Attentional capture by emotional scenes across episodes in bipolar disorder: Evidence from a free-viewing task

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ARTICLE INFO

ABSTRACT

We examined whether the initial orienting, subsequent engagement, and overall allocation of attention are determined exogenously (i.e. by the affective valence of the stimulus) or endogenously (i.e. by the participant's mood) in the manic, depressive and euthymic episodes of bipolar disorder (BD). Participants were asked to compare the affective valence of two pictures (happy/threatening/neutral [emotional] vs. neutral [control]) while their eye movements were recorded in a free-viewing task. Results revealed that the initial orienting was exogenously captured by emotional images relative to control images. Importantly, engagement and overall allocation were endogenously captured by threatening images relative to neutral images in BD patients, regardless of their episode—this effect did not occur in a group of healthy controls. The threat-related bias in BD, which occurs even at the early stages of information processing (i.e. attentional engagement), may reflect a vulnerability marker.

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1. Introduction

Bipolar disorder (BD) can be characterised by successive episodes of mania, euthymia (i.e. lack of symptoms) and frequently depression that entail an impaired emotional processing which is persistent even during symptomless states (Leyman, De Raedt, & Koster, 2009). It has been suggested that cognitive biases towards emotionally/socially relevant stimuli in BD patients may affect the onset and maintenance of illness, as well as their psychosocial functioning (Green, Cahill, & Malhi, 2007). Indeed, attentional orienting towards emotional information is one of the main cognitive functions that are biased in individuals with severe mood dysregulation (Rich et al., 2007). Investigations on attention-orienting biases may provide important insights into the psychological vulnerability in BD patients. In the present experiment, BD patients in their different episodes (mania, euthymia, depression) were asked to attend to emotional images (i.e. happy, threatening, neutral) in a free-viewing task while the participants' eye movements were recorded.

To examine the relation between different subprocesses of attentional orienting (engagement, disengagement, and attentional allocation; see Posner & Petersen, 1990) and mood state

in BD patients, most previous research has employed behavioural paradigms. To examine the effect of emotional information on attentional orienting, double- or simple-cueing tasks have frequently been employed. In the double-cueing tasks, BD patients showed an attentional bias away from positive words in their depressive episode relative to healthy controls (Jabben et al., 2012), while the bias towards threatening faces was correlated with manic symptoms in BD children (Brotman et al., 2007). Importantly, the simple-cueing task (Posner, Snyder, & Davidson, 1980) allows disentangling attentional engagement from attentional disengagement. In this task, both depressed and hypomanic BD patients exhibit greater attentional engagement towards threatening faces than healthy individuals (see Leyman et al., 2009; Putman, Saevarsson & Van Honk, 2007). In addition, Leyman et al. (2009) found that depressed BD patients had more difficulties disengaging their attention away from threatening and happy faces relative to healthy individuals. Taken together, these behavioural experiments reveal that biases in attentional orientation are associated with affective symptomatology of manic (Brotman et al., 2007; Putman et al., 2007) and depressed episodes (Jabben et al., 2012; Leyman et al., 2009) in BD patients.

At a theoretical level, Mansell, Morrison, Reid, Lowens, and Tai (2007) suggested that melancholic symptoms such as the lack of motivation towards positive stimuli could explain the 'anhedonic bias' in bipolar depression, while the conflicting positive and negative appraisals in mania could account for the absence of clear trend

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towards sad stimuli. Additionally, the presence of an attentional bias towards threatening stimuli is consistent with recent theoretical proposals that emphasise the distinctive features of BD relative to other affective disorders (Mansell et al., 2007). In particular, Mansell et al. (2007) indicated that (i) BD patients usually manifests more psychotic and paranoid features—therefore, threatening information could be emotionally relevant; and (ii) BD patients are not only characterised by a ruminative cognitive style, but also by impulsivity and vigilance abnormality—therefore, they could show both an increased sustained attention (i.e. overall attentional allocation) and an earlier hypervigilance (i.e. attentional engagement) towards mood-relevant information.

