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Research paper

Exploring the 'mood congruency' hypothesis of attention allocation – An eye-tracking study

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A R T I C L E I N F O

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A B S T R A C T

Background: The 'mood-congruency' hypothesis of attention allocation postulates that individuals' current emotional states affect their attention allocation, such that mood-congruent stimuli take precedence over non-congruent ones. This hypothesis has been further suggested as an underlying mechanism of biased attention allocation in depression.

Methods: The present research explored the mood-congruency hypothesis using a novel video-based mood elicitation procedure (MEP) and an established eye-tracking attention allocation assessment task, elaborating prior research in the field. Specifically, in Study 1 ($n = 91$), a video-based MEP was developed and rigorously validated. In study 2 ($n = 60$), participants' attention allocation to sad and happy face stimuli, each presented separately alongside neutral faces, was assessed before and after the video-based MEP, with happiness induced in one group ($n = 30$) while inducing sadness in the other ($n = 30$).

Results: In Study 1, the MEP yielded the intended modification of participants' current mood states (eliciting either sadness or happiness). Study 2 showed that while the MEP modified mood in the intended direction in both groups, replicating the results of Study 1, corresponding changes in attention allocation did not ensue in either group. A Bayesian analysis of pre-to-post mood elicitation changes in attention allocation supported this null finding. Moreover, results revealed an attention bias to happy faces across both groups and assessment points, suggestive of a trait-like positive bias in attention allocation among non-selected participants.

Conclusion: Current results provide no evidence supporting the mood-congruency hypothesis, which suggests that (biased) attention allocation may be better conceptualized as a depressive trait, rather than a mood-congruent state.

1. Introduction

The world we live in is highly complex, filled with numerous stimuli and vast amounts of information, all of which may be further processed at any given moment. Yet, as we all experience in our daily lives, this is not the case (Failing and Theeuwes, 2018; Theeuwes, 2018). As cognitive resources are limited, the visual attentional system filters the abundant visual information surrounding us by selecting potentially relevant stimuli and cues (over less relevant ones) to which attentional resources are then allocated (commonly by directing one's gaze toward objects of interest in one's visual environment; Hertz-Palmor et al., 2023a; Itti and Koch, 2001) – a process known as *selective visual attention*, or *selective attention allocation* (Evans et al., 2011). Importantly, visual attention allocation is not a unitary process or construct, but rather a complex one entailing different attentional aspects, including both early attentional features (i.e., the ease or speed in which a stimulus is detected, also referred to as vigilance or attentional capture) and more late ones, mainly attentional maintenance (i.e., the degree to which attention is held by a specific stimulus, once detected, also known as sustained attention). Importantly, these attentional features are not exclusionary and can operate conjointly at different stages of the attentional process (Lazarov et al., 2019b).

An important aspect implicated in the process of selective attention allocation is the emotional valence of stimuli, with research showing emotional information to be attentionally prioritized over non-emotional (i.e., neutral) information, demanding additional and ongoing attentional resources (see Carretié, 2014; Murphy and Isaacowitz, 2008 for meta-analytic studies). Beyond the importance of the

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emotional valence of the stimuli themselves in directing one's visual attention, research has also explored the role of the individual's current mood state. Specifically, the 'mood-congruency' hypothesis postulates that individuals' current emotional states affect their attention allocation to emotionally laden stimuli, such that mood-congruent stimuli take precedence over non-congruent ones (Becker and Leinenger, 2011; for a narrative review see Yiend, 2010). Initial supporting evidence for this hypothesis can be drawn from eye-tracking-based research exploring the attention allocation of participants while in different emotional states, either negative or positive. Regarding the former, research shows that depressed individuals sustain their attention (i.e., dwell longer) on negative/dysphoric stimuli, and allocate less attentional resources (i.e., dwell less) to positive stimuli, compared with non-depressed individuals (for a review see Suslow et al., 2020). Similar findings also emerge among anxious individuals when faced with similar stimuli (dysphoric, positive) as well as with more condition-specific threat stimuli (e.g., Beevers et al., 2011; Kraines et al., 2019; Lazarov et al., 2022; Liang et al., 2017). As for the latter, research demonstrates that healthy participants reporting current positive feelings also show an attentional bias toward positive-valanced stimuli (Blanco and Vazquez, 2021; Strauss and Allen, 2006; Tamir and Robinson, 2007) and away from negative-valanced ones (Mauer and Borkenau, 2007; Sanchez and Vazquez, 2014). While providing some initial support for the 'mood-congruency' hypothesis, mood and attention in the above-stated studies were assessed concurrently at a specific time point (i.e., cross-sectional design), and hence are less able to attest as to the possible causal influence of current mood on attention allocation.

Additional research explored the mood-congruency hypothesis more experimentally, by manipulating current mood states of healthy non-selected participants (e.g., students, volunteer participants from the community) and gauging ensuing changes in attention allocation. However, results were largely inconsistent, with some showing modification of subsequent attention allocation in a mood-congruent manner, others showing attention allocation changes, but in the opposite direction (e.g., an attention bias to positive cues following a negative mood elicitation), and some failing to find any evidence for the mood-congruency hypothesis (Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Speirs et al., 2018; Tamir and Robinson, 2007; Wadlinger and Isaacowitz, 2006). Several features may help explain these mixed findings – some pertaining to the nature of mood elicitation, and others to the utilized attention assessment task. Considering the former, two aspects should be acknowledged. First, while attention was assessed visually, some studies used non-visual mood elicitation procedures (e.g., hearing sad/happy music, writing textual descriptions of emotional life events; (Becker and Leinenger, 2011; Hüttermann and Memmert, 2015; Tamir and Robinson, 2007; Wadlinger and Isaacowitz, 2006)). Importantly, however, this disparity in sensory-modalities have been shown to impair performance in tasks that involve selective attention (Mozolic et al., 2008). Second, some studies elicited mood either positively or negatively, without conducting a direct comparison of the two (Speirs et al., 2018; Wadlinger and Isaacowitz, 2006), which is needed to clarify the valence-specificity of the mood-congruency hypothesis. Considering the attention task used to assess ensuing attention patterns, three features should be noted. First, most studies did not examine the psychometric properties of tasks used (Becker and Leinenger, 2011; Hüttermann and Memmert, 2015; Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Speirs et al., 2018; Wadlinger and Isaacowitz, 2006), which is imperative for trusting emergent results (Lilienfeld and Strother, 2020). Second, studies diverged on the nature of the task, with some using reaction-time (RT)-based tasks, such as the Dot-probe task (Tamir and Robinson, 2007), while others used eye-tracking methodology (Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Sanchez and Vazquez, 2014; Speirs et al., 2018; Wadlinger and Isaacowitz, 2006). As these are very disparate experimental methodologies, they may also yield vastly different results (Lazarov et al., 2016, 2019b; Rodebaugh et al., 2016; Waechter et al., 2014). It is worth mentioning at this juncture that eye-tracking methodology, which offers a nearly instantaneous measure of visual attention, addresses several inherent limitations of RT-based tasks (e.g., poor psychometrics, temporal distance in measurement, confounding elements, etc.; (Armstrong and Olatunji, 2012; Hadwin and Field, 2010; Kimble et al., 2010; Lazarov et al., 2016, 2019b; Skinner et al., 2018)) and hence is currently considered by most as better-suited to assess attention allocation (Armstrong and Olatunji, 2012; Lazarov et al., 2016, 2019a, 2019b). Finally, most studies assessed attention following mood elicitation only (Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Tamir and Robinson, 2007; Wadlinger and Isaacowitz, 2006). Not assessing attention prior to mood elicitation undermines the ability to attribute post-elicitation attention allocation to the effects of the mood elicitation itself (i.e., pre-to-post shifts in attention allocation).

