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Attentional biases in depression: Relation to disorder severity, rumination, and anhedonia

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ABSTRACT

Introduction: According to cognitive models of depression, selective attentional biases (ABs) for mood-congruent information are core vulnerability factors of depression maintenance. However, findings concerning the presence of these biases in depression are mixed. This study aims to clarify the presence of these ABs among individuals with clinical and subclinical depression.
Method: We compared three groups based on a semi-structured diagnostic interview and a depressive symptoms scale (BDI-II): 34 individuals with major depressive disorder (clinically depressed); 35 with a dysphoric mood but without the criteria of major depressive disorder (i.e., subclinically depressed), and 26 never been depressed individuals. We examined AB for sad and happy materials in three modified versions of the exogenous cueing task using scenes, facial expressions, and words. Brooding, anhedonia, and anxiety were also evaluated.
Results: In contrast to our hypotheses, there were no ABs for negative or positive information, regardless of the task and the groups. Neither the association between AB toward negative information and brooding nor the one between AB away from positive stimuli and anhedonia was significant. Bayes factors analyses revealed that the present pattern of findings does not result from a lack of statistical power.
Discussion: Our results raise questions about how common AB is in depression. From a theoretical point of view, because individuals with depression did not exhibit AB, our results also seemingly challenge the claim that AB figures prominently in the maintenance of depression. We believe the present null results to be particularly useful for future meta-research in the field.

1. Introduction

Major depressive disorder (MDD) is one of the most prevalent mental disorders, as well as one of the leading causes of disability worldwide. It results in substantial social costs (e.g., social withdrawal), personal suffering (e.g., marital issues), and economic costs related to health care or absence from work [1]. Furthermore, the rates of relapse and recurrence of depression remain high [2]. In this way, there is a need to improve our understanding of the processes involved in the emergence, maintenance, and recurrence of depression. Recent advances in clinical psychology have suggested that several dysfunctional psychological processes may be involved in depression [3,4]. These psychological processes may be behavioral, cognitive, metacognitive, emotional/affective, motivational, or interpersonal. The present study aims to clarify the characteristics of attentional biases in depression.

According to prominent cognitive models of depression, selective attentional biases to mood-congruent information are key vulnerability factors that contribute to maintaining the disorder [5,6]. The concept of attentional bias (AB) toward mood-congruent stimuli refers to a differential allocation of attentional resources toward emotional stimuli (e.g., sad faces) compared to neutral stimuli (e.g., neutral faces) [7]. Attentional operations of information treatment have different components [8]. The first is an initial shift of attention toward a stimulus; the second is an attentional engagement with this stimulus; the third is a disengagement of attention from this stimulus. Two distinct ABs have been described in depression. The first one stresses prolonged attention to mood-congruent information found at a later stage of information processing (e.g., 1000 ms) and characterized by a difficulty disengaging attention from this information [9,10]. The second one features reduced attention toward positive information in depressed individuals compared to controls, which is sometimes called an *anhedonic bias*. In fact, it is an absence of the protective bias usually observed in healthy

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Table 1
Details of exogenous cueing task studies with depressed or dysphoric groups.

Reference	ECT	Sample size	Participants	Materials	Significant results and effect sizes
[16]	300 trials (+ 20 catch trials) Non-predictive cues Discrimination task Fixation cues SOA: 1500 ms (+50 ms mask)	94	Undergraduate students (non-patients), mostly women with self-reported depression Mean age: 20 years (1) Moderate to severe symptoms (BDI-II score between 20 and 63) (2) Mild symptoms (BDI-II score between 14 and 19) (3) Healthy control (BDI-II < 14)	Words 50 sad, 50 positive, 50 neutral adjectives	In group (1): $CV_{sad} > CV_{neutral}$ [$t(32) = 3.73$, $p < .001$] For CV_{sad}: Group (1) > Group (3) [$F(1,92) = 6.72$, $p < .05$] Effect sizes and standard deviations of CV scores were not reported in the paper.
[14]	256 trials (+ 20 digit trials) Non-predictive cues Detection task Fixation cues SOA: 500 ms and 1250 ms	883	Adult patients and non-patients with diagnosis based on CIDI Mean age: 43 years (1) MDD (without dysthymia and current or past anxiety disorder) (2) MDD + anxiety disorder (without dysthymia) (3) History of MDD, no current MDD or dysthymia or history of anxiety disorder (4) Comparison (no history of depression or anxiety disorder)	Words 16 threatening words, 16 neutral words, 16 negative adjectives and 16 positive adjectives (from trait self-descriptors of depressive and manic persons)	In 1250 ms condition: AB $score_{negative}$: group (3) > Group (4) [mean difference = 9.07 ms, $p = .04$, 95% CI [0.20, 17.93], $d = 0.20$)]
Reference	ECT	Sample size	Participants	Materials	Significant results and effect sizes
[15]	360 trials (+72 catch trials) Predictive cues Detection task Fixation cues SOA: 17 ms and 750 ms	118	Adult non-patients with diagnosis based on the SCID with mood induction conditions Mean age: 24 years (1) MDD (anxiety not excluded) (2) Anxiety disorder (MDD not excluded) (3) Control: no psychopathology	Scenes 15 threatening, 15 sad, 15 neutral	In 750 ms condition and neutral mood induction condition: Index $score_{sad}$: Group (1) > Group (3)n[$F(1,37) = 5.2$, $p = .025$, $\eta^2_p = 0.12$]
[17] Part I	120 trials (+20 digit trials) Non-predictive cues Detection task Fixation cues SOA: 1500 ms (+50 ms mask)	30	Undergraduate students (non-patients) with self-reported depression Mean age: 19 years (1) Dysphoric (>9 BDI-II) (2) Nondysphoric (<5 BDI-II)	Words 5 sad, 5 positive self-referring adjectives and 5 neutral nouns	In group (1): $CV_{sad} > CV_{neutral}$ [$t(14) = 2.26$, $p < .05$, $\eta^2_p = 0.27$] In group (2): $Cv_{sad} > CV_{neutral}$ [$t(14) = 2.05$, $p < .05$, $\eta^2_p = 0.15$] In group (2): $CV_{positive} > CV_{neutral}$ [$t(14) = 2.21$, $p < .05$, $\eta^2_p = 0.26$]
[17] Part II	190 trials Non-predictive cues Detection task Fixation cues SOA: 250, 500 and 1500 ms	40	Non-patients: women with self-reported depression Mean age: 22 years (1) Dysphoric (>9 BDI-II) (2) Nondysphoric (<5 BDI-II)	Words 15 sad, 15 positive self-referring adjectives and 15 neutral nouns	In 1500 ms condition In group (1): $CV_{sad} > CV_{neutral}$ [$t(18) = 2.38$, $p < .05$, $\eta^2_p = 0.24$] In group (2): $CV_{positive} > CV_{neutral}$ [$t(19) = 1.90$, $p = .07$, $\eta^2_p = 0.15$] For Cv_{sad}: Group (1) > Group (2) [$t(38) = 2.41$, $p < .05$, $\eta^2_p = 0.13$]