Although behavioural experiments offer useful information on underlying affective/cognitive processes, there is an inherent limitation in the main dependent variable: In each trial, response times provide one data time at the end of processing (i.e. response times do not inform us about the time course of the underlying attentional processes). The recording of the participants' eye movements can be considered a useful tool to assess attentional orienting to simultaneous visual stimuli that compete for the observer's attention (Hermans, Vansteenwegen, & Eelen, 1999). Eye movements are related to attentional processes during visual tasks because shifts in gaze position are guided by shifts in attentional focus (see Rayner, 2009, for review). Particularly, eye-tracking methodology is ideally suited for measuring the following: (i) temporal and spatial parameters of initial orienting by the latency and duration, and the location of an initial fixation, respectively; and (ii) the subsequent orientation processes, which are reflected in the fixation sequences (where one looks) and in the fixation duration (for how long one looks), offering an online measure of emotional processing. To the best of our knowledge, only two published studies have monitored the participants' eye movements to examine the emotional processing in BD patients across their different episodes (García-Blanco, Perea, & Salmerón, 2013; García-Blanco, Salmerón, Perea, & Livianos, 2014).

In the García-Blanco et al. (2013) experiment, participants were presented with prosaccade blocks which required an automatic orientation response (i.e. facilitating the initial orienting toward a peripheral stimulus), and participants were also presented with antisaccade blocks which involved a controlled inhibition of orientation response (i.e. inhibiting the automatic prosaccade toward a target and voluntarily generating an antisaccade to the mirror position; see Mueller et al., 2010, for review). They found that patients in their manic episodes committed more antisaccade errors in response to happy faces, while patients in their depressive episodes tended to have more antisaccade errors with sad faces. Furthermore, prosaccade latency was only affected by the valence of stimulus (i.e. latencies for happy faces were faster than for sad faces). One possible explanation for the absence of mood effect on initial orienting could be that prosaccades reflect an automatic orientation response that is mainly influenced by bottom-up processes (i.e. stimulus-driven attention) rather than top-down processes (i.e. the participant's mood; see Yiend, 2010).

In another recent experiment, García-Blanco et al. (2014) employed a free-viewing task to examine the initial orienting (by the location of the initial fixation), the subsequent engagement (by the mean of first-pass fixations), and the overall allocation of attention (as measured by the total fixations). BD patients were required to scan/re-scan four images (happy, sad, threat and neutral) presented simultaneously for 20 s. The initial orienting and the attentional engagement were not affected by participants' mood but only by the emotional image (participants' initial orienting were directed more toward happy images than toward the other types of images). However, the overall allocation of attention toward mood-relevant images in BD patients was mood-dependent. Particularly, BD patients (regardless of their episode)

showed an increase in attention to threatening images relative to the healthy controls, while BD patients in their depressive episode showed a decrease in attention to happy images compared to healthy individuals.

Thus, the existing eye-tracking literature has reported that: (i) the initial orientation is stimulus-dependent (see García-Blanco et al., 2013, as evidenced by the prosaccade task; and García-Blanco et al., 2014, as evidenced by the location of the initial fixation in a free-viewing task); (ii) the attentional engagement is also stimulus-dependent (see García-Blanco et al., 2014, as evidenced by the mean duration of first-pass fixations); and (ii) the overall attentional allocation is mood-dependent (see García-Blanco et al., 2014, as indicated by the total number of fixations). That is, similar to behavioural paradigms (Jabben et al., 2012; Leyman et al., 2009), there is an attentional bias away from happy stimuli in BD depression (García-Blanco et al., 2014). And last, but not least, an attentional bias towards threatening stimuli has been found in BD even in asymptomatic states (García-Blanco et al., 2014).

In the present experiment, we employed a free-viewing task similar to that of Nummenmaa, Hyönä, and Calvo (2006), in which a target scene (threatening, happy or neutral) was presented simultaneously with a neutral control scene. In this task, participants were instructed to compare the emotional content of the scenes; this guaranteed that each image was inspected at least once. Importantly, the present experiment allowed us to examine in detail the effects of several emotional stimuli (happy or threatening) on the different components of attentional orienting (initial/engagement/overall allocation) in BD patients depending on their different states (i.e. mania, depression and euthymia). What we should note here is that the above-cited eye-tracking experiments suffered from two limitations at assessing the emotional bias in attentional orienting. First, the prosaccade task used by García-Blanco et al. (2013) only offered an indicator (in terms of errors and latency) of initial orienting, but not of other orientation components (i.e. subsequent engagement of attentional focus). Second, in the simultaneous free-viewing task (García-Blanco et al., 2014), the concurrent presentation of multiple emotional stimuli on each trial reduced the independent effects of each type of stimuli, and this could have contributed to the lack of an overall mood effect–in the current experiment there are only two images on each trial, a neutral [control] image and an emotional image (positive, negative, or threatening).