The present study aimed at examining the mood-congruency hypothesis while addressing the above-reviewed aspects of past research. Specifically, in Study 1, a novel video-based mood elicitation procedure (MEP) was developed and validated, showing effective mood alteration in the intended direction (i.e., eliciting either a sad or a happy mood state). In Study 2, non-selected participants were randomly assigned to one of two groups – a group that underwent a sad MEP, and a group that underwent a happy MEP. Mood states were assessed before and after the MEP, as was participants' visual attention allocation to sad/happy vs. neutral stimuli (faces). Attention allocation was assessed using a well-established eye-tracking attentional paradigm with adequate psychometric properties in both healthy and clinical samples (e.g., McNamara et al., 2022; for a review and meta-analysis see Shamai-Leshem et al., 2023). Importantly, previous research using the present version of the task (using sad and happy faces) has shown biases in attention allocation among dysphoric (Basel et al., 2022; Klawohn et al., 2020; Lazarov et al., 2018) and anxious participants (e.g., Lazarov et al., 2022). Based on the mood-congruency hypothesis, and the above-described attentional research, we expected that the sad MEP would increase attention allocation toward the sad faces, and away from the happy faces, compared to neutral ones. The opposite pattern was predicted for the happy MEP.

2. Study 1

Data are openly available in Open Science Foundation (OSF; https://osf.io/b3jns/?view_only=e823d6df30c24494ad0d1810b9a146a2).

2.1. Method

2.1.1. Participants

Ninety-one non-selected undergraduate students (M_{age} = 23.65 years, *SD* = 4.28, *range* = 18–48 years; 65 females [71.4 %]) were randomized to one of two groups – the Negative film group (*N* = 49; M_{age} = 23.22, *SD* = 1.97, range = 19–29, 35 females [71.4 %]) and the Positive film group (*N* = 42; M_{age} = 24.14, *SD* = 5.95, range = 18–48, 30 females [71.4 %]). The two groups did not differ on age, $t_{(89)} = 1.02$, $p = .31$, or gender distribution, $\chi^2_{(1)} = 0.00$, $p = 1.00$. All participants provided written informed consent and received course credit for participation. The study protocol was approved by the local Institutional Review Board.

2.1.2. Current mood states

Current mood states were assessed using Visual Analog Scales (VASs), commonly used in research to indicate current mood states (Abend et al., 2014; Ahearn, 1997; Sanchez et al., 2014; Williams et al., 2010). Four mood states were assessed – sadness, happiness, anxiety, and anger. Sadness and happiness were the primary target mood states. Feelings of anxiety and anger, which may also increase following exposure to sad content (Ellis et al., 2010; Schwartz and Weinberger, 1980), were also assessed to verify that sadness was the main negative affect elicited by the negative film. Each VAS ranged from 0 to 100, where higher scores representing higher intensity of the inquired mood state. VASs were anchored with "not at all" on the left anchor side and "very much" on the right anchor. Participants were asked to place a vertical mark that best described their present mood.

2.1.3. The emotional film paradigm[1]

2.1.3.1. General description. We based our visual mood elicitation procedure (MEP) on the structure of the "Trauma Film Paradigm" (Holmes and Bourne, 2008; James et al., 2016) shown to effectively induce negative mood (Ball and Brewin, 2012; James et al., 2016; Schartau et al., 2009), also in local samples (Herz et al., 2020). While the overall structure of the MEP followed closely that of the original procedure, the content was modified for the purposes of the present study – eliciting sad or happy mood states.[2]

The current emotional film paradigm consisted of eight short video clips, edited together, ranging in length from 35 to 126 s each, with a 15-s interval between clips, for an overall length of 11:45 min. The eight video clips included scenes from popular movies and viral videos from social media. At the start of each 15-s interval the following instructions were presented: "Please close your eyes, you will hear a sound before the next clip commences, so you will know when to open them. When you hear the sound, please open your eyes." *The negative film,* aimed at eliciting sad mood, included sad video clips depicting, for example, a beloved pet dying. *The positive film,* aimed at eliciting a happy mood, included happy and funny video clips, such as babies laughing and animals playing.

2.1.3.2. Pilot study. Prior to the full-scale validation of the negative and positive films, we conducted an initial pilot study to verify the potential suitability of the used video clips for eliciting the intended moods. First, 20 video clips per film type were chosen. Of those, eight video clips per film type were selected for further piloting – those for whom a consensus was reached by the research team that their content was best suited for eliciting the intended moods. Next, 15 participants watched the negative film, and 12 participants watched the positive film. VAS ratings of sadness and happiness were completed before and after viewing. We compared VAS scores at the two time points within each group using paired-sample *t*-tests. Results were in accordance with our hypothesis, showing increased sadness and reduced happiness following the negative film, and an opposite pattern following the positive film (Table S1).

2.1.4. General procedure

Due to social distancing restrictions imposed in Israel due to the COVID-19 pandemic (Hertz-Palmor et al., 2021, 2023b; Wilder-Smith and Freedman, 2020) the task was delivered remotely using the Qualtrics platform. Participants were contacted via phone and received a brief explanation regarding the nature and purpose of the study, and then instructed as to how to watch the film – they were asked to make sure they watch the video at its original speed, using full screen display and with the sound toggled on. Next, each participant received a link to the experimental task. After signing informed consent, participants were directed to the pre-film VASs (i.e., sadness, happiness, anxiety, and anger), which they were asked to complete. Participants were then randomly assigned to watch either the negative or positive film. Following the film, the same four VASs were completed again (post-film evaluation).[3]

2.1.5. Data analysis

To examine group differences in mood states (VAS ratings) from pre- to post-film, we performed a 2 × 2 × 4 repeated-measures analysis of variance (ANOVA) with Group (negative/positive film) as a between-subject factor, and Time (pre/post) and Emotion (sadness, happiness, anxiety and anger) as within-subject factors. Post-hoc analyses included four separate 2 × 2 repeated-measures ANOVAs, one per emotion, with Group and Time as independent variables. To further explicate significant 2 × 2 interactions, simple effects were analyzed per emotion, namely, within-group changes from pre- to post-film and between-group differences at post-film. Finally, we compared the magnitudes of these simple effects' effect sizes by examining Time-by-Emotion interactions in a mixed-effects linear model.

Statistical analysis was conducted with the 'stats' and 'lmerTest' packages in R (Kuznetsova et al., 2017). All tests were 2-sided, using α of 0.05. Effect sizes are reported using η_p^2 and *Cohen's d* values and were calculated using the 'effectsize' package (Ben-shachar et al., 2020). We adjusted our *p*-values for multiple comparisons using Bejamini and Hochberg's False Discoveries Rate (FDR) adjustment (Benjamini and Hochberg, 1995).