Note. Only studies using self-report depression scales or MDD psychiatric interviews were included. All studies reported used peripheral cues. Only significant results based on long presentation times were reported (>750 ms). ECT = Exogenous cueing task. Non-predictive cues = 50% of trials are valid and 50% of trials are invalid. Predictive cues = 75% of trials are valid and 25% of trials are invalid. SOA = Stimulus onset asynchrony. BDI-II = Beck Depression Inventory-II. SCID = Structured Clinical Interview. CIDI = The lifetime Composite International Diagnostic Interview. MDD = Major depressive disorder. AB score = attentional bias score: [$CV_{emotional} - CV_{neutral}$]. Index score = [$TRinvalid_{emotional} - TRinvalid_{neutra}$.

subjects. Although preliminary data suggest a slower engagement with positive stimuli in depressed participants compared to non-depressed participants [11], the very nature of the attentional components involved in anhedonic bias remains poorly understood.

It should be noted that findings concerning the presence of ABs in depression are mixed. Indeed, the two types of AB (i.e., difficulty disengaging attention from mood-congruent information and reduced maintenance of attention to positive information) have been observed in clinically and subclinically depressed individuals but not in non-depressed individuals [11,12]. On the other hand, a few studies failed to report these ABs in people with MDD or dysphoria compared to non-depressed individuals [13,14]. To help us to move forward regarding these different results, we examined previously published studies relying on an exogenous cueing task with long SOA (>750 ms) conducted among individuals with depression (see Table 1).[1] Evidence of AB for sadness was reported in three studies [15–17], whereas evidence for AB toward positive stimuli was described in two studies [17] and not investigated in one [15]. The sample characteristics (e.g., clinical status) or the methodological choices (e.g., stimulus onset asynchrony, material) do not seem to explain these inconsistencies provided that these studies (regardless of their results) were characterized by different

[1] We used the following keywords to identify the studies: attention, bias, attention bias, cognitive bias, depression, dysphoria, negative information, exogenous cueing task, spatial cueing task, and modified Posner. We searched in the following databases: PsycINFO, PubMed, and Scopus.

clinical status, stimulus onset asynchrony, or materials. As such, uncertainty remains regarding the presence of AB in depression. In addition, prior studies often comprised samples of undergraduate students, and only a few studies included adults (e.g. [14]). The main goals were twofold. First, we aimed at testing the replicability of previous studies reporting an AB among adults with depression. Second, we also wanted to further clarify the nature of the attentional components (see below) at play.

In this project, we thus assessed ABs among both currently depressed (clinically diagnosed MDD) and subclinically depressed individuals, as compared to never-depressed individuals. We hypothesized that, at a later stage of information processing, both clinically and subclinically depressed individuals would maintain their attention on sad stimuli with longer times to disengage from these stimuli. They would also avoid positive stimuli. Provided that the attentional component involved in this type of AB is not well understood, we have no specific hypothesis regarding the attentional components involved. Conversely, never-depressed individuals would avoid sad stimuli with shorter times to disengage from sad stimuli and focus their attention on positive stimuli.

Rumination is another vulnerability factor in depression. Brooding rumination, which is "a passive comparison of one's current situation with some unachieved standard" [18], is particularly maladaptive and is strongly linked to depression [19]. According to Koster et al. [20], impaired disengagement from negative information may lead to persistent brooding, which maintains a depressive mood. Prior research has pointed to selective attention to negative stimuli as a potential harbinger of brooding [18,19], and some have distinguished between the engagement versus disengagement components of AB to test the impaired disengagement hypothesis. Those studies reported a significant association between brooding scores and scores for disengagement from sad information but no association with engagement scores [22–24]. Eye-tracking studies also support these findings with similar results in a non-depressed sample, a subclinical sample, and a clinical sample with MDD [25–27]. From these data, we expected to find a significant positive correlation between disengagement scores for sad stimuli and scores for brooding in the overall sample.

Anhedonia, defined as diminished pleasure and/or decreased reactivity to pleasurable stimuli [28,29], is characterized by a hyposensitive response to reward [30] and precedes the onset of depression in non-clinical populations [31]. In their meta-analysis of selective attention in depression, Armstrong and Olatunji [32] assumed that the hypo-sensitive response to reward might influence the stimulus driven-system responsible for selective attention. From their view, positive and rewarding stimuli may fail to capture depressed participants' attention or may reduce their motivation to maintain the attentional focus on positive stimuli. However, uncertainties remain regarding the relations between selective attention to positive stimuli and hyposensitivity to reward or loss of pleasure [5,33]. To our knowledge, only Brailean et al. [30] have explored the relationship between anhedonia and selective attention to positive stimuli. Specifically, they investigated the link between the reduced sensitivity to reward and the development of AB toward conditioned rewarding stimuli in dysphoria. Their results suggest that dysphoric individuals failed to develop a reward-related AB, unlike non-depressed individuals. The authors concluded that the impaired processing of rewarding stimuli might be a vulnerability factor for anhedonia in depression. Accordingly, we hypothesized that anhedonia might affect the attentional processing of positive information. In other words, we expected to find a significant negative correlation between AB for positive stimuli and anhedonia scores in our overall sample without specific hypotheses regarding attentional engagement or disengagement components.

