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Research paper

Looks interesting: Attention allocation in depression when using a news website – An eye tracking study

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ABSTRACT

Background: Eye-tracking-based attention research has shown attentional biases toward dysphoric and away from positive stimuli in depression. However, most research used prototypical stimuli (co-presented contrasting emotional faces/pictures), less reflective of real-life situations. The current study addressed this limitation by examining participants' attentional allocation patterns while freely viewing a news website containing dysphoric and positive news articles.

Methods: Participants with high levels of depression (HD; n = 30) and with minimal levels of depression (MD; n = 30) freely viewed a fictitious news website for 3.5 min, containing six articles (picture + text) with dysphoric content and six with positive content. Gaze patterns on corresponding areas of interest (AOIs) were compared. Following the task, participants rated each article's valence, authenticity, and interest.

Results: Compared to MD participants, HD participants spent more time dwelling on dysphoric articles and less time dwelling on positive articles. Within group analyses showed that while HD participants spent more time dwelling on dysphoric compared to positive articles, MD participants showed no preference, allocating their attention equally to both article types. Echoing within-group gaze patterns, HD participants rated the dysphoric articles as being more interesting than the positive articles, while MD participants rated both types of articles as being equally interesting.

Conclusion: Attentional biases in depression were also evident when using a more ecologically valid task such as viewing a news website, manifesting as increase attention allocation to dysphoric over positive content. This attention pattern may be related to corresponding differences in the level of interest participants found in each article type.

1. Introduction

Major Depressive Disorder (MDD) is a persistent and debilitating psychiatric disorder, with a world-wide prevalence rate of about 5%, and a lifetime prevalence rate at around 15% (for a review see Kessler and Bromet, 2013). It is characterized by nine main symptoms – depressed mood, anhedonia (i.e., reduced motivation or ability to experience pleasure), significant changes in sleep and weight/appetite, psychomotor agitation or retardation, fatigue or loss of energy, feelings of worthlessness or excessive/inappropriate guilt, diminished concentration or indecisiveness, and suicidal ideation (American Psychiatric Association, 2013). Depression is ranked as the leading non-fatal disability cause by the World Health Organization (Friedrich, 2017; World Health Organization, 2017), and without adequate treatment, it can lead to a variety of emotional and physical problems, seriously decreasing one's adaptive functioning and well-being (American Psychiatric Association, 2013).

Cognitive models of depression suggest that attention biases contribute to the onset and maintenance of the disorder (for theoretical reviews see Gotlib and Joormann, 2010; LeMoult and Gotlib, 2019). While some implicate attentional biases toward dysphoric over positive or neutral information in depression (e.g., Dalgleish and Watts, 1990; De Raedt and Koster, 2010; Klawohn et al., 2020; Koster et al., 2011; Peckham et al., 2010), others suggest lack of a normative or "protective" bias toward positive over neutral information, typical of non-depressed individuals (e.g., Bodenschatz et al., 2019; Shane and Peterson, 2007). These two biases, which are not mutually exclusive, often operating conjointly (Duque and Vazquez, 2015; Lazarov et al., 2018), have been widely established in early attentional studies using first-generation reaction-time (RT)-based tasks (for a systematic review and meta-

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analysis see Gotlib and Joormann, 2010; Peckham et al., 2010), and in more advanced eye-tracking-based research (Duque and Vazquez, 2015; Lazarov et al., 2018; Lu et al., 2017; for a recent systematic review and meta-analysis see Suslow et al., 2020).[1] Eye-tracking research has further elucidated the specific nature of attention biases in depression, showing them to manifest mainly in sustained attention (i.e., increased attention maintenance on dysphoric information and decreased maintenance on positive information), and less so in early processes of attentional vigilance (for systematic reviews and meta-analyses see Armstrong and Olatunji, 2012; Suslow et al., 2020).