2.2. Results

Comparing the groups on pre-film mood states showed no group differences in sadness, $F_{(1,89)} = 0.58$, $p = .45$, happiness, $F_{(1,89)} = 0.06$, $p = .80$, anxiety, $F_{(1,89)} = 0.93$, $p = .34$, or anger, $F_{(1,89)} = 0.00$, $p = .97$.

A significant Group-by-Time-by-Emotion interaction emerged, $F_{(3,712)} = 58.3$, $p < .001$, $\eta_p^2 = 0.31$, with significant Group-by-Time interactions across all examined emotions: sadness, $F_{(1,178)} = 106.5$, $p < .001$, $\eta_p^2 = 0.37$; happiness, $F_{(1,178)} = 72.7$, $p < .001$, $\eta_p^2 = 0.29$; anxiety, $F_{(1,178)} = 6.90$, $p = .009$, $\eta_p^2 = 0.04$, and anger, $F_{(1,178)} = 37.1$, $p < .001$, $\eta_p^2 = 0.17$. Within-group analysis of pre-to-post changes in mood showed that the VAS scores of participants who watched the negative film significantly increased in sadness, anxiety, and anger, and significantly decreased in happiness, with the largest effect size being for increased sadness (see Table S2 for the group's complete statistics). Contrasting sadness against all other emotions in a mixed-effect linear model showed significant negative effects for all contrasted emotions (*Standardized* β between −0.80 to −3.00, $p < .001$), indicating that, as intended, the pre-to-post increase in sadness was significantly greater than pre-to-post changes in other emotions. VAS scores of participants who watched the positive film showed that they significantly increased in happiness and significantly decreased in anger but did not significantly change in sadness or anxiety (see Table S3 for the group's complete statistics). The mixed-effects linear model, contrasting happiness against all other emotions, showed significant negative effects for all contrasted emotions (β between −0.67 to −0.63, $p < .001$), indicating that, as intended, the pre-to-post increase in happiness was significantly greater than pre-to-post changes in all other emotions. Comparing the groups at post-film (Table S4) showed significant group differences on

[1] Researchers interested in receiving the emotional film paradigm for their own research are welcome to contact the corresponding author.

[2] The original paradigm was designed to elicit negative emotions related to traumatic experiences, and hence included extremely negative films designed to mainly induce horror, terror, and fear.

[3] Since the task was delivered online, we measured participants' overall participation time – the time that elapsed from completion of the pre-film VAS, right before the film started, to the presentation of the post-film VAS – as an indicator for adequately watching the film. Participants with viewing time shorter than the film's duration were excluded. Five participants, two from the negative film group and three form the positive film group, were excluded for this reason (initially 96 participants were recruited).

all emotions, with the strongest effect size noted for sadness, followed by happiness, and then anger, and anxiety.

3. Study 2

Data are openly available in OSF –https://osf.io/b3jns/?view_only=e823d6df30c24494ad0d1810b9a146a2.

3.1. Method

3.1.1. Participants

Sixty non-selected university students took part in Study 2 (See Table 1 top section for demographic characteristic per group). Participants were randomly assigned to one of two groups – the negative film group undergoing a sad MEP and the positive film group undergoing a happy MEP. Participants provided written informed consent and received course credit for participation. The study protocol was approved by the local Institutional Review Board. To avoid eye-tracking calibration difficulties we only invited participants with normal or corrected-to-normal vision, excluding multi-focal eyewear.

3.1.2. Measures

Depression levels were measured using the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) – a 9-item self-report questionnaire evaluating symptoms of Major Depressive Disorder (MDD) according to DSM criteria (American Psychiatric Association, 2013). It has good test-retest reliability, validity and internal consistency (Kroenke et al., 2001). Cronbach Alpha in the present sample was $\alpha = 0.79$.[4]

Trait Anxiety was measured with the State-Trait Anxiety Inventory-Trait subscale (STAI-T), a commonly used 20-item measure of trait anxiety (Spielberger et al., 1970). Items are rated in relation to the participant's usual behavior, with no focus on a specific time period, and include items such as “I worry too much over something that really doesn't matter”, “I am a steady person”, etc. The STAI-T has good internal consistency and test-retest reliability (Barnes et al., 2002). Cronbach Alpha in the present sample was $\alpha = 0.87$.

Current mood states were assessed as described in study 1.[5]

3.1.3. Mood elicitation

Mood elicitation was operationalized using the MEP validated in Study 1, but with one exception - participants viewed the film in a lab setting as part of the experimental session. Hence, audio and display settings were adjusted and monitored to ensure optimal viewing conditions – participants watched the film alone in a dark room, at full screen, with sound adjusted to a fixed volume (Herz et al., 2020). Before the film commenced, participants were given the following instructions: “You will now watch a film comprised of a number of short video clips. Before each clip there will be a short break during which we ask that you close your eyes. You can think of anything you want during these breaks. Before the next clip commences you will hear a short beep sound, please open your eyes once this happens to view the next clip. Please sit comfortably and at ease and focus on the film. Please do not divert your gaze from the film or close your eyes. I will soon turn off the lights and wait outside the room. Do you have any questions?” Following these instructions, the research assistant closed the lights, started the film, and waited outside the room until the film ended.

3.1.4. Eye-tracking attention allocation task

Attention allocation was assessed using the Matrix task – a well-established free-viewing eye-tracking task with adequate psychometric properties across different samples and conditions (for a meta-analysis of this task see Shamai-Leshem et al., 2023; for specific studies see Lazarov et al., 2016; Lazarov et al., 2017; Lazarov et al., 2021b; McNamara et al., 2022; Schneier and Lazarov, 2022; Shamai-Leshem et al., 2021). Importantly, the presently used version of the task (i.e., using sad and happy faces; see below) has shown biases in attention allocation among depressed participants (Basel et al., 2022; Klawohn et al., 2020; Lazarov et al., 2018) as well as in other anxiety-related psychopathologies (e.g., Lazarov et al., 2019a). The task was designed and executed using the Experiment Builder software (version 2.1.140; SR Research Ltd., Mississauga, Ontario, Canada).

The task included two blocks identical to those used in previous eye-tracking studies assessing attention allocation mainly among depressed participants (e.g., Basel et al., 2022; Klawohn et al., 2020). One block comprised of 30 matrices of eight sad and eight neutral facial expressions (the S—N block), and the other of 30 matrices of happy and neutral facial expressions (the H—N block). Block order was counterbalanced across participants.

For each block, colored photographs of eight male and eight female actors, each contributing one emotional (sad or happy) and one neutral facial expression, were taken from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist et al., 1998), with different actors chosen for each block to avoid repetitions of the neutral faces across blocks. Each individual face extended 225-by-225 pixels, including a 10-pixel white margin frame, for an overall size of 900-by-900 pixels (see Fig. 1 for a matrix example per block). Each face appeared randomly at any position on the matrix while ensuring the following: (a) each actor appeared only once in any single matrix; (b) each actor only appeared in only one of the two blocks; (c) each matrix contained eight male and eight female faces; and (d) the four inner facial expressions always contained two emotional and two neutral faces.