Verbal stimuli (i.e., words) are the most frequently used material in studies exploring the interaction between AB and mental rumination as well as in studies using exogenous cueing tasks. Nonetheless, one might expect that nonverbal stimuli, such as faces or pictures, would attract the attention of depressed individuals more quickly than verbal ones because of their higher interpersonal relevance. These stimuli appear more ecologically valid than words in investigating AB [34]. The meta-analysis by Peckham et al. [35] suggests that AB tasks with verbal and nonverbal stimuli may yield similar effect sizes. However, a more recent meta-analysis recommends using photographs rather than words to study the AB toward positive information [36]. Given the uncertainty concerning the material, we employed both verbal (words) and nonverbal material (scenes and faces) and made no specific predictions regarding the effect of material on AB.

Anxiety might also play a role in the ABs reported in depression. A previous study showed that participants with high anxiety symptoms, in addition to high depressive symptoms, paid more attention to sad stimuli and less attention to positive stimuli, whereas participants with high levels of depression without anxiety did not [37]. Consequently, we measured anxiety to control for its potential impact on AB.

2. Method

2.1. Participants

The participants were French-speaking adults aged between 18 and 55 years. They were recruited from the community and mental health care centers via advertisements, university intranets, and the waiting rooms of health care centers. We recruited participants via a two-step procedure. First, they were all initially screened using the Beck Depression Inventory-IIII (BDI-II) to assess depression symptoms [38]. Then, based on their BDI-II score, they were invited to take part in the experiment, wherein we asked them to complete the BDI-II a second time to control for their mood on the day of the experiment. Participants with no history of psychiatric disorders and with a BDI-II score of <8 at both the first and second sessions were classified as never-depressed. Participants who fulfilled the criteria for MDD based on the DSM-IV criteria and had a minimum score of 12 at both evaluation sessions were regarded as clinically depressed. Participants who had a minimum score of 12 at the first evaluation and 10 at the second but who did not fulfill the MDD criteria were regarded as subclinically depressed. The cut-offs applied were based on those provided by Beck et al. [38] and other studies made in this field.

Data analyses were based on 95 adults (62 females, 33 males) with a mean age of 38.01 years ($SD = 11.12$; range: 18–55). Exclusion criteria were a history of psychotic mental disorders, history of bipolar disorder, history of substance abuse or dependence (less than three years of abstinence – except nicotine or caffeine), a history of any neurological disorder, anxiolytic/drug consumption on the day of the evaluation, recent changes in antidepressant medication (less than four weeks) and vision that was not normal or corrected to normal. Fig. 1 depicts the participants' flow throughout the enrollment.

2.2. A priori power analysis

The required sample size was a priori determined to reach a predicted power of 0.80 (alpha = 0.05, beta = 0.20) for a two-way interaction with a small effect size, $f = 0.15$ [39], with one within-subject factor and one between-subject factor. We anticipated this effect size from a previous meta-analysis [35].

2.3. Materials

Materials consisted of a semi-structural interview, three computerized tasks, and self-report questionnaires.[2]

[2] In addition to the measures reported in this article, the participants completed three self-report scales. Relations between these scales and AB are reported elsewhere.

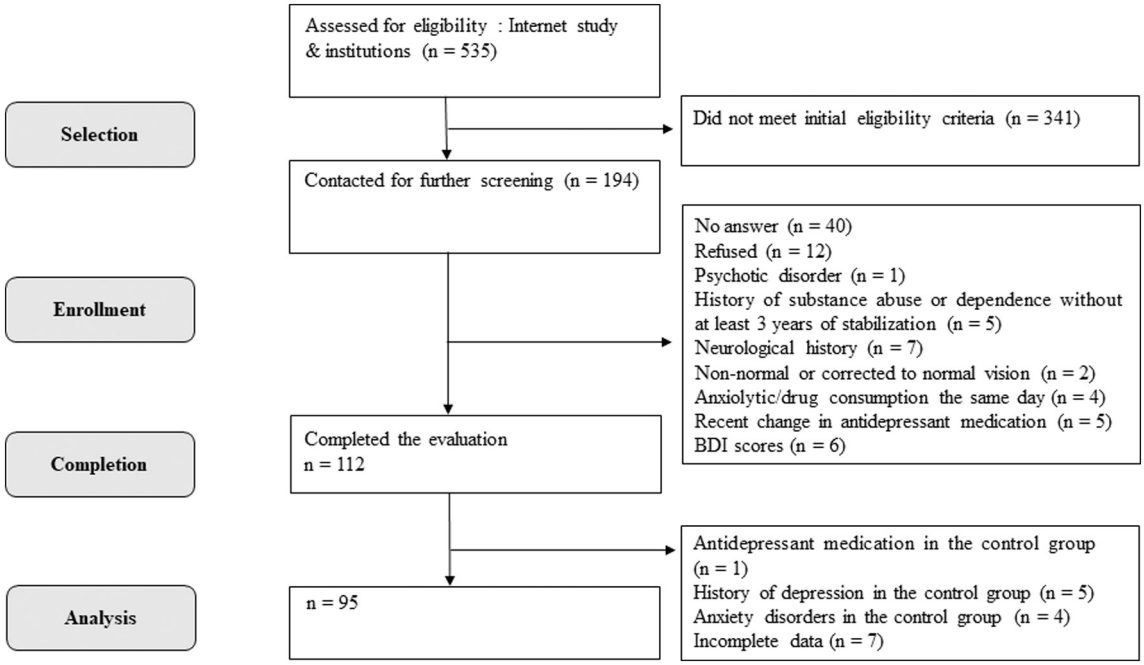

Fig. 1. Enrollment chart.

2.3.1. Current mental disorders

The Mini-International Neuropsychiatric Interview (MINI) is a semi-structured interview focusing on current and lifetime psychiatric disorders based on DSM-IV criteria [40]. The first author, who is a certified clinical psychologist, and two advanced clinical psychology students working under the supervision of the first author[3] conducted the interview.