The predictions are as follows. First, according to Yiend (2010), the initial fixation would be influenced by the stimuli's valence but not by the patients' mood. The rationale is that automatic processes (such as initial orienting) seem to be mostly affected by bottom-up processes. Therefore, higher and faster initial fixations on happy images were expected because their content could be more effective in capturing initial attention than other content (see García-Blanco et al., 2013, 2014). Second, according to Mansell et al. (2007), threatening images would be more attended to by BD patients in terms of engagement and attentional allocation. The idea here is that psychotic symptoms and both hypervigilance and rumination are inherent features of BD. Thus, higher and longer fixations were expected on threatening images in BD patients in their depressive, manic and euthymic state (see Leyman et al., 2009, for BD patients in their depressive episode; see Putman et al., 2007, for individuals with hypomanic traits; and see García-Blanco et al., 2014, for BD patients, regardless their episode). Finally, given that anhedonic symptoms and conflicting positive and negative appraisals are characteristic of bipolar depression and mania, respectively (see Mansell et al., 2007), happy images would be less attended to by depressed BD patients and more attended to by manic BD patients. Thus, lower and shorter fixations were expected on happy images in BD patients in their depressive episode (see

García-Blanco et al., 2014; Jabben et al., 2012), and vice versa for manic patients.

2. Method

2.1. Participants

Seventy-six patients with BD Type I who were in one of three mood states – manic ($n=26$), depressed ($n=24$) or euthymic ($n=26$) – at the time of assessment, took part in the experiment. They were recruited from the Psychiatry Department in-patient wards ($n=46$) and in Bipolar Disorders Unit for out-patients ($n=30$) at the "La Fe" University and Polytechnic Hospital (Valencia, Spain). Six patients in a manic episode refused to collaborate. Twenty-three healthy individuals recruited through advertising in the community served as a control group. The ethics committee of the "Health Research Institute La Fe" authorised this study.

No participant reported neurological history, major medical disorders or use of non-psychotropic drugs that could affect cognition (e.g. treatment with corticosteroids), or troubles in carrying out stable eye tracking (e.g. eye diseases, interference from glasses or frequent crying). Extra exclusion criteria for patients were as follows: other psychiatric diagnoses based on DSM-IV-TR criteria (American Psychiatric Association, 2000) or having received electroconvulsive therapy in the previous three months. No healthy control showed any type of psychiatric history. A total of 18 participants from the original sample (89 patients, 28 healthy controls) were excluded on the basis of those criteria, resulting in a final sample of 99 participants.

Every patient had to fulfil the DSM-IV-TR criteria for BD. DSM-IV-TR diagnoses were established by a clinical interview and case note review (every BD patient was reported to have at least one manic episode). The responsible psychiatrist and a postgraduate clinical psychology intern corroborated the diagnosis. In order to ensure the exclusion of mixed states as well as the absence of mood symptoms in euthymic patients and healthy participants, the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) and Young Mania Rating Scale (YMRS; Young, Biggs, Ziegler, & Meyer, 1978) were used (BDI-II scores < 9, except in the depressed group > 18; YMRS scores < 6, except in the manic group > 20). Furthermore, every participant filled out the following: (1) the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988) to measure anxiety; and (2) the Social Adaptation Self-evaluation Scale (SASS; Bosc, Dubini, & Polin, 1997) to measure social functioning. The demographic and clinical data for the final sample are presented in Table 1.

2.2. Apparatus

The participant's eye movements were monitored using a remote eye tracking system (SMI RED250). This system allows the participant free head movements across a wide range. The sampling rate of gaze-point position was 250 Hz. Areas of interest (AOIs) were also identified for each trial and corresponded to the total area for each of the target images.

2.3. Materials

The stimuli were 128 images selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). We used the same stimuli employed by Nummenmaa et al. (2006), which differed only with respect to valence and arousal, but not with respect to visual features (i.e. complexity and luminance). A total of 16 happy, 16 threatening and 16 neutral target images and 80 neutral control images were chosen. The happy target images represented people showing agreeable affect or taking pleasure in something. The threatening target images depicted hostile people or people suffering from a serious threat or harm. Neutral target images represented people in non-emotional activities or aspects of daily life. The control images illustrated various inanimate scenes and non-living objects.