Each trial of the task began with a fixation-cross, shown until a fixation of 1000_{ms} was recorded by the eye-tracker apparatus, verifying that each trial began only when the participant's gaze was fixated at the matrix' center (participants were shown a demonstration of this contingency before the task began). The matrix was then presented for 6000_{ms}, followed by an inter-trial interval of 2000_{ms}. Participants were instructed to look freely at each matrix until it disappeared. A 2-min break was introduced between blocks to reduce fatigue. Each block was preceded by a 5-point calibration and validation procedure, which was repeated if the visual deviation was above 0.5° on the X or Y-axis. The task did not proceed until these calibration parameters were achieved. Each block took about 5 min, for a task duration of about 12 min.

The task (see Eye-tracking measures below) demonstrated acceptable internal consistency for both the happy-neutral matrix (Cronbach's $\alpha = 0.80$), and the sad-neutral matrix (Cronbach's $\alpha = 0.73$).

3.1.5. Apparatus

Eye-tracking data were collected and recorded using the remote head-free high-speed EyeLink Portable-Duo apparatus and the Experiment Builder software (SR-research, Ottawa, Ontario, Canada). Participants were seated approximately 700_{mm} away from the screen. Real-time monocular eye-tracking data were recorded continuously throughout the task at 500 Hz, with a 1920 × 1080-pixel display resolution.

3.1.6. Eye-tracking measures

Eye tracking data were processed using the EyeLink Data Viewer software (SR Research Ltd.; version 3.1.246). Fixation was defined as at least 100_{ms} of stable fixation within a 1-degree visual angle. For each presented matrix we defined two areas of interest (AOIs), one for each emotional contrast – sad and neutral AOIs for the S—N block and happy and neutral AOIs for the H—N block.

[4] While a Cronbach Alpha of 0.79 is relatively low compared to what is usually found in research among the general population (i.e., >0.80; Keum et al., 2018; Kocalevent et al., 2013), this is actually similar to the internal consistency of the general population when the Hebrew version of the PHQ-9 is administered, which is reported as being around 0.79 (Yona et al., 2021).

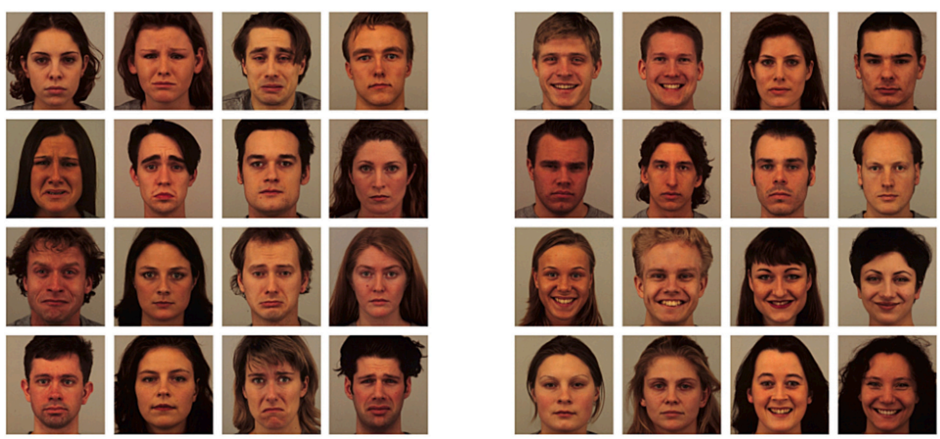
[5] In this study, VAS scores ranged between 0–30.

Table 1
Demographic, clinical, and mood characteristics by group.

Measure	Negative film group (n = 30) M (SD)	Positive film group (n = 30) M (SD)	$t_{(58)}$	p
Age	23.77 (2.91)	23.33 (1.81)	0.69	0.49
Age range	20–34	21–31	–	–
Gender	24 female	23 female	$\chi^2 = 0.10$	0.75
PHQ-9	7.13 (3.43)	6.23 (2.74)	1.12	0.27
STAI-T	38.47 (8.27)	38.07 (8.93)	0.18	0.86

Mood state	Negative film group				Positive film group				Group comparison at post-film	
	Pre-film	Post-film	$t_{(29)}$	Cohen's d	Pre-film	Post-film	$t_{(29)}$	Cohen's d	$t_{(58)}$	Cohen's d
Sadness	5.93 (6.10)	17.90 (6.20)	11.2***	2.08	5.07 (5.52)	3.47 (4.71)	−2.78**	−0.52	10.2***	2.67
Happiness	18.53 (4.64)	11.60 (4.79)	−9.73***	−1.81	18.13 (5.10)	22.20 (4.53)	4.50***	0.83	−8.81***	−2.31
Anxiety	7.43 (6.80)	11.30 (8.63)	3.56**	0.66	7.50 (8.11)	5.40 (6.83)	−3.01**	−0.56	2.94**	0.77
Anger	3.47 (5.14)	9.80 (9.80)	4.50***	0.84	2.37 (4.55)	1.33 (3.20)	−2.82**	−0.52	4.49***	1.18

Note. PHQ-9 = Patient Health Questionnaire-9; STAI-T = State-Trait Anxiety Inventory – Trait.
* $p < .05$.
** $p < .01$.
*** $p < .001$.



(a) A sad-neutral matrix **(b) A happy-neutral matrix**

Fig. 1. An example of a single matrix for the sad-neutral block (a; left panel) and the happy-neutral block (b; right panel.)

Sustained attention served as the primary outcome measure. It was quantified following the guidelines of a recent meta-analysis of 1567 participants that completed the Matrix task, across a wide range of psychiatric diagnoses and ages, aggregated from nine sites around the world (Shamai-Leshem et al., 2023). Specifically, attention allocation was computed per block as dwell time percent (DT%) spent on the emotional AOI (sad, happy) – total DT on the emotional AOI of divided by the total dwell time on both AOIs (i.e., $\frac{DT\ on\ emotional\ stimuli}{Overall\ DT}$). Thus, higher DT% reflects higher relative gaze allocation to the emotional over the neutral stimuli (see examples for the DT% computation via the OSF link above). Importantly, the above-cited meta-analysis has shown the attentional index of DT% to be a reliable measure of sustained attention when using both SN and HN matrices among healthy participants (Shamai-Leshem et al., 2023).

While previous eye-tracking research among depressed individuals show no evidence for indices of early attention allocation (for a review see Suslow et al., 2020), a finding also echoed by studies using the current task in depression (e.g., Klawohn et al., 2020; Lazarov et al., 2018) and in other conditions (Bollen et al., 2023; Lazarov et al., 2021a, 2016), we still opted to include these measures for two reasons – to be consistent with prior research in the field, and to be comprehensive in assessing attention allocation given that the current study is the first to use this task following a mood elicitation procedure. Yet, based on the prior research noted above, we had no specific predictions for these measures. As customary in the field (Lazarov et al., 2019b), early attention allocation indices included latency to first fixation, first fixation location, and first fixation dwell time. *First fixation latency* was calculated by averaging the latency to first fixations, in milliseconds, per AOI, and then subtracting the latency to the neutral AOI from that of the emotional AOI (i.e., Δ Latency). *First fixation location* was measured by counting the number of times the first fixation was in each AOI, and then computing a percentage ratio (i.e., number of first fixations on the emotional AOI divided by the total number of first fixations on both AOIs), in a similar manner as described above for DT%. *First fixation dwell time* was computed by averaging first fixation duration, in milliseconds, per AOI and then subtracting the duration of the neutral AOI from that of the emotional AOI (i.e., Δ dwell time).[6] See the OSF link provided above for examples of these computations.

