After the DP, participants completed the SLIPS and other self-report measures to assess other research questions.

Results

Participant characteristics

Of the 152 participants who completed the study, 12 were excluded from analyses for the following reasons: vision problems (1), non-fluency in English (1), use of headphones to listen to music during the 2AFC task (1), failure to follow task instructions (3), noise outside the experimental room (2), computer malfunctions (3), and excessive missing responses on self-report measures (1). Finally, one participant obtained DP bias scores that were extreme outliers (+/− 6 *SD*s) for both positive–neutral and negative–neutral trials, and was therefore excluded from analyses. After these participants were removed, there were no missing values in the data set. A final total of 139 participants (91.4% of the original data) were included in analyses. Demographic characteristics in the final sample were as follows: 59.7% female, 40.3% male; 89.2% aged 18–20, 10.1% aged 21–34 (data on age was missing for one participant); 70.5%

Caucasian, 28.1% African American, 0.7% Asian/Pacific Islander, and 0.7% Multiracial.

Screening individual trial data

In addition to excluding outlying participants, DP data were also screened at the level of individual trials for outlying RTs (Gotlib et al., 2004). The 139 participants included in analyses completed a total of 17,792 DP trials (128 trials per person). Seventeen of these trials (<0.1% of the total 17,792) had RTs <100 ms. These trials were excluded from analyses on the grounds that <100 ms is not enough time for the probe to be detected and a motor response to be carried out, therefore the key-presses on these trials must have been initiated before the probe was detected. Another 18 trials (<0.1% of the total 17,792) had RTs >2000 ms. These trials were retained on the grounds that a delay of >2000 ms could still be related to the emotional content of the stimuli that preceded the probe, but the RTs were recoded as 2000 ms to prevent them from having a disproportionate influence on analyses.

Preliminary analyses

Use of bias differentials

Bias differential scores were computed for each task and served as the independent variables in the present study. A bias differential is a single score that quantifies the relative magnitude of bias for positive and negative information – that is, the relative magnitude of attentional bias in the DP task and the relative magnitude of accuracy bias in the 2AFC task. Bias differentials are computed by subtracting an individual's speed or accuracy at processing positive stimuli from his or her speed or accuracy at processing negative stimuli, and therefore the resulting score for each task is a single number that captures the *comparative* difference in that individual's processing of positive versus negative information.

Both heightened processing of negative stimuli and avoidance/inhibition of positive stimuli have been identified as markers of depressotypic processing (Winer & Salem, 2016), and bias differentials capture both of these effects.

In previous DP research, bias differentials have been found to account for a significant amount of variance in depressive symptomatology above and beyond what is accounted for by absolute bias for positive or negative stimuli alone (Shane & Peterson, 2007). Moreover, previous studies stemming from the combined cognitive bias hypothesis have relied on bias differentials when examining performance on attention, memory, and interpretation tasks (Everaert et al., 2014).

In the current study, we examined bias differentials (as opposed to analysing biases for each valence category in isolation) to increase the sensitivity of our analyses for detecting relationships between cognitive biases and anhedonic symptoms in persons who exhibit both heightened processing of negative information *and* avoidant/inhibitory processing of positive information. In addition, the use of bias differentials allows us to differentiate persons who show valence-sensitive biases from those who show similarly heightened or impaired processing of all emotional information. For example, exhibiting attentional bias towards both positive and negative information in the DP task would result in a small bias differential score for that task, because the difference between the two DP bias scores would be relatively small in magnitude. By contrast, exhibiting attentional bias towards negative information and away from positive information in the DP task would result in a larger bias differential score for that task, because the difference between the two DP bias scores would be relatively large in magnitude.

Combined negative–positive 2AFC accuracy bias index

First, each participant's mean identification accuracy on the 2AFC task was computed for positive and negative valence categories separately. Mean accuracy was expressed as proportion of trials for which participants gave a correct response, such that all scores fell between 0 and 1, with a score of .5 indicating chance accuracy. Next, accuracy for positive words was subtracted from accuracy for negative words to yield a broad index of 2AFC accuracy bias, wherein positive values express a combined pattern of both facilitatory processing of negative information and inhibitory processing of positive information.