2.3.2. Depressive symptomatology

The BDI-II is a 21-item scale that assesses the severity of depressive symptoms during the last two weeks [38]. Higher scores indicate higher severity. We used the validated French-speaking version of the scale [41]. In the present sample, the Cronbach's α was 0.93.

2.3.3. Anxiety

Spielberger's State and Trait Anxiety Inventory (STAI Form Y—B) comprises two 20-item scales assessing state and trait anxiety [42]. Higher scores indicate higher anxiety. We used the validated French-speaking version of these scales [43]. In this study, Cronbach's α was 0.95 for the state scale and 0.94 for the trait scale.

2.3.4. Mental rumination

The Ruminative Response Scale (RRS) is a 22-item scale assessing rumination when respondents feel depressed, sad, or discouraged [18]. Higher sum scores indicate greater tendencies to engage in rumination. Two subscales are identified, one related to brooding (5 items) and one related to reflection (5 items). The latter was not reported because this aspect of rumination is more adaptive than brooding and less central in depression. Higher scores on these subscales indicate a higher brooding component and a higher reflective component, respectively. We used the validated French-speaking version of the scale [44]. In this sample, Cronbach's α for the brooding subscale was 0.81.

2.3.5. Anhedonia

The Temporal Experience of Pleasure Scale (TEPS) is an 18-item scale assessing trait dispositions in anticipatory and consummatory experiences of pleasure [45]. Two subscales are identified, one related to anticipatory pleasure (10 items) and one about consummatory pleasure (10 items). Higher scores indicate greater anticipation of pleasure and greater consummatory pleasure, respectively. We used the validated French-speaking version of the scale [46]. In this sample, Cronbach's α was 0.78 for the anticipatory pleasure subscale and 0.71 for the consummatory pleasure subscale.

2.3.6. Demographic questionnaire

A sociodemographic questionnaire addressed questions about age, sex, marital status, employment status, medication, quality of vision, neurological history, and past depressive episodes.

2.3.7. Exogenous cueing task (ECT)

The ECT is a reaction-time-based attention task, which was programmed using *E*-Prime software and run on a computer with a 60 Hz, 15-inch color monitor. The original exogenous cueing task asked participants to detect a visual target presented in the left or right peripheral location of a screen [47]. In emotion research, this paradigm has been modified by using emotional and neutral cues to allow a comparison of their attentional processing. Here, three tasks were created with different materials (15 scenes, 15 faces, and 15 words). Scenes were selected from the International Affective Picture System (IAPS) [48] and faces from the Karolinska Directed Emotional Face database (KDEF) [49,50]; the words were common nouns. Cues were selected based on their emotional content and were matched for valence and arousal for each stimulus of each task. Words were also matched for their length.[4]

Scenes were 133 pixels high X 100 pixels wide and were located on the left and right sides of a fixation cross with visual angles of 2.43° X 0.86°. Faces were 100 pixels high X 136 pixels wide with visual angles

[3] The two students were intensively trained to administer the MINI. Their training included sessions of role-play (at least two 2 h-sessions) and several practices under supervision before the start of the experiment.

[4] One hundred and eighty stimuli were selected by the first author based on validation studies and other studies of AB in depression. Sixty scenes, 60 faces, and 60 words were rated by a population of psychology students for the intensity of valence, arousal, and emotion, as well as familiarity in the case of words.

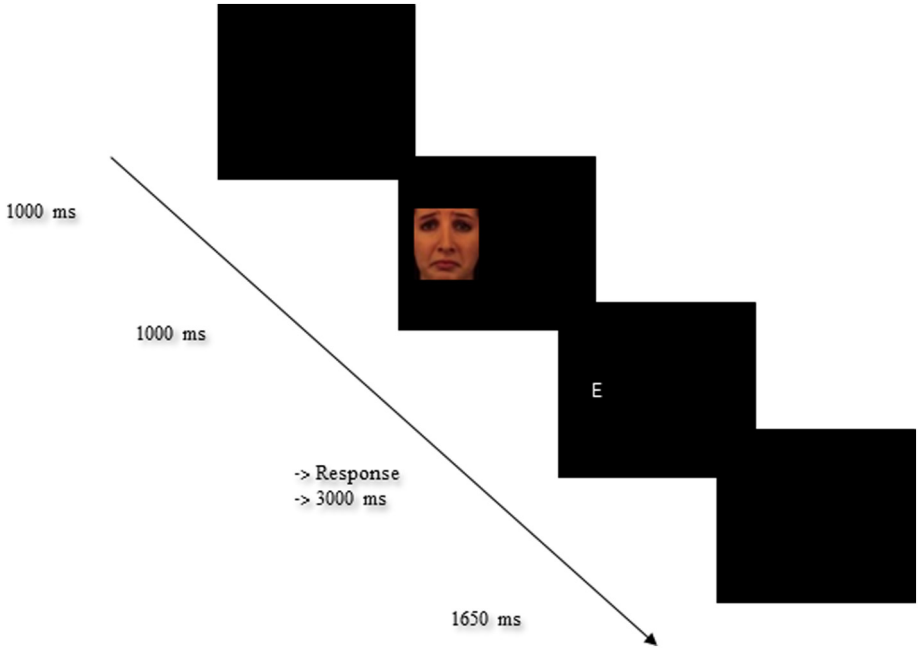

Fig. 2. Stimulus presentation in a valid trial (e.g., faces).

of 2.05° X 1.25°. Words appeared in 10-point Courier New with visual angles of 1.97°. Each trial started with a fixation cross for 1000 ms in the center of the screen. Then, the emotional cue appeared on the left or right side of the screen for 1000 ms (SOA of 1000 ms). Finally, the target ("E" or "F") remained onscreen until a response occurred. If a participant did not respond within 3 s, the next trial started. A black background intertrial was then presented for 1650 ms before the upcoming trial started. Fig. 2 illustrates this sequence. In the test trials, two-thirds of all trials (120 trials) were valid (left cue–left target and right cue–right target), one-sixth (30 trials) were invalid (left cue–right target and right cue–left target), and one-sixth (30 trials) had no cues. Our decision to rely on this trial distribution arises from prior research using a similar task [51,52]. We presented the stimuli in random order in the left or right hemifield with an equal number of presentations for each stimulus (five times) and each emotion category (sad, happy, and neutral) (30 trials each).