Despite these promising results, most eye-tracking studies in depression have included very prototypical stimuli, namely, co-presented contrasting emotional faces or pictures (i.e., positive/neutral vs dysphoric/negative), with no real-world contexts for their presentation (Suslow et al., 2020). This may less accurately represent daily situations more commonly encountered by depressed individuals, questioning the ecological validity of emergent findings. For example, we have recently shown contradictory patterns of attention allocation among socially anxious individuals depending on context – while social anxiety was found to be related to sustained attention on threat cues when presenting traditional contrasting emotional face stimuli (disgust vs neutral faces; Lazarov et al., 2016), exploring attention allocation when viewing a genuine Facebook profile page surprisingly revealed avoidance of socially threatening pictures among socially anxious individuals (Elias et al., 2021). This divergence in results demonstrates the importance of examining attention processes in more ecological valid contexts/tasks (Shechner et al., 2012). To the best of our knowledge, only one study in depression to date has attempted to address this issue by using more real-world stimuli – depressive and neutral internet memes, with results showing depressed participants to fixate more and spent more time observing the depressive memes (Akram et al., 2021). However, while these stimuli may be considered as more contemporary real-world stimuli, they were still presented in contrasting pairs, and out of the context in which they usually appear, namely, internet-based social platforms (Akram et al., 2021).

The current study aimed to examine attention allocation in depression using an ecological valid task – when participants use an internet news website. Many use news websites on a daily basis to keep updated with current events. These sites contain news articles of varying emotional value, some devoted to dysphoric content (e.g., the hardship of the elderly), and some to describing more positive/happier events (e.g., the international success of a favorable national sports team). Hence, this platform may serve as a more ecological space to explore attentional patterns among depressed individuals. Moreover, research on usage of news websites in depression has shown that depressed individuals tend to use the internet more frequently compared with non-depressed individuals (Ha et al., 2006; Ko et al., 2009; Ko et al., 2012; Young and Rogers, 1998), and to report higher levels of negative emotions and lower levels of positive emotions after watching the news (Potts and Sanchez, 1994). Research has also found an association between depressive symptoms and consumption of negative news (Dutta-Bergman, 2005; Olagoke et al., 2020). Taken together, these lines of evidence demonstrate the relevance of internet usage to depression, highlighting the importance of also exploring corresponding attention allocation patterns in this setting.

Here, gaze patterns of individuals with high levels of depression symptoms and participants with minimal levels of depression symptoms (reflecting non-depressed control participants) were recorded, while participants freely used/viewed a fictitious news website programmed especially for the present study. The news website contained 12 different news articles – six dysphoric and six positive – each article comprised of a pictorial and a textual section as customary on different news websites (see Fig. S1). Based on previous attentional eye-tracking studies in depression, we expected the two groups to show different attention allocation patterns while viewing the opposing valenced news articles. Specifically, we predicted that relative to participants with low levels of depression symptoms, those with high depression levels would show an attention allocation pattern favoring dysphoric articles over positive ones to a higher extent.

2. Method

2.1. Participants

Participants were first-year college students with high levels of depression symptoms (HD) and college students with minimal levels of depression symptoms (MD), reflecting non-depressed control participants. Two hundred and ninety-eight college students completed the Beck Depression Inventory (BDI-II; Beck et al., 1996) and the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) questionnaires at the beginning of the academic year. Students who scored 14 and above on the BDI-II, a score representing mild depression (Beck et al., 1996; Dozois et al., 1998), and also 10 and above on the PHQ-9, representing moderate depressive symptoms (Kroenke et al., 2001; Manea et al., 2012), were deemed eligible for participation and hence contacted by phone and invited to participate in the study. Those who accepted constituted the HD group (n = 30; 22 females; *Mage* = 22.73, *SD* = 2.06, *Range* = 18–26). Participants scoring above the cutoff score on one measure, but not on the other, were not invited to participate in the study (e.g., a BDI-II score of 15 but coupled with a PHQ-9 score of 9; a PHQ-9 score of 11 with a BDI-II score of 12). The MD group (n = 30; 21 females; *Mage* = 22.8, *SD* = 1.86, *Range* = 19–26) were recruited among students who scored at the bottom of the BDI-II sampling pool, contingent on having a BDI-II score < 12, which reflects non-depression (Dozois et al., 1998), with all MD participants included in the final sample actually scoring below 8. MD participants also needed to score below 5 on the PHQ-9, a score reflecting minimal depression (Kroenke et al., 2001). As noted for the HD group, here, too, participants had to score below both these scores to be included in the MD group. Clinical characteristics by group are described in Table 1. All participants provided informed consent and received course credit for their participation.