[6] A subtraction index was used for first fixation latency and dwell time (unlike first fixation location and total dwell time) as in these measures the two AOIs are not "relative", and hence a percentage-based index cannot be computed.

3.1.7. General procedure

The experiment took place in a quiet room. After a brief explanation of the nature and purpose of the study, participants signed informed consent, and were then positioned in front of an eye-tracking monitor. They then completed the pre-film attention assessment task, followed by the pre-film VASs. Next, participants watched the film (per participants' randomization – negative/positive), following which they completed the post-film VASs. Participants then completed the post-film attention assessment task. Finally, participants completed the self-report questionnaires, including a short inquiry about the film content to verify adequately viewing the film.

3.1.8. Data analysis

Sample size was pre-determined following a power analysis using G*Power 3.1.9.4 (Faul et al., 2009), and was based on a previous study of attention allocation that used the same task and blocks (i.e., S—N, H—N) among a similar sample of student participants with different levels of depressed mood (Basel et al., 2022). Specifically, this study showed a significant group-by-AOI (negative, positive) interaction reflecting a differential attention allocation of the two groups to the two AOIs, with an effect size of $\eta_p^2 = 0.15$. Accordingly, we used this effect size to power the present study to detect a similar between-group difference in attention allocation to the sad and happy AOIs. The power analysis indicated that a group size of 42 (21 per group) would suffice to achieve a power of 0.80 (with $\alpha < 0.05$; two-sided). Yet, as this was the first study to use this task following a mood elicitation procedure, and following standard sample sizes of similar studies using this task among participants with elevated depressive mood (Basel et al., 2022; Klawohn et al., 2020; Lazarov et al., 2018; Shamai-Leshem et al., 2021), we opted to include 30 participants per group.[7]

Independent sample *t*-tests compared between groups on age, PHQ-9 and STAI-T scores, with a chi-square test comparing groups on gender ratio.

Current mood states (VAS scores) were evaluated as described in Study 1, to verify the intended changes in mood states from pre- to post-film.

Attention allocation indices (DT% and the three first fixation measures) were examined using a 2X2X2 repeated-measures ANOVA with Group (negative film, positive film) as a between-subjects factor, and Time (pre, post) and Emotion (sad, happy) as within-subject factors.

Statistical analysis was conducted with the 'stats' package in R. All tests were 2-sided, using α of 0.05. Effect sizes are reported using η_p^2 values for ANOVA, and *Cohen's d* for t-tests, and were calculated using the 'effectsize' package. Akin to Study 1, multiple comparisons were corrected using FDR.

3.2. Results

Groups did not differ in age, gender, depression (PHQ-9 scores), or trait-anxiety scores (STAI-T; see Table 1, top section).

3.2.1. Current mood states

There were no group differences in pre-film mood ratings of sadness, $t_{(58)} = 0.58$, $p = .57$, happiness, $t_{(58)} = 0.32$, $p = .75$, anxiety, $t_{(58)} = 0.03$, $p = .97$, or anger, $t_{(58)} = 0.88$, $p = .38$. Replicating Study 1, a significant Group-by-Time-by-Emotion interaction emerged, $F_{(3,464)} = 21.9$, $p < .001$, $\eta_p^2 = 0.12$, with significant Group-by-Time interactions emerging across all examined emotions: sadness, $F_{(1,116)} = 43.1$, $p < .001$, $\eta_p^2 = 0.27$; happiness, $F_{(1,116)} = 39.9$, $p < .001$, $\eta_p^2 = 0.26$; anxiety, $F_{(1,116)} = 4.58$, $p = .034$, $\eta_p^2 = 0.04$, and anger, $F_{(1,116)} = 10.6$, $p = .001$, $\eta_p^2 = 0.08$. Within-group pre-to-post changes followed the expected directionality, and between-groups comparison at post-film showed the two groups to differ significantly at post-film on sadness, happiness, anxiety, and anger (see Table 1, bottom section, for full statistics). Again, as in study 1, within-group mixed-effects linear models contrasting pre-to-post change in sadness/happiness against similar changes in other emotions (time-by-emotion interaction) showed that the effect of pre-to-post change in sadness was significantly greater than the equivalent changes in other emotions for the negative film group, β between −0.67 to −2.27, $p < .01$, and the effect of pre-to-post change in happiness was greater than the equivalent changes in other emotions for the positive film group, β between −0.68 to −0.56, $p < .01$.

3.2.2. Attention allocation

3.2.2.1. First fixations measures.

No significant findings emerged for any of the first fixation measures (i.e., latency, location, dwell time; see Tables S5, S6, S7, respectively), except for a significant main effect for Emotion for first fixation location (Fig. 2), $F_{(1,232)} = 60.9$, $p < .001$, $\eta_p^2 = 0.21$, with participants making more first fixations on sad faces ($M = 0.53$; $SD = 0.08$) than on happy faces ($M = 0.45$; $SD = 0.07$) across groups and assessment points. Post-hoc exploratory analysis of the main effect of emotion per assessment time revealed that participants made more first fixations on sad faces ($M = 0.52$; $SD = 0.08$), than on happy faces ($M = 0.45$; $SD = 0.08$), on the pre-film assessment, $t_{(59)} = 2.64$, $p = .022$, $d = 0.34$, as well as on the post-film assessment ($M = 0.54$; $SD = 0.08$, and $M = 0.46$; $SD = 0.07$, respectively), $t_{(59)} = 1.96$, $p = .054$, $d = 0.26$, although at trend-level.

3.2.2.2. Sustained attention (DT%)

3.2.2.2.1. Main analysis. Contrary to our predictions, only a significant main effect for Emotion emerged, $F_{(1,232)} = 14.1$, $p = .0014$, $\eta_p^2 = 0.06$, with participants dwelling longer on happy faces ($M = 0.54$; $SD = 0.07$) compared with sad faces ($M = 0.51$; $SD = 0.06$) across groups and assessment points. No significant effect for Time, Group, or any interaction effect emerged (see Fig. 3 and Table S8). Post-hoc exploratory analysis of the main effect of emotion per assessment time revealed that participants dwelled longer on happy faces ($M = 0.54$; $SD = 0.05$), compared with sad faces ($M = 0.51$; $SD = 0.05$), on the pre-film assessment, $t_{(59)} = 2.64$, $p = .022$, $d = 0.34$, as well as on the post-film assessment ($M = 0.53$; $SD = 0.08$, and $M = 0.50$; $SD = 0.06$, respectively), $t_{(59)} = 1.96$, $p = .054$, $d = 0.26$, although at trend-level.

To address potential individual variations in the efficacy of the mood elicitation procedure, we complemented the above-described main analysis with a series of linear regressions testing whether VAS change from pre- to post-MEP (i.e., VAS delta) predicts a change in attention allocation to emotional stimuli (i.e., DT% delta). Hence, we conducted a hierarchical multiple regression with DT% delta as the dependent variable. For participants who watched the negative film, DT% delta was computed based on DT% on sad stimuli, while for participants who watched the positive film DT% was computed based on DT% on happy stimuli. In Step I, *VAS delta* was introduced as the independent variable. Results showed no significant effect ($p = .08$, Table S9). In Step II *group* and *group*VAS delta* were introduced to the model, to differentiate between participants who watched the sad or happy movie. Here, too, no significant effects were detected (Table S9). Lack of effects was further confirmed when examining the sad and happy film groups separately, using separate models with the relevant VAS scores and emotional stimuli (Tables S10-S11).