In each trial, two pictures appeared namely a target picture (happy, threatening or neutral) and a control image. The target and control images were randomly paired, resulting in three groups of experimental trials—16 happy-control, 16 threatening-control and 16 neutral-control trials. Additionally, 16 pairs of control images were included as filler trials to obscure the nature of the task. Thus, a total of 64 trials (48 study + 16 filler) were presented. Each trial began with a centrally presented fixation cross, followed by simultaneous presentation of two images for 3000 ms. For each trial, the images were presented in two opposing corners of the computer screen (top left/bottom right or top right/bottom left). The horizontal and vertical locations of the target pictures were balanced across trials, with the constraint that each stimulus category appeared in each of the four positions four times across 16 trials. The presentation order of the images was randomised across participants. The variation in the image locations and the randomisation of trials guaranteed that the participants were not able to use any predetermined scanning strategy.

2.4. Procedure

After signing an informed consent form, all participants filled out a demographic interview and the SSAS, BAI and BDI rating

Table 1
Demographic and clinical data from control group, depressed, euthymic and manic patients. Data shown are averages and standard deviations.

	Control ($n=23$)	Euthymic ($n=26$)	Depressed ($n=24$)	Manic ($n=26$)	p
% Female	47.8	38.5	50.0	38.5	0.77
Age	41.8 (12.7)	41.4 (10.7)	48.5 (10.1)	44.5 (14.0)	0.15
SASS	43.8 (6.0)	40.1 (5.3)	40.8 (6.8)	39.5 (6.2)	0.07
No. of episodes	–	6.3 (5.4)	8.0 (4.6)	7.2 (5.9)	0.55
BAI	12.0 (7.3)	6.1 (5.1)	26.1 (8.7)	11.2 (7.5)	0.00
BDI	6.3 (6.4)	3.6 (4.2)	25.3 (8.0)	5.0 (3.7)	0.00
YMRS	–	1.0 (1.9)	2.0 (2.5)	23.6 (5.5)	0.00
Medication (% of patients)					
Lithium (%)	–	88.5	66.7	73.1	0.17
Antiepileptic (%)	–	50.0	66.7	42.3	0.21
Antipsychotic (%)	–	38.5	54.2	100.0	0.00
Antidepressive (%)	–	7.7	50.0	3.8	0.00
Anxiolytic (%)	–	46.2	79.2	88.5	0.00

Note: The p values correspond to the omnibus test for all groups.

Table 2
Mean (standard deviation) for the latency of fist fixations, the glance duration, and the total time fixation for each stimulus category for control (C), euthymic (E), depressed (D) and manic (M) groups.

Stimulus category	Latency of fist fixation (ms)				Glance duration (ms)				Total time fixation (ms)			
	C	E	D	M	C	E	D	M	C	E	D	M
Happy	724 (185)	686 (112)	765 (146)	737 (143)	423 (108)	503 (155)	635 (157)	544 (194)	722 (239)	827 (228)	835 (164)	767 (226)
Threat	734 (202)	690 (114)	735 (111)	762 (163)	515 (169)	620 (171)	744 (175)	618 (239)	763 (296)	938 (241)	966 (224)	853 (265)
Neutral	795 (258)	744 (127)	829 (127)	816 (173)	478 (144)	521 (146)	606 (158)	523 (213)	775 (289)	843 (183)	822 (231)	719 (233)

scales. Additionally, patients responded to a clinical interview and the YMRS. In the same session, participants carried out the experiment. They were tested individually in a silent room and were seated in a height adjustable chair approximately 60 cm from the monitor. The experimenter was located in the room and monitored the responses of participants to the stimulus presentation and their eye tracking throughout each trial. The experimental session began once the calibration was accepted (i.e. average error was less than 1.5° of visual angle for each calibration point) and six practice trials were completed.