The study protocol was approved by the Research Ethics Council of Tel-Aviv University. We only invited participants that had normal or corrected-to normal vision, excluding usage of multi-focal eyewear to prevent eye-tracking calibration difficulties.

2.2. Measures

2.2.1. Depression

Self-reported measures of depression were assessed using the BDI-II (Beck et al., 1996) and the PHQ-9 (Kroenke et al., 2001). The BDI-II is

Table 1
Demographic and psychopathological characteristics per group.

Measure	HD group (n = 30)		MD group (n = 30)		*p* value
	M	*SD*	*M*	*SD*	
Age	22.73	2.06	22.8	1.86	0.89
Gender ratio (F:M)	22:8	–	21:9	–	0.77
BDI-II	19.7	9.24	4.36	3.97	<0.001
PHQ-9	12	5.24	2.53	2.06	<0.001
STAI-T	55.3	9.82	30.23	7.67	<0.001

Note. HD, high depression; MD, minimal depression; BDI-II, Beck Depression Inventory-II; PHQ-9, Patient Health Questionnaire-9; STAI-Trait, State-Trait Anxiety Inventory-Trait subscale.

[1] In eye-tracking studies of attention allocation in depression, presented information is usually either sad and happy faces (e.g., Duque and Vazquez, 2015; Lazarov et al., 2018), or dysphoric and positive pictures (e.g., Eizenman et al., 2003).

a 21-item self-report questionnaire evaluating symptoms of depression related to the past two weeks. The BDI-II has good internal consistency of 0.90, and adequate convergent validity, showing significant correlations of about 0.70 with several other self-report depression scales. The BDI-II also shows sufficient discriminant validity, showing lower but significant correlations of about 0.60 with anxiety scales (Segal et al., 2008). The PHQ-9 is a 9-item self-report questionnaire evaluating symptoms of MDD according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013). Each item corresponds to one of the nine symptoms of depression, rated in relation to the previous two weeks. The PHQ-9 has good reliability, both internal consistency (around 0.89) and test-retest reliability (0.84), as well as adequate validity, showing strong correlations with mental health measures (0.73), measures of social functioning (0.52), role functioning (0.43), physical functioning (0.37), bodily pain (0.33), and symptom-related difficulty (0.55; Kroenke et al., 2001).

2.2.2. Anxiety

As depression and anxiety commonly co-occur (Essau et al., 2018), we also assessed participants' trait anxiety, which allowed us to control for anxiety levels when analyzing potential group differences on the different dependent measures (see Data analysis section below). Self-reported trait anxiety was assessed using the 20-item State-Trait Anxiety Inventory-Trait questionnaire (STAI-T; Spielberger et al., 1983). Each item on the STAI-T is a sentence that people usually use to describe themselves and respondents are asked to rate how well each sentence describe them in general. The STAI-T has good internal consistency reliability, ranging between 0.86 and 0.91, and test-retest reliability. Considerable evidence also attests to its validity, showing high correlations with other anxiety measures (Balsamo et al., 2013; Spielberger and Vagg, 1984).

2.3. The news website eye-tracking task

2.3.1. Task description

During the task participants freely viewed a specially designed news website containing 12 news articles, six dysphoric and six positive, for 3.5 min. The news articles were arranged in six consecutive rows, each row displaying two articles positioned side by side – one positive and one dysphoric. Each article consisted of a picture, a title, and a short textual description as customary on most news websites. The structure of all articles was identical, including a picture of the same size (500 × 300 pixels), and text of similar length (i.e., one and a half rows for the title [$M_{\text{word-count}} = 7.16$], and four rows containing a short description of the article's content [$M_{\text{word-count}} = 22.5$]), for an overall size of 1045 × 300 pixels (see Fig. S1 for an example). Two different versions of the website were created, differing on articles location within the website, which were randomized across participants to eliminate article presentation order as a possible confound. Participants were allowed to scroll up and down the website page, but were asked to refrain from clicking on specific articles.