3.2.2.2.2. Bayesian inference. To test the possibility of no-effect following mood elicitation, we used Bayesian inference to analyze pre-to-post shifts in attention allocation. For this purpose we utilized the Bayesian *t*-test framework proposed by Jeffreys (Jeffreys, 1939; Ly et al., 2020; Rouder et al., 2009), and used the open-source JASP statistical

[7] A post-hoc sensitivity analysis (i.e., the minimum detectable effect size based on used the sample size) showed that given a sample size of 60 participants, a minimal effect size of $\eta_p^2 = 0.06$ (critical F = 2.65) was required to detect a significant Group*Time*Emotion interaction effect with an α < 0.05 and a power of 0.80.

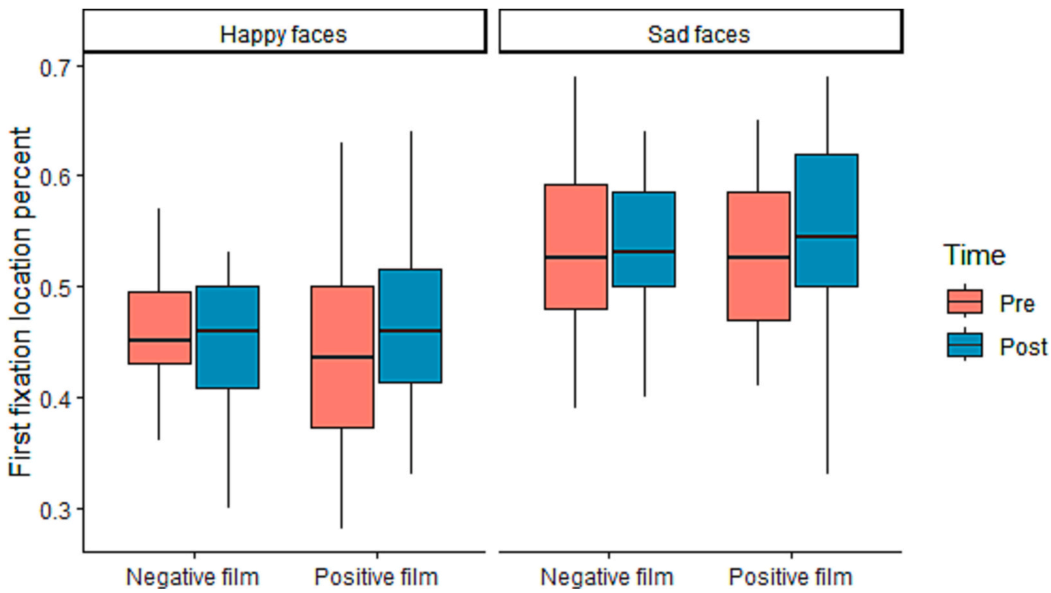


Fig. 2. Boxplots presenting first fixation location percent (i.e., number of first fixations on the emotional AOI divided by the total number of first fixations on both AOIs) by Emotion (sad, happy), Group (negative film, positive film), and Time (pre, post).

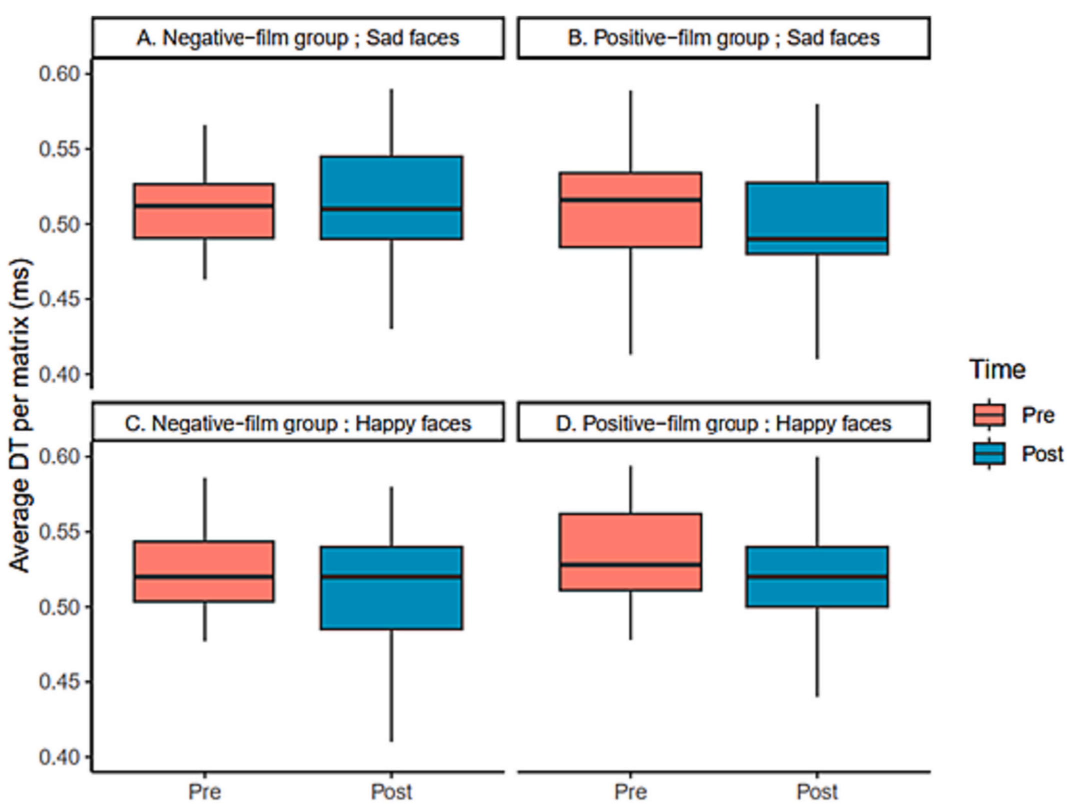


Fig. 3. Boxplots presenting attention allocation (dwell time percent; DT%) by Group (negative film, positive film), Time (pre, post), and Emotion (sad, happy).

software for conducting the analysis (Love et al., 2019; van Doorn et al., 2021). Bayesian inference affords a probabilistic inference about whether the collected data is non-diagnostic (i.e., can be predicted equally by both the null and the alternative hypotheses), and can suggest quantifiable evidence to evaluate whether it supports the absence of an effect (i.e., the null hypothesis), which is represented by the *Delta* (δ) measure of effect size.