The general procedure was parallel to Experiment 1 of Nummenmaa et al. (2006). Before the experiment, and to illustrate the task, participants were presented with examples of pleasant, unpleasant, neutral and control pictures. Then, participants were instructed to freely look at pairs of images while their eye movements were recorded. The participants' task was to estimate whether the emotional valence of the two images on each trial was similar or dissimilar. Thus, the two images had to be looked at least once. After looking at the pictures for 3000 ms, the following message appeared on the screen: 'Were the images equally pleasant?' After the participant's response, the message was replaced with a fixation cross, and the next trial was initiated. There were 64 experimental trials, which were preceded by six practice trials.

2.5. Data analyses

We computed several eye movement measures, as follows: (a) latency of the initial fixation on the target image (the time taken to fixate a target picture for the first time); (b) probability of initial fixation (i.e. the probability that the initial fixation landed in the target image); (c) first-pass fixation duration on the image (i.e. the sum of fixation duration made on the image when looking at it for the first time, before fixating away from it); (d) number of the first-pass fixations (i.e. the number of fixations on the image when looking at it for the first time, before fixating away from it); (e) the total fixation time (i.e. the amount of gaze duration with possible re-fixations on the picture during the 3 s exposure period); and (f) the total number of fixations (i.e. the number of times that each subject fixated and re-fixated on a particular target image). Initial attentional orienting was assessed through the latency and the probability of initial fixation on the target picture. First-pass fixation duration and the number of first-pass fixations assessed subsequent attentional engagement. Finally, the total fixation time and the total number of fixations assessed allocation of attention.

3. Results

The descriptive statistics on eye movement measures for the different target types (means and standard errors) are displayed in Table 2. Eye movement measures were analysed in a 4 (Group: control, euthymic, depressed, manic) × 3 (Valence of image: happy, threatening, neutral) analysis of variance (ANOVA) in which Group

was a between-subjects factor and Valence was a within-subject factors. When the interaction was significant, Bonferroni tests were used to perform planned comparisons, which consisted in within-group comparisons between emotional images (happy or threatening) versus control images. The number of errors in the valence discrimination task was very small (less than 1% in all groups) and was not further considered.

3.1. Initial orienting

3.1.1. Latency of the initial fixation
The ANOVA of the latency of initial fixation revealed an effect of Valence ($F(2, 190) = 12.56$, $p < 0.001$, $\eta^2 = 0.12$). Neither the effect of Group nor the interaction between the two factors approached significance ($F(3, 95) = 1.48$, $p = 0.226$, and $F < 1$, respectively). Bonferroni comparisons revealed that the participants' latency of the initial fixation were directed more rapidly towards happy and threatening images (i.e. emotional images) than neutral ones (all p values < 0.001), regardless of Group.

3.1.2. Probability of initial fixation
The ANOVA of the location of the initial fixation revealed an effect of Valence ($F(3, 190) = 20.55$, $p < 0.001$, $\eta^2 = 0.18$). Again, neither the effect of Group nor the Valence × Group interaction approached significance (both F values < 1). Bonferroni comparisons revealed that the participants' initial fixations were directed more quickly towards happy and threatening images than towards neutral images (all p values < 0.001). See Fig. 1.

3.2. Attentional engagement

3.2.1. First-pass fixation duration
The ANOVA of the mean first-pass fixation duration revealed an effect of Valence ($F(2, 190) = 31.72$, $p < 0.001$, $\eta^2 = 0.25$) and an
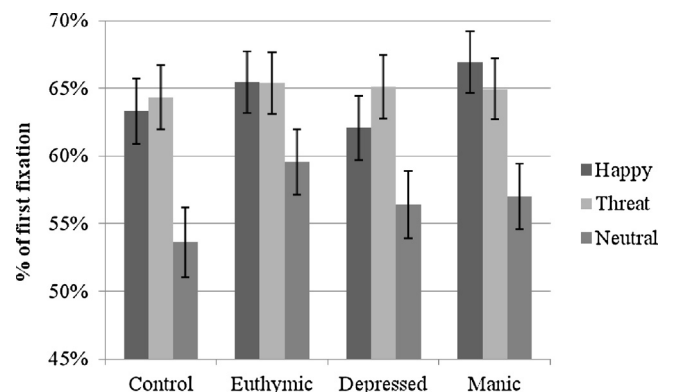

Fig. 1. Percentage of first fixations on each valence for control, euthymic, depressed, and manic groups.