The adequacy of the dysphoric and positive articles was ascertained in a preliminary pilot study, verifying that the two article types differed only in their valence, but not in authenticity and interest levels. Specifically, 25 potential articles were prepared and then rated by 24 non-selected participants on a 7-point scale in terms of their valence (1 = *sad*; 7 = *happy*), authenticity (0 = *not authentic at all*; 7 = *very authentic*), and interest (0 = *not interesting at all*; 7 = *very interesting)*. Authenticity and interest were assessed to verify that the final pool of pictures per article type (i.e., dysphoric, positive) did not differ on these measures. The six most positive and six most dysphoric articles out of the 25 rated articles were chosen for the study (see Table 2 for the final ratings of each article type used in the study). Paired sample *t*-tests were used to compare valence, authenticity, and interest ratings between the dysphoric and the positive articles (see Results section below). Finally, we also measured the time it took participants to go through the entire website page and read the 12 included articles.

Table 2
Article ratings per article type – pilot study results.

Measure	Dysphoric articles (n = 6)		Positive articles (n = 6)		*p* value
	M	*SD*	*M*	*SD*	
Valence	1.68	0.82	5.5	0.52	<0.001
Authenticity	5.47	0.82	5.42	0.67	0.76
Interest	4.32	1.2	4.05	0.68	0.34

2.3.2. Eye-tracking measures – total dwell time (in seconds) and fixation count

Eye-gaze data were collected using EyeLink Data Viewer software (SR-research, Ottawa, Ontario, Canada). Fixations were defined as at least 100 ms of stable fixation within 1-degree visual angle. For analysis of collected eye-gaze data, we defined two Areas of Interest (AOIs), one including the six dysphoric articles (i.e., the dysphoric AOI) and one including the six positive articles (i.e., the positive AOI). *Total dwell time* per article type/AOI was calculated as the sum of dwell time (in seconds) that each participant spent on each AOI during the 3.5 min of viewing the news website. As a secondary measure of attention allocation, we also assessed *fixation count* – the total number of fixations made in each of the two AOIs.

2.3.3. Subjective article ratings – valence, authenticity, and interest

Following the completion of the free-viewing task, participants completed three article rating scales, similar to those used in the preliminary pilot study, namely, valence, authenticity, and interest. Specifically, participants were presented with each of the 12 included articles, one by one, and were asked to rate on a 1-to-7 scale the following for each article: 1) the emotional valence the article evoked in them (1 = *sad*; 7 = *happy*); 2) how authentic they believed the article to be (1 = *not authentic at all*; 7 = *very authentic*); and 3) how interesting they thought the article was (1 = *not interesting at all*; 7 = *very interesting*). For each participant we then aggregated the scores of the six positive articles and the six dysphoric articles, for a final score per participant ranging from 6 to 42 for each article type.

2.4. Apparatus

Eye-tracking data were collected and recorded using the remote head-free high-speed EyeLink Portable-Duo apparatus and the recently developed WebLink screen recording 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.

2.5. General procedure

The study took place in a small and quiet room at the University. Participants were told that they would participate in an eye-tracking-based pilot study examining a new university news website about to go online in the near future, to examine its appeal and usability for future users. They were also told that the articles on the site, while based on true events, were not necessarily "up-to-date" as the main aim of the study was to visually simulate the appearance of the to-be-launched news website. Next, participants were informed that the news website would be presented for about three minutes, during which they were able to scroll up and down at will, but that no other action (i.e., clicking on a specific article) was feasible as this was a pilot version of the website. No other requirements were made except for freely viewing the news website page. Participants then signed informed consent and were seated in front of the eye-tracking monitor. A 5-point calibration followed by 5-point validation was then performed, providing the required

reference data for computing gaze positions. The calibration procedure was repeated if visual deviation was above 0.5° on the X or Y axes for each calibration point. The experiment did not ensue until such parameters were achieved. The news website was then automatically displayed on the computer monitor for 3.5 min (each participant was randomized to view one of the two versions of the news website). Finally, participants completed the article rating questionnaire described above and the additional measures (i.e., BDI-II, PHQ-9, STAI-T). Upon completion of the study, participants were debriefed and received the course credit for their participation.