Combined negative–positive DP bias index

First, DP bias scores were computed for positive–neutral and negative–neutral trials separately (MacLeod et al., 1986):

$$(EL/PrR - ER/PrR) + (ER/PrL - EL/PrL)/2,$$

where E is the emotional stimulus, Pr the probe, L the

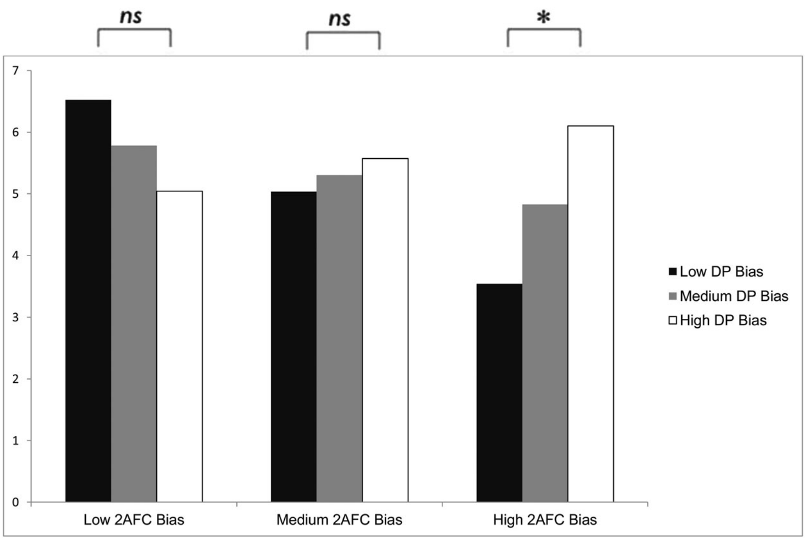

Figure 1. Anhedonia is positively related to DP latency bias when participants have high 2AFC accuracy bias scores. DP: dot-probe; 2AFC: two-alternative forced-choice; low/high: ±1 SD; *$p < .05$.

left, and *R* the right. Bias scores that are positive values indicate attentional bias towards emotional words in comparison to neutral words, whereas bias scores that are negative indicate attentional bias away from emotional words in comparison to neutral words. Next, DP bias for positive words was subtracted from DP bias for negative words to yield a broad index of DP bias, wherein positive values indicate a combined latency bias expressing both negative vigilance and positive avoidance.

Main analyses

To test the hypothesis that the strength of the relationship between 2AFC accuracy bias and recent changes in anhedonia would differ based on the severity of DP latency bias, we used the moderation model (Model 1) of the PROCESS macro for SPSS (Hayes, 2013). The model was specified to include (1) accuracy bias, (2) attentional bias, and (3) their interaction, as independent variables, and recent changes in anhedonia as the outcome variable. Independent variable means were centred before the interaction was computed and probed and the outcome variable was within acceptable limits for normality (skewness = 1.25, kurtosis = .97).

The full model was not significant $F(3, 135) = 1.99$, $p = .12$, $R^2 = .04$. The main effects of 2AFC accuracy bias $t(135) = -1.03$, $p = .30$ and DP attentional bias, $t(135) = .56$, $p = .53$, also were not significant, contrary to our hypotheses. However, consistent with the combined cognitive bias hypothesis, the interaction of accuracy and attentional biases was significant, $F(1, 135) = 4.93$, $p = .03$, $b = .36$ (CI: .04 to .68).[2]

To clarify the nature of the significant interaction, the conditional strength of 2AFC accuracy bias as a predictor of anhedonic symptoms was estimated at one standard deviation above and below the mean of DP attentional bias (Figure 1). Consistent with the hypothesis that biased recognition of emotional words and attentional biases would be most predictive in tandem, follow-up analyses demonstrated that the relationship between attentional biases and anhedonia approached significance when accuracy biases were high ($t = 1.83$, $p = .07$, CI: −.003 to .08), but did not when accuracy biases were low ($t = -1.03$, $p = .30$, CI: −.05 to .01). Thus, the significant interaction effect was in the predicted direction; the relationship between one cognitive bias and anhedonia approached significance, but only when the other cognitive bias was high.