The Split-half reliability indices were computed separately for each task via Spearman-Brown correlations with the first and the second half of trials of each experimental condition. Spearman-Brown correlations ranged from 0.77 (Scenes, Happy invalid) to 0.96 (Scenes, Happy valid). We run the same analyses for CV, engagement, and disengagement scores. Spearman-Brown correlations ranged from −0.06 (Scenes, engagement for sad cues) and 0.36 (Faces, CV for happy cues). All these statistical analyses are reported in the supplementary material section (i.e., Tables S1 and S2). Following recommendations in research transparency and replicability, the *E*-Prime versions of the tasks, as well as all the stimuli, can are available via the following link: https://osf.io/k97tf/?view_only=bf803c5e485b4dfc8b4d8a3ca0f79c26.

2.4. Procedure

Each participant was tested alone in a quiet room with dim light. Participants first completed the clinical interview and then the self-report questionnaires and all three spatial cueing tasks. The order of the questionnaires remained fixed, whereas the order of the three spatial cueing tasks was counterbalanced across participants. Participants were seated 60 cm from the computer. They were asked to discriminate, as quickly as possible, the nature of the target, the letter "E" or "F" (target "E": left mouse button with left index finger; target "F": right mouse button with right index finger), without sacrificing accuracy. The instructions were presented onscreen. Participants were instructed that a cue would precede the onset of the target and that the cue predicted the location of the target on some but not all trials. Participants practiced the attentional task for 10 trials. The test phase consisted of one block with 180 trials. Trials were presented in a different order for each participant.

This study was approved by the local Ethical Committee.[5] All participants gave their informed consent. The total time for data acquisition was approximately two hours (i.e., preparation of the subject, familiarization with the tasks, breaks, debriefing).

2.5. Data analysis

First, a cue validity (CV) index was calculated for each emotion (sad, happy, and neutral) by subtracting the mean reaction times (RTs) for valid trials from the mean RTs for invalid trials. With a short stimulus onset asynchrony (SOA), participants typically respond faster to valid than invalid trials. This phenomenon is called the *cue validity effect*. However, at longer SOAs, the cue validity effect often disappears or even reverses. This phenomenon is called the *inhibition of return effect* (IOR) [53]. IOR may suggest that attention to the location of a previously attended stimulus is inhibited in favor of a new spatial location [53,54]. With longer SOAs, as were used in this study, IOR is usually observed. However, when an emotionally charged cue is used, some participants may continue to respond faster to valid trials and present a cue validity effect because the emotional cue captures their attention. At longer SOAs, a cue validity effect suggests that attention is maintained on the cue. The CV index must be calculated for each valence to allow comparisons.

For each task, CV scores were entered in a 3 (Valence: sad, happy, neutral) X 3 (Group: clinically depressed, subclinically depressed, never-depressed) mixed-design analysis of variance (ANOVA). Estimates of effect sizes are also reported (i.e., partial eta-squared; ηp2). To control for the potential impact of anxiety on AB, two additional analyses of covariance (ANCOVA) were conducted with state and trait anxiety scores as covariates.

[5] The central ethical committee of Liège University located in CHU Sart-Tilman, B35, 4000 Liège approved this study in 2018 (Belgium number: B707201734155, reference number: 2017-278).

For each task, an attentional engagement score (i.e., by subtracting the mean RTs of valid emotional trials from the mean RTs of valid neutral trials) and an attentional disengagement score (i.e., by subtracting the mean RTs of invalid neutral trials from the mean RTs of invalid emotional trials) were calculated for positive and sad stimuli to allow group comparisons [17].

3. Results

3.1. Group characteristics

Group characteristics appear in Table 2. Groups did not differ in age, $F(2, 92) = 1.65$, $p = .20$, $\eta p2 = 0.03$, gender, Pearson $\chi^2 = 0.97$; $df = 2$; $p = .62$, and ethnicity (all participants were Caucasian). Depression, brooding, state anxiety, and trait anxiety scores were significantly different in the three groups, with moderate to large effect sizes. Anticipatory and consummatory pleasure scores were significantly different in group comparisons, with moderate to large effect sizes, except for the comparison between the subclinically depressed group and the never-depressed group, whose effect sizes were small. Table 3 reports the means and standard deviations of all scales. *t*-tests are reported in the supplementary material section (i.e., Table S3).

3.2. Data preparation

First, we discarded trials with errors from the analyses (0.58% of all data). To take into account the processing speed of each participant, we followed Radcliff's (1993) guidelines in dealing with outliers [55]. To do so, we relied on an individual approach based on deviations below or above each participant's mean for each experimental condition. Participants' RTs >1.96 standard deviations from their individual mean RT for all indices (Invalid Sad, Valid Sad, Invalid Happy, Valid Happy, Invalid Neutral, and Valid Neutral) were considered as outliers.[6] These outliers were excluded on the basis that they indicate anticipatory responses (0.21% of all data) or delayed responses (3.55% of all data). In the three tasks, the three groups did not differ with regard to the number of erroneous responses ($F(4,184) = 0.40$, $p = .81$, $\eta p2 = 0.00$), anticipatory responses ($F(4,184) = 1.69$, $p = .15$, $\eta p2 = 0.04$) and delayed responses ($F(4,184) = 0.16$, $p = .96$, $\eta p2 = 0.00$). None of the participants exhibited >15% of erroneous responses or outliers. The analyses were conducted on the remaining 95.67% of the data. The de-identified data, as well as the MATLAB script of the cleaning procedure reported above, can be downloaded on the Open Science Framework (https://osf.io/k97tf/?view_only=bf803c5e485b4dfc8b4d8a3ca0f79c26).

3.3. Overall effects

Mean RTs and standard deviations for all tasks are shown in Table 4. The results of the 3 × 3 ANOVA on CV scores were non-significant for all three tasks. No other effects were significant (all *p*s > .05). *F*-tests, *p*-values, and effect sizes (η_p^2) as a function of material and mixed-design ANOVA (η_p^2) are reported in Table 5.