2.6. Data analysis

A sample size of 60 has a power of 80% to detect a Group-by-AOI interaction of an effect size similar to that reported in previous eye-tracking studies on attention allocation in depression (Basel et al., 2021; Klawohn et al., 2020; Lazarov et al., 2018). Hence, 30 participants per group were determined as the target sample size for this study. Power analysis was performed using G*Power 3.1.9.4 (Faul et al., 2007).

The internal consistency reliability of the different questionnaires (i.e., BDI-II, PHQ-9, STAI-T) used in the study was assessed using Cronbach's Alpha (Cronbach, 1951), a measure indicating whether the different items of a given scale/questionnaire measure the same construct or concept, hence reflecting the inter-relatedness of the items within the scale/questionnaire (Tavakol and Dennick, 2011).

Independent sample *t*-tests were used to compare groups on descriptive characteristics (e.g., BDI-II, PHQ-9, age) and a Chi-square test was used to compare groups on gender ratio.

To examine group differences in total dwell time on the two article types, we performed a repeated-measures analysis of variance (ANOVA) with group (HD, MD) as a between-subject factor and article type/AOI (dysphoric, positive) as a within-subject factor. Follow up analysis included simple effect analyses to further explicate significant findings. As groups differed on trait anxiety, we performed analysis of covariance (ANCOVA) for significant findings entering STAI-T scores as a covariate to the above-described analyses. Similar analyses were also performed on total fixation count.

To examine group differences in subjective article ratings in terms of valence (i.e., the emotional valence each article evoked in participants), authenticity (how authentic participants believed each article to be), and interest (how interesting participants found each article), we performed a repeated-measures ANOVA with group (HD, MD) as a between-subject factor and article type (dysphoric, positive) as a within-subject factor, for each subjective rating (i.e., valence, authenticity, interest).

All statistical tests were two-sided, using α of 0.05. Effect sizes for significant findings are reported using η^2_p for ANOVAs and *Cohen's d* for mean comparisons. Bonferroni correction was applied to multiple comparisons (Armstrong, 2014).

3. Results

3.1. Preliminary pilot study

As intended, a significant difference emerged only for picture valence, $t(23) = 18.11$, $p < .001$, *Cohen's d* = 3.69, but not for authenticity, $t(23) = 0.3$, $p = .76$, or interest, $t(23) = 0.96$, $p = .34$. Thus, our final set of articles was clearly of different valence, but with similar authenticity and interest ratings (see Table 2). Regarding completion time, as results indicated an average of 1.98 min (*SD* = 0.8), we decided on a presentation duration of 3.5 min of free viewing, by adding two standard deviations to the mean viewing time.

3.2. Data availability

The data that support the findings of this study are openly available in Open Science Foundation (OSF) at https://osf.io/aktfj/?view_only=d653bfddf46d4d91a9b377154502068e, including each participant's group, age, gender, eye-gaze data (i.e., dwell time and fixation count) per article type and content type, and subjective ratings (i.e., valence, authenticity, and interest) per article type.

3.3. Demographic characteristics

Cronbach's Alpha in the present sample was 0.93 for the BDI-II, 0.91 for the PHQ-9, and 0.96 for the STAI-T. Demographic and clinical characteristics of the two groups are described in Table 1. As expected, significant group differences emerged for BDI-II and PHQ-9 questionnaires. In addition, there was also a significant group difference on the STAI-T questionnaire. No differences emerged for age or gender ratio.