Discussion

We examined relationships between two emotional information-processing biases and anhedonia in a sample with elevated but relatively mild symptom severity. Neither processing bias was predictive of anhedonia on its own, but the interaction of the two was a significant predictor of anhedonia and the effect was in the hypothesised direction. Our findings are consistent with the combined cognitive bias hypothesis (Everaert et al., 2012) and with previous research assessing valence-specific biases across domains in relation to concurrent depressive symptoms.

This study represents the first time, to our knowledge, that the combined cognitive bias hypothesis has been examined with these two tasks and a single core symptom of psychopathology, anhedonia. By examining anhedonia in a sample that included both healthy and anhedonic individuals, the present study advances understanding of the role of combined biases in the early stages of symptom development. Our findings suggest that facilitatory processing of negative information and/or avoidant processing of positive information across multiple domains might be an early indicator of psychopathology. Thus, our findings serve as (a) further evidence that combining cognitive biases can yield more sensitive predictors of psychopathology than single cognitive biases alone and (b) novel evidence that combining cognitive bias indices for sensitivity while focusing on specific symptoms of psychopathology may yield the most translatable predictors of psychological crisis (Fried & Nesse, 2015).

Limitations and future directions

One limitation of this study is the low overall level of anhedonic symptoms in the sample. Despite the preselection of a subset of participants for recent loss of interest, the mean SLIPS score for the current sample was 5.29, $SD = 5.52$. For comparison, a previous mean score from a non-preselected student sample using the SLIPS was 3.23, $SD = 5.27$ (Winer, Veilleux, et al., 2014); thus, this sample had elevated anhedonia in comparison to a student sample, though not analogous to a clinical population. The range of anhedonic symptoms in the present sample still allowed for enough variability to detect the interaction between processing biases, however. Moreover, one aim of this study was to investigate combined biases in persons with mild to moderate anhedonic symptoms that have recently developed or increased, because disturbances in the experience of positive affect and anhedonia have been found to prospectively predict increases in broader depressive symptoms (Raes et al., 2012). Thus, this range of anhedonic symptoms may have been *ideal* for the aims of the present investigation, as it clearly illustrates the benefit combining bias markers may have for predicting psychopathology. Further examination of combined emotional information-processing biases in persons with mild depressive symptoms is critical to advance understanding of what role they play in the emergence of psychopathology (Everaert et al., 2014; Kircanski & Gotlib, 2015).

Another limitation of the current study is that the task order was not counterbalanced. Rather, we opted to administer the 2AFC task first, so as to preserve the fidelity of the 2AFC stimulus presentations. It is therefore possible that performance on the 2AFC might have affected performance on the DP task. However, the lack of significant pairwise relationships (Table 1) between the 2AFC and DP tasks strongly suggests that 2AFC performance did not affect DP performance.

The present study also shares some of the limitations that are common in research using the DP task or other similar behavioural paradigms that assess bias. Namely, studies examining the psychometric properties of the DP task have shown it to possess modest reliability (Price et al., 2015; Schmukle, 2005), and meta-analytic and other findings indicate that the DP task may be especially inconsistent when used to detect biases in non-clinical samples with lower symptom severity (Price et al., 2015; Schmukle, 2005; Winer & Salem, 2016). Consistent with those findings, both the DP and the 2AFC tasks' bias differential scores evidenced low split-half reliability in the current study (DP task

Table 1. Descriptive statistics and zero-order correlations ($N = 139$).

Variable	Mean (*SD*)	1	2	3	4	5	6	7
1. DP Bias for Negative Words	2.25 (27.07)	–	.17*	.63**	−.07	.04	−.07	.10
2. DP Bias for Positive Words	1.65 (28.20)		–	−.66**	−.09	−.01	−.05	.07
3. DP Bias Differential	.60 (35.66)			–	.02	.04	−.02	.02
4. 2AFC Negative Word Accuracy	.51 (.05)				–	−.01	.67**	−.06
5. 2AFC Positive Word Accuracy	.49 (.06)					–	−.74**	.06
6. 2AFC Accuracy Differential	.02 (.08)						–	−.08
7. Recent Changes in Anhedonia	5.29 (5.51)							–

*$p < .05$.
**$p < .01$.
DP: dot probe; 2AFC: two-alternative forced-choice.