Fig. 2. Number of first-pass fixations on each valence for control, euthymic, depressed, and manic groups.
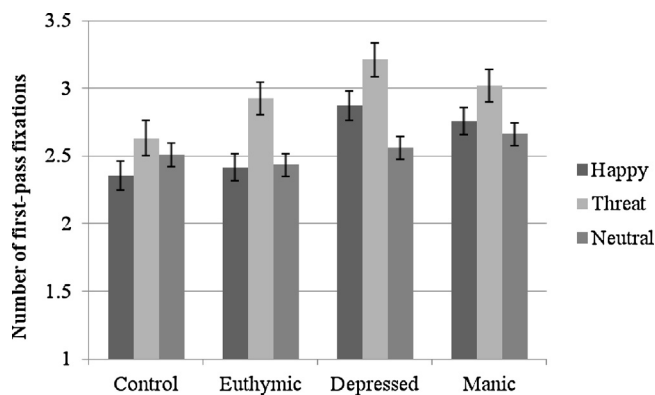

Fig. 3. Number of total fixations on each valence for control, euthymic, depressed, and manic groups.

effect of Group ($F(1, 95) = 6.02$, $p = 0.001$, $\eta^2 = 0.16$). The effect for the Valence × Group interaction was not significant ($F(6, 190) = 1.52$, $p = 0.17$). Bonferroni comparisons for Valence revealed that the participants' first-pass fixation duration were longer on threatening images than neutral images ($p < 0.001$), regardless of Group. Additionally, Bonferroni comparisons for Group revealed that the first-pass fixation duration were longer from the depressed patients than from healthy individuals ($p < 0.001$), while no differences were found between the other groups.

3.2.2. Number of first-pass fixations

The ANOVA of the number of first-pass fixations revealed significant effects of Valence ($F(2, 190) = 31.12$, $p < 0.001$, $\eta^2 = 0.25$) and Group ($F(1, 95) = 4.55$, $p = 0.005$, $\eta^2 = 0.13$), which were qualified by a Valence × Group interaction ($F(6, 190) = 2.66$, $p = 0.017$, $\eta^2 = 0.08$). Simple effect tests on the effects of the valence within each group were conducted to examine this interaction. There were significant differences between images within the control group ($F(2, 44) = 4.39$, $p = 0.018$, $\eta^2 = 0.16$), euthymic group ($F(2, 50) = 18.03$, $p < 0.001$, $\eta^2 = 0.42$), manic group ($F(2, 50) = 5.68$, $p = 0.006$, $\eta^2 = 0.19$) and depressed group ($F(2, 46) = 11.02$, $p < 0.001$, $\eta^2 = 0.32$). Planned Bonferroni comparisons showed that the threatening targets received more first-pass fixations than the neutral targets from euthymic ($p < 0.001$), manic ($p = 0.011$) and depressed ($p < 0.001$) BD patients, but not healthy individuals ($p = 0.83$). No other comparisons were significant. See Fig. 2.

3.3. Overall allocation of attention

3.3.1. Total fixation time

The ANOVA of the total fixation time revealed an effect of Valence ($F(2, 190) = 26.32$, $p < 0.001$, $\eta^2 = 0.22$), while the effect for Group was not significant ($F(3, 95) = 1.89$, $p = 0.14$). More importantly, we found a significant Valence × Group interaction ($F(6, 190) = 3.22$, $p = 0.005$, $\eta^2 = 0.09$), revealing significant differences between images within the euthymic ($F(2, 50) = 6.81$, $p = 0.002$, $\eta^2 = 0.21$), manic ($F(2, 50) = 16.69$, $p < 0.001$, $\eta^2 = 0.40$) and depressed groups ($F(2, 46) = 12.30$, $p < 0.001$, $\eta^2 = 0.35$), but not in the control group ($F(2, 44) = 2.21$, $p = 0.12$). Planned Bonferroni comparisons showed that the threatening targets received longer time fixation than the neutral targets from euthymic ($p = 0.042$), manic ($p < 0.001$) and depressed ($p < 0.001$) BD patients.