3.4. Attention allocation

3.4.1. Main analysis – eye-gaze data per article type

Total dwell time, in seconds, by group and article type (AOI) is presented in Fig. 1. As expected, a significant Group-by-AOI interaction emerged, $F(1,58) = 13.65$, $p < .001$, $\eta^2_p = 0.19$, indicating differential attention allocation patterns of the two groups with regard to the dysphoric and positive AOIs. Follow-up simple effects analysis comparing the two groups on each AOI revealed that the MD group spent significantly more time dwelling on the positive AOI ($M_{seconds} = 85.18$, $SD = 12.47$) compared with the HD group ($M_{seconds} = 76.57$, $SD = 13.69$), $t(58) = 2.54$, $p = .01$, *Cohen's d* = 0.65. For the dysphoric AOI an opposite pattern emerged, with the HD group spending significantly more time dwelling on dysphoric AOI ($M_{seconds} = 91.31$, $SD = 13.09$) than the MD group ($M_{seconds} = 80.18$, $SD = 12.87$), $t(58) = 3.32$, $p = .002$, *Cohen's d* = 0.85. Follow-up simple effects analysis comparing the two AOIs within each group showed that HD participants spent significantly more time dwelling on the dysphoric AOI compared to the positive AOI, $t(29) = 4.2$, $p < .001$, *Cohen's d* = −0.76. No significant difference between the two AOIs emerged within the MD participants, $t(29) = 1.24$, $p = .22$, reflecting an equal attention allocation to both AOIs. The Group-by-AOI interaction effect remained significant after introducing STAI-T scores as a covariate, $F(1,57) = 5.07$, $p = .03$, $\eta^2_p = 0.08$.

Analyzing fixation count revealed an identical pattern of results. In brief, results showed a significant Group-by-AOI interaction ($p < .001$) which remained significant following the introduction if STAI-T scores as a covariate ($p = .03$). Between-groups simple effects analysis showed that the MD group made more fixations on the positive AOI compared with the HD group ($p = .02$). For the dysphoric AOI an opposite pattern emerged, with the HD group making more fixations on the dysphoric AOI than the MD group ($p = .02$). Within-group analysis showed that HD

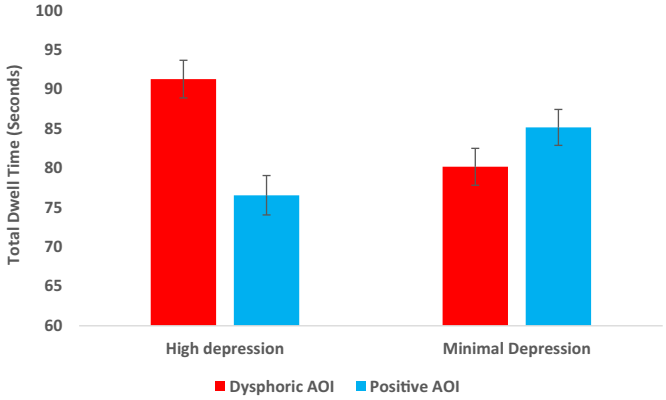

Fig. 1. Total dwell time (in seconds) by Group and Area of interest (AOI). Greater values indicate greater dwell time in seconds. Error bars denote standard error.

participants made more fixations on the dysphoric AOI compared to the positive AOI ($p < .001$) with no significant difference found for the MD participants ($p = .16$). See Supplementary material for a full description of the fixation count results.

3.4.2. Exploratory analysis - eye-gaze data per article type and content type

To deepen our understanding of the observed Group-by-Article type interaction, we decided to explore the potential specific effects of the pictorial and textual parts of the presented articles. Hence, each article was further divided into two separate areas of interest – picture and text. We then repeated the above-reported main analysis incorporating content type (picture, text) as a second within-subject variable and performed a repeated measures ANOVA with group (HD, MD) as a between-subject factor, and article type (dysphoric, positive) and content type (picture, text) as within-subject factors.