$r_s = .16$; 2AFC task $r_s = -.01$). While the present study provides evidence that combining biases may be fruitful for detecting meaningful signals in noisy emotional-processing data, further research is needed to assess the value of this approach with other samples and populations. In addition, future work could examine other more complex approaches to analysing emotional processing bias data from multiple domains, such as the use of network models or indices that capture bias variability rather than mean bias scores (Price et al., 2015).

A final limitation of the current study is its reliance on cross-sectional data, and indeed these findings represent a first step in assessing how and whether these combined cognitive biases predict psychopathology. Future longitudinal research will be able to track the development of cognitive biases in relation to symptom severity and assess whether a combination of cognitive biases and self-reported core symptoms are together predictive of psychiatric crisis over time.

Conclusion

A novel combination of cognitive bias tasks yielded increased sensitivity to uncover relationships between emotional processing biases and symptoms of anhedonia. More sensitive assessments can inform basic science regarding cognitive mechanisms underlying specific depressive symptoms. Moreover, the eventual translation of more sensitive performance-based techniques will provide personalised information about clients' processing of emotional information to identify and address dysfunctional cognitive/affective patterns.

Notes

1. These are iterations of a 140 Hz refresh rate. E-prime logged the following presentation duration ranges: 135–136 ms for the initial fixation cross; 7–8 ms for the target word; 49–51 ms for the mask; and 999–1000 ms for the second fixation cross.
2. *b* represents an unstandardised coefficient. DP trial RTs >2000 ms were recoded as 2000 ms and included in analyses, as delayed responding may be a valid indicator of biased processing of emotional information. The interaction effect is reduced ($p = .07$) if trials with RTs >2000 ms are removed entirely.

Acknowledgements

Portions of the research reported in this article were previously reported as part of the first author's master's thesis. The authors would like to thank Jared Keeley for his helpful comments.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Research reported in this article was supported by the National Institute of Mental Health of the National Institutes of Health under a Loan Repayment Award and grant number [R15MH101573] (PI: E. S. W.). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of Beck Depression inventories-IA and-II in psychiatric outpatients. *Journal of Personality Assessment*, *67*, 588–597. doi:10.1207/s15327752jpa6703_13

Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings* (Vol. Technical Report C-1). The Center for Research in Psychophysiology, University of Florida.

Bradley, B. P., Mogg, K., & Millar, N. (1996). Implicit memory bias in clinical and non-clinical depression. *Behaviour Research and Therapy*, *34*, 865–879.

Bringmann, L. F., Lemmens, L. H. J. M., Huibers, M. J. H., Borsboom, D., & Tuerlinckx, F. (2015). Revealing the dynamic network structure of the Beck Depression Inventory-II. *Psychological Medicine*, *45*, 747–757. doi:10.1017/S0033291714001809

Ellis, A. J., Beevers, C. G., & Wells, T. T. (2011). Attention allocation and incidental recognition of emotional information in dysphoria. *Cognitive Therapy and Research*, *35*, 425–433. doi:10.1007/s10608-010-9305-3

Everaert, J., Duyck, W., & Koster, E. H. W. (2014). Attention, interpretation, and memory biases in subclinical depression: A proof-of-principle test of the combined cognitive biases hypothesis. *Emotion*, *14*, 331–340. doi:10.1037/a0035250

Everaert, J., Koster, E. H. W., & Derakshan, N. (2012). The combined cognitive bias hypothesis in depression. *Clinical Psychology Review*, *32*, 413–424. doi:10.1016/j.cpr.2012.04.003

Everaert, J., Tierens, M., Uzieblo, K., & Koster, E. H. W. (2013). The indirect effect of attention bias on memory via interpretation bias: Evidence for the combined cognitive bias hypothesis in subclinical depression. *Cognition and Emotion*, *27*, 1450–1459. doi:10.1080/02699931.2013.787972

Fried, E. I., & Nesse, R. M. (2015). Depression is not a consistent syndrome: An investigation of unique symptom patterns in the STAR*D study. *Journal of Affective Disorders*, *172*, 96–102. doi:10.1016/j.jad.2014.10.010

Gotlib, I. H., Kasch, K. L., Traill, S., Joormann, J., Arnow, B. A., & Johnson, S. L. (2004). Coherence and specificity of information-processing biases in depression and social phobia. *Journal of Abnormal Psychology*, *113*, 386–398. doi:10.1037/0021-843X.113.3.386

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford.