To control for the effect of fatigue, we compared, for each participant and each task the mean RTs of the first 20 trials to the mean RTs of the last 20 trials. via a 3 (Type of stimuli: faces, words) X 2 (Time: first trials, last trials) X 3 (Group: clinically depressed, subclinically depressed, never-depressed) mixed-design ANOVA. No main or interaction effects were significant (all *F*s > 0.25).

[6] All analyses were also conducted with stricter outliers' criteria—i.e., RT below 200 ms and above 1000 ms were considered as outliers as in Koster et al. (2006). Nine participants had >10% of errors or delayed answers and were excluded from the analyses. These different outliers' criteria did not change results and conclusions.

Table 2
Group characteristics.

Measure	Group		
	Clinically depressed	Subclinically depressed	Never-depressed
N	34	35	26
Age	40.74 (10.22)	36.17 (10.65)	36.92 (12.51)
Gender ratio (M/F)	14/20	11/24	8/18
Employment status			
Student	3	1	0
Worker	8	4	3
Employee	13	21	12
Executive	2	1	0
Independent	1	3	8
Homemaker	3	0	0
Unemployed	3	5	3
Retired	1	0	0
Have children	24	18	14
Unable to work	20	6	0
With history of depression	23	14	0
Currently on psychotropic medication (antidepressant)	18	4	0
SSRI	10	2	0
SNRI	2	1	0
NDRI	1	0	0
Tricyclic	2	0	0
Missing	3	1	0
Currently on psychotropic medication (anxiolytic)	5	1	0
Have comorbid anxiety disorders	25	5	0
Have comorbid dysthymia	14	1	0
Have trauma in last six months	8	7	0

Note. Standard deviations are shown in parentheses. SSRI = Selective Serotonin Reuptake Inhibitor. SNRI = Selective Norepinephrine Reuptake Inhibitors. NDRI = Norepinephrine–Dopamine Reuptake Inhibitor.

Three (Valence: sad, happy, and neutral) X 2 (Cue validity: valid, invalid) X 3 (Group: clinically depressed, subclinically depressed, control) ANOVAs were also performed on mean RTs to evaluate the attentional cueing effect. The results revealed a significant main effect of validity in the scene task ($F(1, 92) = 8.33$, $p = .004$, $\eta_p^2 = 0.08$), the face task ($F(1, 92) = 13.35$, $p = .000$, $\eta_p^2 = 0.13$) and the word task ($F(1, 92) = 9.11$, $p = .003$, $\eta_p^2 = 0.09$), with slower RTs for invalid cued locations than for valid ones. These results suggest an attentional cueing effect, as expected.

Table 3
Means and standard deviations for all scales.

Measure	Group					
	Clinically depressed		Subclinically depressed		Never-depressed	
	Mean	SD	Mean	SD	Mean	SD
BDI-II***	28.47	11.06	16.34	5.23	2.85	2.44
STAI-T***	56.35	9.72	47.83	7.45	32.31	8.21
STAI-S***	46.82	11.61	32.63	7.2	26.77	6.00
RRS – Brooding***	13.76	3.04	11.77	3.48	8.77	3.1
TEPS – Anticipatory pleasure**	34.64	9.46	43.77	6.94	44.62	6.77
TEPS – Consummatory pleasure**	29.56	7.85	36.66	5.96	36.65	6.42

Note. BDI-II = Beck Depression Inventory-II. STAI-T = Trait version of the State-Trait Anxiety Inventory. STAI-S = State version of the State-Trait Anxiety Inventory. RRS – Brooding = Ruminative Response Scale, brooding subscale. TEPS – Anticipatory pleasure = Temporal Experience of Pleasure Scale, Anticipatory Pleasure subscale. TEPS – consummatory pleasure = Temporal Experience of Pleasure Scale, Consummatory Pleasure subscale.

*** $p < .05$ Significant differences between all three groups.

** $p < .05$ Significant differences between two groups, but no differences between subclinically depressed and never-depressed groups.

Table 4
Mean reaction times in milliseconds, standard deviations, and mean cue validity (CV) as a function of group, validity, cue valence and materials.

Material	Group										
			Clinically depressed			Subclinically depressed			Never-depressed		
	Cue valence	Validity	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Scenes	Neutral	Invalid	567	144	24	526	176	22	517	116	3
		Valid	543	129		504	151		514	135	
	Happy	Invalid	584	156	41	520	158	16	525	152	14
		Valid	543	134		504	153		511	143	
	Sad	Invalid	573	130	28	518	154	16	520	135	−6
		Valid	545	132		502	145		526	147	
Faces	Neutral	Invalid	568	148	41	542	141	32	497	111	23
		Valid	527	145		510	143		474	96	
	Happy	Invalid	564	154	44	557	159	54	492	98	13
		Valid	520	147		503	144		479	101	
	Sad	Invalid	559	135	34	541	148	34	489	101	10
		Valid	525	147		507	135		479	101	
Words	Neutral	Invalid	555	113	29	525	123	14	525	127	3
		Valid	526	126		511	147		522	123	
	Happy	Invalid	557	126	32	518	126	23	533	134	14
		Valid	525	124		495	132		519	120	
	Sad	Invalid	553	130	25	523	134	9	548	154	35
		Valid	528	124		514	147		513	110	

3.4. Independent sample t-tests

The *t*-tests were first performed on CV scores, even where the results of ANOVAs were not significant to report the effect sizes of the hypothesized differences. The *t*-tests were performed between groups for sad and happy valences (see Table 6) and between valences for each group (see Table 7). Bonferroni adjusted *t*-tests indicated that none of the comparisons were statistically significant.

The *t*-tests were then performed on engagement and disengagement scores to report the effect sizes of the differences. The *t*-tests were performed between groups on engagement and disengagement scores for sad and happy valence and between engagement and disengagement scores for sad and happy valence in each group. Bonferroni adjusted *t*-tests indicated that none of the comparisons were statistically significant (these results are reported in supplementary material Tables S4, S5, and S6). Finally, given the poor split-half reliability of CV scores, engagement, and disengagement scores, *t*-tests were also performed between groups for invalid and valid mean reaction times as well as between valences for each group. Bonferroni adjusted *t*-tests indicated that none of the comparisons were statistically significant (these results are reported in supplementary material Tables S7 and S8).