Results indicated a significant Group-by-Article type-by-Content type interaction effect, $F(1,58) = 12.15$, $p < .001$, $\eta^2_p = 0.17$. In addition, there was a main effect of content type, indicating that participants across both groups spent more time dwelling on text compared to pictures, $F(1,58) = 647.67$, $p < .001$, $\eta^2_p = 0.91$. To further explore this triple interaction, we performed two separate repeated measures ANOVAs with group (HD, MD) as a between-subjects factor and article type (dysphoric, positive) as a within-subject factor, one for each content type (picture, text). Total dwell time, in seconds, by group and article type for each content type is presented in Fig. 2. For the *Text* content type (Fig. 2b) a significant Group-by-AOI interaction emerged, $F(1,58) = 15.26$, $p < .001$, $\eta^2_p = 0.21$. Conversely, no significant Group-by-AOI interaction, $F(1,58) = 2.22$, $p = .14$, emerged for the *Picture* content type (Fig. 2a). Follow-up simple effects analyses showed that the HD group spent significantly more time dwelling on dysphoric text ($M = 77.27$, $SD = 14.52$) compared to the MD group ($M = 64.93$, $SD = 13.99$), $t(58) = 3.35$, $p = .001$, *Cohen's d* = 0.86. No significant group difference were noted for time spent dwelling on the positive text between the HD ($M = 63.52$, $SD = 11.72$) and MD ($M = 68.06$, $SD = 13.14$) groups, $t(58) = 1.41$, $p = .16$. Exploring within group simple effects showed the HD participants dwelled significantly longer on dysphoric text than on positive text, $t(29) = 4.54$, $p < .001$, *Cohen's d* = 0.83, while MD participants showed no significant difference between time spent dwelling on dysphoric and positive text, indicating an equal attention allocation pattern, $t(29) = 1.01$, $p = .31$.

Analyzing fixation count revealed, again, an identical pattern of results showing a main effect of content type as well as a significant Group-by-Article type-by-Content type interaction, which remained significant also after introducing STAI-T scores as a covariate. Similar to the dwell time results, a significant Group-by-AOI interaction emerged for the *Text* content type, but not for the *Picture* content type. Follow-up between-groups simple effects analysis showed that the HD group made significantly more fixations on dysphoric text compared to MD participants, with no group difference noted for fixations made on the positive text. Within-group simple effects analysis showed while HD participants made significantly more fixations on the dysphoric text compared to the positive text, MD participants showed no difference between the two AOIS, indicating an equal attention allocation pattern. See Supplementary material for a full description of the fixation count results.

3.4.3. Sensitivity analysis - eye-gaze data

To strengthen our confidence in emergent results and account for possible type-II errors, we conducted a sensitivity analysis by performing linear mixed-effects models, in which we included each article viewed by each participant as a separate observation (instead of separately aggregating dwell time on the dysphoric and positive article types/AOIs), resulting in 24 overall observations per participant (12 articles × 2 content type [picture/text]). Participants (N = 60), articles (k = 12) and content type (picture/text) were modeled as random factors, while valence (reference: positive) and group (reference: MD) were modeled as fixed factors. Specific article content (picture or text) that were not fixated by the participant were modeled as such, that is as zero dwell-time.[2]

The sensitivity analysis revealed a significant Group-by-Valence interaction effect across content types, $t(1,425) = 4.21$, $p < .0001$, *Standardized* $\beta = 0.28$, *95% CI* = 0.15, 0.41 (Table S1; Supplementary materials). Following the approach used in the main analysis, we stratified the analysis by content type and performed two separate models, one for each content type. Replicating the results of the main analysis, a significant Group-by-Valence interaction effect emerged for the textual-content model, $t(648) = 4.26$, $p < .0001$, *Standardized* $\beta = 0.58$, *95% CI* = 0.31, 0.85, but not for the pictorial-content model, $t(648) = 1.61$, $p = .11$ (Tables S2 and S3, respectively; Supplementary materials).

3.5. Subjective article ratings – valence, authenticity, and interest

Subjective article ratings by group are presented in Table 3.