3.3.2. Total number of fixations

The ANOVA of the total number of fixations revealed an effect of Valence ($F(2, 190) = 24.14$, $p < 0.001$, $\eta^2 = 0.20$), while the effect for Group was not significant ($F(3, 95) = 1.25$, $p = 0.30$). More importantly, we found a significant Valence × Group interaction
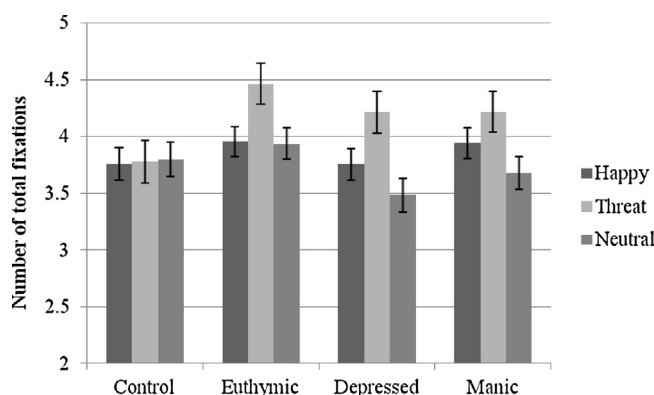
($F(6, 190) = 3.29$, $p = 0.004$, $\eta^2 = 0.09$). Simple effect tests on the effects of the valence within each group revealed significant differences between images within the euthymic ($F(2, 50) = 7.65$, $p = 0.001$, $\eta^2 = 0.23$), manic ($F(2, 50) = 12.43$, $p < 0.001$, $\eta^2 = 0.33$) and depressed groups ($F(2, 46) = 12.70$, $p < 0.001$, $\eta^2 = 0.36$), but not the control group ($F < 1$). Planned Bonferroni comparisons showed that the threatening targets received more fixations than the neutral targets from euthymic ($p = 0.011$), manic ($p < 0.001$) and depressed ($p < 0.001$) BD patients. Additionally, the happy targets received more fixations than the neutral targets from manic BD patients ($p = 0.045$)[1]. See Fig. 3.

4. Discussion

The present free-viewing eye-movement experiment was designed to examine the different components of attentional orienting when an emotional picture (happy, threatening, neutral) is compared with a neutral stimulus in BD patients across their different episodes (i.e. manic, depressive and euthymic). The key findings can be summarised as follows. First, the initial orienting in all participants (both patients and healthy controls) was determined exogenously: Participants oriented their gaze to emotional images (both happy and threatening) faster and more frequently than to neutral images. Second, the attentional engagement was determined endogenously (i.e. by the participants' mood) as indicated by the number of first-pass fixations. BD patients, regardless of their episode, exhibited higher first-pass fixations on the threatening images than neutral images, while healthy controls had similar first-pass fixation across target images, regardless of their valence. Third, the overall attentional allocation was also determined endogenously (i.e. mood conditioned the total fixation time and the number of total fixations). All BD patients made more fixations and spent more time viewing threatening images than neutral images. Furthermore, manic BD patients made more fixations on happy images than neutral ones. In contrast, healthy individuals attended all target images (i.e. emotional and control) equally.

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[1] As suggested by a reviewer, we also examined the relationship between clinical severity (as measured by BDI, YMRS, and BAI) and eye-tracking parameters. Overall, the bias scores for the threatening images (the number of first-pass fixations, the total fixation time, and the total number of fixations on threatening images) and for the happy behaviour (the total number of fixations on happy images) were not significantly correlated with the participants' mood symptoms. Specifically, we only found a marginal relationship between the bias score for the threatening images between the first-pass fixation and the BDI score ($r = 0.22$, $p = 0.063$). In addition, depressed symptoms were not associated with the threatening bias in total fixation time, and total number of fixations (all $ps > 0.15$). This is consistent with the idea that clinical severity does not play a major role in the threat-related attentional biases in BD individuals (i.e. it would be an inherent trait of illness).

In the following paragraphs, we discuss the following: (i) how attentional orienting towards emotional stimuli is affect endogenously and exogenously in BD patients; and (ii) the time course of attentional capture (in terms of initial orienting, engagement and allocation) by emotional visual scenes.

First, most participants directed their initial fixation more frequently and faster towards emotional (happy and threatening) images. This pattern is also typical of previous studies with healthy individuals that have reported that emotional images capture attentional orienting more easily than neutral images (see Nummenmaa et al., 2006, for a similar finding with the probability of initial fixation). We found no signs of differential attentional biases depending on the participants' mood. This is consistent with the idea that initial orienting is an automatic process that is mainly influenced by bottom-up processes (i.e. stimulus-driven attention) (Nummenmaa et al., 2006; see also García-Blanco et al., 2013, for a similar reasoning).