Our null hypothesis (H_0) postulated that there is no difference in pre- vs. post-film attention allocation to emotional stimuli (i.e., sad and happy faces; AOI), therefore H_0 hypothesizes that $\delta = 0$. The two-sided alternative hypothesis (H_1) hypothesizes that $\delta \neq 0$, therefore, an effect for a mean difference in attention allocation between pre- and post-elicitation is expected, in a valence-congruent direction. Effect size δ was assigned a Cauchy prior distribution with the standard $r = 1/\sqrt{2}$ (Rouder et al., 2009; van Doorn et al., 2021). The outcome of our analysis was the Bayes Factor (*BF*), representing the likelihood of our data under H_0 over H_1, or vice versa. To present the results in an intuitive way, we calculated the probability of the null hypothesis over the

Journal of Affective Disorders 347 (2024) 619–629

alternative hypothesis (BF_0) as the main outcome. We also present the mirrored Bayes Factor for the alternative H_1 Hypothesis (BF_1). Thus, a BF_0 value larger than one means that the evidence is in favor of the null hypothesis, and a BF_0 value smaller than one means that the evidence is in favor of the alternative hypothesis. BF_1 values represent the exact opposite conclusions. Results are interpreted in light of Jeffrey's scale and recommendations (Jeffreys, 1939): *BF* between 1 and 3 = anecdotal evidence; *BF* between 3 and 10 = moderate evidence; and *BF* between 10 and 30 = strong evidence.

Fig. 4 depicts the results of the Bayesian analysis. Among the negative-film group, the data suggest moderate evidence in favor of the null hypothesis, indicating that given observed data it is ~5-fold more likely that sad MEP does not affect attention allocation toward sad faces, $BF_0 = 5.14$, *Median* $\delta = 0.01$, *95 % CI* = -0.34 to 0.34, or happy faces, $BF_0 = 5.06$, *Median* $\delta = -0.03$, *95 % CI* = -0.37 to 0.31. Among the positive-film group, the Bayesian analysis suggested anecdotal evidence toward lack of effect of the happy MEP on attention allocation, indicating that the likelihood that the happy MEP did not modify attention allocation to sad faces was only 1.64-fold more likely than the likelihood of such affect, $BF_0 = 1.64$, *Median* $\delta = 0.27$, *95 % CI* = -0.08 to 0.62, and 2.72-fold more likely regarding attention allocation to happy faces, $BF_0 = 2.72$, *Median* $\delta = 0.20$, *95 % CI* = -0.15 to 0.55.

3.2.2.2.3. Exploratory analyses – first five matrices. To try and explore whether the null findings related to mood elicitation (i.e., no effects involving Time) may be related to a "decay" of the mood elicitation (i.e., short duration of the resultant mood), we repeated the above-described main analysis while modeling DT% of the first 5 matrices of the post-film assessment only, instead of averaging all 30 matrices per block.[8] Since emotional decay is only relevant for emotion-congruent stimuli, we only included participants for whom the first block at post-film assessment matched their mood elicitation valence (e.g., for participants in the negative film group we only included those for whom the first post-film block was the SN block, not those who completed the HN block first). As block order was counterbalanced across participants within each group, this resulted in 15 participants per group. Here, too, results did not reveal any significant effects involving Time (Table S12).

4. Discussion

The present study examined the mood-congruency hypothesis of attention allocation, namely, that one's attention allocation is reflective of one's current mood states. In Study 1 we developed and validated a video-based MEP aimed at eliciting either a sad or a happy mood state, with results showing significant mood alterations in the intended direction. This procedure was then used in Study 2 to evaluate whether elicited mood (sad or happy), would result in a congruent modification of attention allocation patterns following the procedure. While a significant mood elicitation was once again achieved, replicating the findings of Study 1, no findings emerged for ensuing attention allocation – neither in early nor in late attentional features. This (unexpected) null finding as to sustained attention were supported by a Bayesian analysis of pre-to-post changes in attention allocation.

The present lack of support for the mood congruency hypothesis echoes mixed findings in the field (Becker and Leinenger, 2011; Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Tamir and Robinson, 2007; Wadlinger and Isaacowitz, 2006). Yet, the present research entails several advantages over past research that should be noted. First, we rigorously pre-validated our mood elicitation paradigm, while using a (visual) modality that matches that of the attention allocation task, which is crucial for assessing selective attention (Mozolic et al., 2008). Second, we focused on both positive (happy) and negative (sad) mood elicitation, enabling the exploration of the potential specificity of the mood-congruency hypothesis (Newman and Sears, 2015; Wadlinger and Isaacowitz, 2006). Third, we used an eye-tracking-based attention task, which entails several advantages over RT-based tasks (Armstrong and Olatunji, 2012; Lazarov et al., 2018). Relatedly, the specific eye-tracking task used to assess attention is a well-validated one (for a meta-analysis see Shamai-Leshem et al., 2023; for specific studies see (Basel et al., 2022; Lazarov et al., 2019b, 2021a, 2021b; McNamara et al., 2022; Shamai-Leshem et al., 2021)), also showing adequate psychometrics in the present study. Finally, attention allocation was also assessed before the mood elicitation, not only following it (Isaacowitz et al., 2008; Newman and Sears, 2015; Sanchez et al., 2014; Wadlinger and Isaacowitz, 2006), increasing confidence that any changes in attention which may arise could be more directly related to the preceding mood elicitation.

Current results also showed that participants dwelled longer on happy faces, compared with sad faces, across groups and assessment points. This result resonates nicely with the notion of a "protective bias" among non-depressed individuals – favoring positive over negative or neutral information (Dunn et al., 2009; Karparova et al., 2007; McCabe and Gotlib, 1995). Experimentally, it is also in line with eye-tracking studies of attention allocation in depression which show that non-depressed participants are biased in favor of positive stimuli (Armstrong and Olatunji, 2012; Duque and Vázquez, 2015; Rudich-Strassler et al., 2022), including studies using the same attention allocation task employed here (Basel et al., 2022; Lazarov et al., 2018; Shamai-Leshem et al., 2021). The fact that this positive bias emerged non-contingent on mood elicitation also echoes the conclusions of a recent meta-analysis on attention biases in previously depressed individuals that found an increased attention allocation to positive content among never-depressed individuals, compared to both currently and previously depressed participants, which was not moderated by the use of mood elicitation procedures (Shamai-Leshem et al., 2022). Thus, present results strengthen the notion that among non-depressed individuals, positively biased attention allocation is a trait-like feature, rather than a state-like mood-dependent one.

Interestingly, contrary to the DT% results indicating sustained attention on the happy over sad faces, results of first fixation location showed that across both groups and assessment points participants made more first fixations on sad faces than on happy faces, reflective of attentional capture (i.e., vigilance) by negative/dysphoric stimuli. This finding is in line with previous research showing that negative information has precedence over positive information in (automatic) capturing one's attention (Carretié, 2014). More relevant to the present study, this finding also echoes previous mood manipulation eye-tracking studies showing that participants allocate more attention to positive images (i.e., sustained their attention) following a sad mood induction (a mood-incongruency effect on attention), suggesting that this attentional pattern may reflect an affect regulation strategy related to mood repair (Newman and Sears, 2015; Sanchez et al., 2014; Speirs et al., 2018). These studies, however, only assessed sustained attention (i.e., dwell time or total fixation count), with no measures of early attention allocation following the mood induction. Considering present findings of vigilance to sad faces suggests that the proposed "mood repair" process via sustained attention on positive stimuli may be also related to the general phenomenon of early attention allocation to sad stimuli in one's environment, not exclusively to the induced sad mood. The fact that in the present study this vigilance was evident in both groups, coupled with subsequent sustained attention on happy faces, both before and after the MEP, strengthens this possibility. Put differently, it is possible that among healthy individuals a general vigilance tendency toward dysphoric content is then compensated via sustained attention on extant positive cues in one's environment.