Kircanski, K., & Gotlib, I. H. (2015). Processing of emotional information in major depressive disorder: Toward a dimensional understanding. *Emotion Review*, *7*, 256–264. doi:10.1177/1754073915575402

Koster, E. H. W., De Raedt, R., Leyman, L., & De Lissnyder, E. (2010). Mood-congruent attention and memory bias in dysphoria: Exploring the coherence among information-processing biases. *Behaviour Research and Therapy*, *48*, 219–225. doi:10.1016/j.brat.2009.11.004

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, *95*, 15–20. doi:10.1037/0021-843X.95.1.15

McClelland, G. H., & Judd, C. M. (1993). Statistical difficulties of detecting interactions and moderator effects. *Psychological Bulletin*, *114*, 376–390. doi:10.1037/0033-2909.114.2.376

Phillips, W. J., Hine, D. W., & Thorsteinsson, E. B. (2010). Implicit cognition and depression: A meta-analysis. *Clinical Psychology Review*, *30*, 691–709. doi:10.1016/j.cpr.2010.05.002

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*, 365–376. doi:10.1037/pas0000036

Raes, F., Smets, J., Nelis, S., & Schoofs, H. (2012). Dampening of positive affect prospectively predicts depressive symptoms in non-clinical samples. *Cognition and Emotion*, *26*, 75–82. doi:10.1080/02699931.2011.555474

Schmukle, S. C. (2005). Unreliability of the dot probe task. *European Journal of Personality*, *19*, 595–605. doi:10.1002/per.554

Shane, M. S., & Peterson, J. B. (2007). An evaluation of early and late stage attentional processing of positive and negative information in dysphoria. *Cognition and Emotion*, *21*, 789–815. doi:10.1080/02699930600843197

Snodgrass, M., & Shevrin, H. (2006). Unconscious inhibition and facilitation at the objective detection threshold: Replicable and qualitatively different unconscious perceptual effects. *Cognition*, *101*, 43–79. doi:10.1016/j.cognition.2005.06.006

Teachman, B. A., Joormann, J., Steinman, S. A., & Gotlib, I. H. (2012). Automaticity in anxiety disorders and major depressive disorder. *Clinical Psychology Review*, *32*, 575–603.

Wells, T. T., Beevers, C. G., Robison, A. E., & Ellis, A. J. (2010). Gaze behavior predicts memory bias for angry facial expressions in stable dysphoria. *Emotion*, *10*, 894–902. doi:10.1037/a0020022

Winer, E. S., Cervone, D., Newman, L. S., & Snodgrass, M. (2011). Subchance perception: Anxious, non-defensive individuals identify subliminally-presented positive words at below-chance levels. *Personality and Individual Differences*, *51*, 996–1001. doi:10.1016/j.paid.2011.08.010

Winer, E. S., Drapeau, C. W., Veilleux, J. C., & Nadorff, M. R. (2016). The association between anhedonia, suicidal ideation, and suicide attempts in a large student sample. *Archives of Suicide Research*, *20*, 265–272. doi:10.1080/13811118.2015.1025119

Winer, E. S., Nadorff, M. R., Ellis, T. E., Allen, J. G., Herrera, S., & Salem, T. (2014). Anhedonia predicts suicidal ideation in a large psychiatric inpatient sample. *Psychiatry Research*, *218*, 124–128. doi:10.1016/j.psychres.2014.04.016

Winer, E. S., & Salem, T. (2016). Reward devaluation: Dot-probe meta-analytic evidence of avoidance of positive information in depressed persons. *Psychological Bulletin*, *142*, 18–78. doi:10.1037/bul0000022

Winer, E. S., Veilleux, J. C., & Ginger, E. J. (2014). Development and validation of the Specific Loss of Interest and Pleasure Scale (SLIPS). *Journal of Affective Disorders*, *152*, 193–201. doi:10.1016/j.jad.2013.09.010

Zvielli, A., Vrijsen, J. N., Koster, E. H., & Bernstein, A. (2016). Attentional bias temporal dynamics in remitted depression. *Journal of Abnormal Psychology*, *125*, 768–776.