Second, with respect to attentional engagement, the participants' mood modulated the number of first-pass fixations. BD patients (but not healthy individuals) exhibited more first-pass fixations on threatening images than neutral images. This threat bias was not only present in clinical episodes (see also Leyman et al., 2009; Putman et al., 2007, for similar findings with depressed and hypomanic BD patients, respectively), but also in asymptomatic episodes[2]. According to cognitive vulnerability–stress theories (Beck, 1976), the presence of dysfunctional cognitive schemata based on threat (which can be deduced from attentional biases) may constitute a general vulnerability factor of BD. This threat bias would increase the emotional reactivity and may contribute to the onset or exacerbation of an affective episode when people with a vulnerability to BD experience stressful life events. The high emotional reactivity to stressful events may be influenced by the hypervigilance to threatening stimuli in BD patients due to their psychotic features (Mansell et al., 2007).

Third, unlike initial orienting, attentional allocation was also influenced by participants' mood: there were more fixations, as well as longer fixations, on threatening stimuli in BD patients, but not healthy individuals (see García-Blanco et al., 2014, for a threatening bias with BD patients regardless of their episode). Additionally, manic BD patients exhibited an attentional bias towards happy stimuli. In the García-Blanco et al. (2014) experiment, manic patients also paid more attention to the happy images than the control group (i.e. healthy individuals), but the difference was not statistically significant. According to Mansell et al. (2007), the attentional preference by unpleasant (i.e. threatening) and pleasant (i.e. happy) stimuli in mania could reflect their conflict between negative and positive appraisals. Furthermore, the high fixation frequency for threatening images in BD patients and for happy images in manic BD patients would reflect a difficulty to disengage attention from those pictures, and this may contribute to the rumination on this information by its through continuous processing (see Koster, De Lissnyder, Derakshan, & De Raedt, 2011, for a similar reasoning for major depression).

Finally, the present eye-tracking experiment comes with weaknesses that are usual in studies with patients. At the time of testing, all BD patients were medicated (see Table 1), including those in a euthymic state. Although medication may partly explain some between-group differences in terms of duration and number of fixations, we should stress that medication alone cannot explain the within-subject mood effect. Additionally, although the use of scenes may increase generalisation of findings in a more ecological setting, it may also decrease experimental control. Future studies may help to overcome these limitations.

To conclude, the present experiment has demonstrated that there are specific orientation processes (i.e. attentional engagement) that are biased in BD, in particular with threatening images. While the initial orienting in BD is modulated exogenously (i.e. emotional images capture the initial attention more frequently and faster than neutral images), the engagement and the overall allocation of attention are modulated endogenously: BD patients, but not healthy individuals, exhibited an attentional engagement for threatening images. Another important finding is that, for BD individuals in a manic episode, we found a positive bias during attentional allocation (i.e. higher number of total fixations for happy images). That is, while initial orienting is more influenced by the stimuli's characteristics (i.e. their valence), elaborative cognitive processes such as attentional engagement and allocation are more influenced by the individuals' characteristics (i.e. their mood; see Yiend, 2010). Importantly, the present findings suggest that there is a threat bias in BD patients as a trait (i.e. common to the three possible states of BD) and a positive bias as a state (i.e. typical of manic episodes). From a clinical perspective, determining the components of attentional orienting is not only crucial for understanding the role of psychological factors in BD, but also for founding new treatment options. In particular, future research should examine whether training of biases toward mood-relevant information can decrease the affective symptomatology in BD individuals (see Wadlinger & Isaacowitz, 2008, for evidence in major depression).

Acknowledgements

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[2] García-Blanco et al. (2014) failed to find a significant bias in attentional engagement, although the numerical trend was similar. Note, however, that the participants in the García-Blanco et al. (2014) experiment were presented simultaneously with four stimuli (happy, sad, threatening, and neutral), and this makes it difficult to extract firm conclusions on the effect of each type of stimulus. In the current experiment, participants were presented with only one emotional image competing with a neutral image (i.e., this is a more controlled scenario than in the García-Blanco et al., 2014, experiment).

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