Table 5
F-tests, p-values and effect sizes as a function of material and mixed-design ANOVA.

Analyses	Material	F	p	η_p^2
ANOVA 3 X 3	Scenes	0.84	.50	0.02
	Faces	1.35	.25	0.03
	Words	2.28	.06	0.05
ANCOVA (STAI-T)	Scenes	1.23	.30	0.03
	Faces	1.68	.50	0.04
	Words	1.27	.15	0.03
ANCOVA (STAI-S)	Scenes	1.06	.38	0.02
	Faces	1.33	.26	0.03
	Words	1.88	.12	0.04

Note. ANOVA 3 X 3 = 3 (Valence: sad, happy and neutral) X 3 (Group: clinically depressed, subclinically depressed, never-depressed) mixed-design analysis of variance on CV scores. ANCOVA (STAI-T) = 3 (Valence: sad, happy and neutral) X 3 (Group: clinically depressed, subclinically depressed, never-depressed) mixed-design analysis of covariance on CV scores with trait anxiety scores as a covariate. ANCOVA (STAI-S) = 3 (Valence: sad, happy and neutral) X 3 (Group: clinically depressed, subclinically depressed, never-depressed) mixed-design analysis of covariance on CV scores with state anxiety scores as a covariate.

Table 6
Independent sample t-tests for each group on CV scores.

Valence	Group contrast	Material	CV Mean difference	p	CI Lower bound	CI Upper bound	d
Sad	Clinically depressed	Scenes	34	.02	−12.42	13.72	0.65
	versus	Faces	24	.19	−16.86	17.57	0.35
	Never-depressed	Words	10	.56	−17.04	16.73	0.15
	Subclinically	Scenes	22	.18	−14.83	15.54	0.36
	depressed versus	Faces	24	.18	−16.02	16.74	0.36
	Never-depressed	Words	26	.13	−16.89	16.58	0.15
Happy	Clinically depressed	Scenes	27	.15	−17.56	18.33	0.38
	versus	Faces	31	.05	−14.37	15.42	0.53
	Never-depressed	Words	18	.26	−14.77	15.37	0.30
	Subclinically	Scenes	2	.94	−16.68	16.72	0.02
	depressed versus	Faces	41	.02	−15.38	16.66	0.64
	Never-depressed	Words	9	.55	−13.76	14.08	0.16

Note. *CI* = 95% confidence interval. *d* = Cohen's *d* score.

3.5. Correlation analyses

Contrary to our hypotheses, correlation analysis revealed no significant correlations between CV scores for sad stimuli and depression severity and between CV scores for happy stimuli and depression severity scores in all three materials (all *rs* < 0.13, with all *ps* > .17). No significant relationship between CV scores for sad stimuli and brooding was reported (all *rs* < 1.00, with all *ps* > .10). In addition, correlation analyses revealed that the correlations between disengagement scores for sad stimuli and brooding were small and not significant (all *rs* < 0.11, with all *ps* > .30). No significant associations between CV scores for happy stimuli and anticipatory and consummatory pleasure

Table 7
Paired sample t-tests for each valence on CV scores.

Group	Valence contrast	Material	CV mean difference	p	CI Lower bound	CI upper bound	d
Clinically	Sad versus	Scenes	4	.37	−10.72	10.57	0.08
depressed	Neutral	Faces	7	.68	−15.20	15.39	0.09
		Words	4	.66	−15.14	15.28	0.07
Subclinically	Sad versus	Scenes	6	.78	−15.10	15.30	0.10
depressed	Neutral	Faces	2	.80	−11.85	11.76	0.04
		Words	5	.65	−13.87	14.00	0.06
Never-depressed	Happy	Scenes	11	.42	−16.54	16.16	0.19
	versus	Faces	10	.32	−15.97	16.31	0.17
	Neutral	Words	11	.25	−18.07	17.75	0.16

Note. *CI* = 95% confidence interval. *d* = Cohen's *d* score.

scores were reported with any of the three materials (all $rs < 0.02$, with all $ps > .15$). Moreover, the correlations between engagement and disengagement scores for happy stimuli and anhedonia were small and not significant (all $rs < 0.19$, with all $ps > .07$). To control for the potential influence of symptom severity, we also computed partial correlations controlling for BDI-II scores. These partial correlations were not significant.

As expected, anxiety and depression scores were significantly correlated ($r = 0.80$, $p < .001$), as were brooding and depression ($r = 0.63$, $p < .001$), anticipation of pleasure and depression ($r = -0.56$, $p < .001$), and consummatory pleasure and depression ($r = -0.49$, $p < .001$).

3.6. Complementary analyses

Although our sample size had enough power to detect medium-to-large effect sizes, one cannot exclude the possibility that some analyses would require a larger sample size. However, neither the *p*-values nor the effect sizes associated with our non-significant effects even approached statistical significance. Moreover, it should be noted that a complementary a priori power analysis for the main ANOVA suggested that a total sample size of at least 357 participants would be required to produce enough power to detect a small-size effect (i.e., $d = 0.15$) in the present study. However, such small effect sizes have no clinical relevance. To further examine this issue, we thus calculated Bayes factors (BF01) using default priors in JASP [56] to express the likelihood of the null (H0) over the alternative hypothesis (H1) given the data for each analysis of our study. A BF under 3 is conventionally considered to indicate 'anecdotal' evidence, while a BF under 10 indicates 'moderate' evidence. Analyses systematically revealed BF01 under 3 (statistical results are reported in supplementary material Tables S9, S10, S11, and S12). Altogether, all these analyses suggest that the pattern of findings cannot be attributed solely to a lack of power.

4. Discussion

In this study, we investigated whether attentional engagement and disengagement toward sad and happy stimuli, as assessed using verbal and nonverbal emotional cues, vary according to depression severity. We also aimed to replicate previous results showing a significant relationship between attentional disengagement from sad information and brooding rumination, and finally, explore the relationship between attentional bias to positive information and anhedonia. In both groups of individuals with depression, we did not observe the maintenance of attention on sad stimuli or withdraw attention from happy stimuli at a later stage of information processing.