Our study has several limitations that should be acknowledged. First, the present study explored the mood-congruency hypothesis using a

[8] While our pilot study showed efficient mood elicitation by the emotional film at post-film assessment, its natural decay (i.e., for how long does the elicited mood sustain before regressing to baseline levels) was unknown.

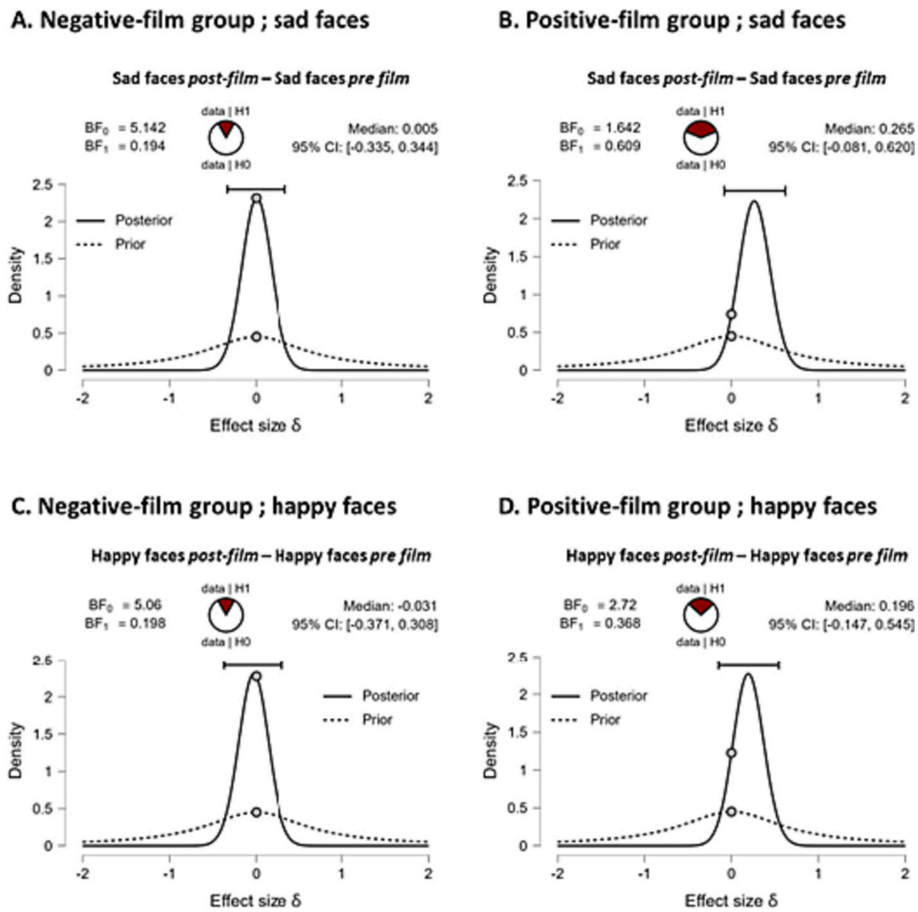


Fig. 4. Within-group Bayesian analysis of pre-elicitation to post-elicitation changes in dwell time percent (DT%) on emotional (sad/happy) faces. Dashed lines represent the estimated prior distribution, centered around effect size $\delta = 0$ (no effect). Continuous lines represent the data-informed posterior distribution. Narrower distributions represent higher confidence in the effect; *BF_0 – Bayes Factor H_0*, represents the likelihood of H_0 over H_1 given the data; *BF_1 – Bayes Factor H_1*, represents the likelihood of H_1 over H_0 given the data; Horizontal error bars represent posterior confidence intervals; Pie charts represent the normalized likelihoods of H_1 (red surface) and H_0 (white surface) given the data. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

mood elicitation procedure among non-selected participants. Hence, it is still possible that congruent mood states do affect attention allocation, but only among those who are at risk for depression (i.e., possessing an attentional diathesis activated by current negative mood) or, alternatively, who are currently depressed (i.e., current depression symptom as moderating the association between current mood states and attention allocation), as suggested by prior research in the field (Erickson et al., 2005; Koster et al., 2005, 2010). Future studies could replicate the present procedures among at-risk and/or depressed participants. Second, while we did demonstrate the effectivity of the MEP, its duration remains to be explored. Put differently, the mood elicited may have rapidly decayed, such that participants were truly affected by the mood elicitation, but only short-term, returning to their baseline levels shortly after commencing the attention task. Indeed, prior research has explored this very question – how long does an elicited mood last – but with mixed results (Kuijsters et al., 2016). Some found no supporting evidence for the persistence of an induced mood, which tended to decay rapidly following an intervening task (i.e., a task completed after a mood induction and before the mood re-assessment, similar to the present procedure with the attention task serving as the intervening task) or a waiting period (Frost and Green, 1982; Gillies and Dozois, 2021). Conversely, others have shown a more lasting mood induction (i.e., following an intervening task or a time period), albeit subsequent mood assessment was usually conducted in a matter of minutes following the initial one (Chou et al., 2007; Kliegel et al., 2007; Kuijsters et al., 2016). In trying to address this issue we performed an exploratory analysis of only the first 5 matrices following mood elicitation. While this yielded no significant findings, this exploratory analysis could only use a small subsample of participants, lowering statistical power. To better address the potential issue of rapidly decaying mood effects future studies could conduct a second post-film mood assessment following the completion of the post-film attention task to verify the durability of the induced mood, or alternatively, "combine" the MEP and attention task by interspersing the eye tracking trials within the film paradigm (in-between individual clips). Relatedly, the current MEP, while effective, remains somewhat artificial, not fully comparable with "natural" sad or positive mood states stemming from real-life situations/events (e.g., experiencing a dispute with one's partner vs celebrating an achievement). Third, all face stimuli of the attention task were chosen from the KDEF database, which includes only White actors. Hence, only white faces were used, rendering the task not ethnically diverse. This, in turn, hinders the ability to generalize present findings/conclusions to other ethnic groups (Dickter and Bartholow, 2007). While in the present study all participants were also white (matching the presented stimuli), future research should rectify this shortcoming by using more racially diverse face stimuli. Fourth, participants in both studies were predominantly female (71 % in Study 1, 78 % in Study 2), which may potentially limit the generalizability of our results, especially of Study 1. Future research could replicate the present studies while using more gender-balanced samples. Finally, sad and happy faces that were separately presented alongside neutral ones in the attention task. Using matrices directly contrasting happy and sad faces may increase the ability to find mood-congruent attentional shifts, especially as models of depression postulate a "double" bias in the disorder. Moreover, a previous research using the same attentional paradigm with sad-happy matrices has found differences between depressed and non-depressed participants in sustained attention (Lazarov et al., 2018).

In sum, the present research found no evidence in support of the mood-congruency hypothesis of attention allocation (Koster et al., 2010) among non-selected healthy participants, either in early or late attentional features. Yet, present results do strengthen the notion of attentional "protective" or "pink" glasses among non-depressed individuals following an enhanced detection of dysphoric stimuli, which may be construed as a trait, rather than a mood-contingent state, characteristic.

Declaration of competing interest

The other authors have no financial disclosures. We wish to confirm that there are no known potential conflicts of interest associated with this publication.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2023.12.004.

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