Moreover, in both groups of individuals with depression, there was no significant difficulty disengaging attention from sad stimuli. Finally, there were no significant relationships between attentional disengagement from sad stimuli and brooding rumination, or between AB, attentional engagement or disengagement with positive information and anhedonia. Altogether, these results are at odds with the notion that individuals with depression are characterized by AB toward sad or away from happy stimuli, and thus cast some doubts about the robustness of earlier findings [57,58].

To explain the absence of AB, we compared this study to previously published studies relying on an exogenous cueing task with long SOA (>750 ms) that were conducted among individuals with depression. The results, effect sizes, and methodological characteristics of the five studies are reported in Table 1 [14–17].

Some differences in the design are apparent. Contrary to four of the five other studies, our ECT was a discrimination task and a task with predictive cues. Likewise, we did not use fixation cues, as other studies did, before the presentation of the cue. In an ECT, these methodological choices might not potentiate the appearance of an IOR [59]. Thus, these choices might explain why an IOR effect for neutral information does not characterize the never-depressed group in our study, as is usually observed in studies with long SOA. A small IOR in the never-depressed group reduces the likelihood of finding significant differences between groups. On the other hand, these limitations do not explain the lack of an enhanced cue validity effect for emotional valence in our sample. Future studies should further clarify this issue.

SOAs used in ECT studies described in Table 1 vary from 750 ms to 1500 ms. In Ellenbogen et al. (2009), an SOA of 750 ms was associated with difficulty in disengaging from mood-congruent information. Koster et al. (2005) and Baert et al. (2010) used an SOA of 1500 ms and also found maintained attention for negative words in depressed groups. However, in Elgersma et al., (2018), an SOA of 1250 ms was not related to any AB. In the present study, we decided to choose an SOA of 1000 ms, which is a duration located between 750 ms and 1500 ms. One cannot exclude that other results would have emerged with a presentation duration inferior or superior to 1000 ms. As such, although the current presentation duration should not come as a surprise given these previous studies, future studies should further clarify this issue.

The selection criteria employed in this study did not differ from those reported in Table 1: cut-off scores for the BDI-II were used to designate participants as dysphoric or not, and a semi-structured interview served to investigate past or present psychiatric disorders. Moreover, it is worth noting that our clinically depressed groups showed the expected characteristics of depression in terms of severity of depressive symptoms, anxiety, brooding, and anhedonia. Indeed, the individuals of the clinically depressed group were characterized by higher levels of depression, anxiety, and brooding than the subclinically depressed group, which, in turn, exhibited higher levels than the never-depressed group [18]. The clinically depressed group was also characterized by lower levels of anticipatory and consummatory pleasure than the never-depressed group, which dovetails earlier studies [26]. Finally, our results corroborate previous data suggesting a strong relationship between depression and anhedonia [56]. Therefore, the non-significant results cannot be attributed to a lack of differences between groups in terms of symptom severity and disturbed processes, especially since the effect sizes for these differences were moderate-to-large.

Rather than a methodological problem, the absence of evidence for AB in our sample may mirror the heterogeneity of depression. Indeed, depression is characterized by highly heterogeneous depressive symptoms and a wide diversity of profiles [58,59]. In our sample, we compared our participants' expression of symptoms by recoding each symptom from the BDI-II as absent (item = 0) or present (item ≥1). All participants in the subclinically depressed group had a different profile from the other participants, and only two participants in the clinically depressed group had a similar profile when all symptoms were reported, which suggests that symptom profiles in our sample were heterogeneous. ABs might be related to specific depressive symptoms or part of a network of related symptoms [60,61]. Future research may benefit from exploring the interplay between AB with specific depressive symptoms like increased interest and involvement in everyday activities using computational network analysis [60,61].

4.1. Limitations

This study has limitations. First, although we instructed participants to fixate their attention to a predetermined spatial location during the presentation of stimuli, we could not ensure that participants did so. Recently developed experimental eye-tracking paradigms enabling verification of participants' initial attentional allocation and subsequent attentional shift may accomplish this aim (e.g., [62,63]).

Second, even if fatigue did not influence the mean processing speed of the last trials, it might have altered the fluctuation of performance during the tasks due to a decrease of vigilance and impact the present results.

Third, like most extant procedures for assessing AB (e.g., [64–66]), the psychometric properties of the task used in this study were less than ideal. In this way, our results echo recent doubts about the relevance of relying on difference scores in AB research [65,67,68]. When cognitive measures are expected to be strongly correlated between participant's performance for different conditions, a difference score is likely to increase the proportion of measurement error relative to between-participant variance and then reduce the reliability. In the ECT tasks, the cognitive measures (e.g., mean RT for invalid and valid trials) are highly correlated, leading to unreliable resultant CV, engagement, and disengagement scores [64].

Furthermore, the temporal experience of pleasure scale used in the present study only distinguishes between a couple of reward processes found to be relevant to depression (i.e., anticipation and consumption of reward; e.g. [69]). Future studies should thus investigate the relations between reward learning or motivation for reward and selective attention in depression. Finally, the total sample of participants with MDD was too small to reliably examine potential gender differences or test for the influence of antidepressant medication on AB. It is important to note that previous studies have not shown antidepressants to influence later stages of information processing in subclinically and clinically depressed participants [70,71].

5. Conclusion

Results revealed no ABs for negative or positive information, regardless of the material and the symptom severity. In line with some past studies, these findings do not support the view that AB toward sad stimuli or away from happy one is a crucial feature of depression. Our findings cast some doubt on the robustness of earlier findings and contribute to magnifying the gap between research results and cognitive models of depression. In future research, there is a need to critically examine the active mechanisms and the symptoms underlying attentional biases and to propose more relevant cognitive models of depression. Finally, the impact of the emotional contexts (e.g., stressful, sad, anger, or happy situations) on the display of AB could also be further investigated.

Declaration of competing interest

None.

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Appendix A. Supplementary data

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