3.5.1. Article valence

Only a main effect of article type emerged, $F(1,58) = 862.86$, $p < .001$, $\eta^2_p = 0.94$, with participants across both groups rating the dysphoric articles as provoking more sadness ($M = 1.50$, $SD = 0.62$) compared with the positive articles ($M = 5.64$, $SD = 0.67$), replicating the results of the above-described pilot study.

3.5.2. Article authenticity

As in the above-described pilot study, no significant findings emerged for authenticity.

3.5.3. Article interest

Article interest rating (i.e., how interesting participants found the articles to be) by group and article type is presented in Fig. 3. Results indicated a significant Group-by-Article valence type interaction, $F(1,58) = 6.04$, $p = .01$, $\eta^2_p = 0.09$. Follow-up simple effects analysis revealed that while MD participants did not differ in their rating of the dysphoric ($M = 4.56$, $SD = 1.29$) and positive ($M = 4.43$, $SD = 1.11$) articles, HD participants rated the dysphoric articles ($M = 4.72$, $SD = 0.83$) as significantly more interesting than the positive articles ($M = 3.83$, $SD = 0.88$), $t(29) = 3.9$, $p < .001$, *Cohen's d* = 0.72. Comparing groups on each article type showed that the HD group rated the positive articles ($M = 3.83$, $SD = 0.88$) as significantly less interesting than the low depression group ($M = 4.43$, $SD = 1.11$), $t(58) = 2.3$, $p = .02$, *Cohen's d* = 0.59. Conversely, no group differences emerged for the ratings of dysphoric articles, $t(58) = 0.59$, $p = .55$.

4. Discussion

The current study compared gaze patterns of participants with high levels of depression symptoms to those with minimal levels of depression while freely viewing a news website comprising positive and dysphoric news articles. Results showed that compared to MD participants, HD participants spent more time dwelling on dysphoric articles and less time dwelling on positive articles. Also, while HD participants spent more time dwelling on dysphoric compared to positive articles, no difference was noted among MD participants, that allocated their attention equally to both types of articles. Identical results also emerged for fixation count, our secondary eye-gaze index of attention allocation. Echoing within-group gaze patterns, HD participants rated dysphoric articles as being more interesting than positive articles, while MD participants rated both types of articles as equally interesting. MD

[2] Overall, 26 out of 1440 observations (1.8%) had zero dwell-time, all of which were of the picture content type. An alternative model in which these observations are considered as missing values ($N = 1414$) yielded similar results.

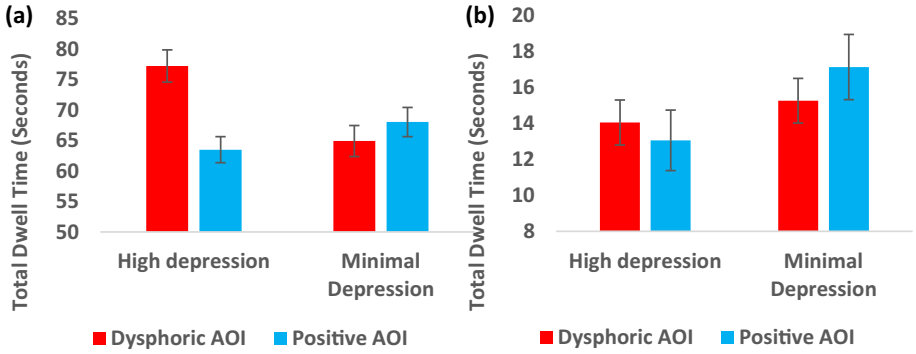

Fig. 2. Total dwell times (in seconds) by Group and Area of interest (AOI) for: (a) the textual section; (b) the pictorial section. Greater values indicate greater dwell time in seconds. Error bars denote standard error.

Table 3
Article ratings per group.

Measure	Valence	HD group (n = 30)		MD group (n = 30)		*p* value
		M	*SD*	*M*	*SD*	
Valence	Positive	5.44	0.58	5.85	0.7	NS
	Dysphoric	1.54	0.55	1.46	0.68	NS
Authenticity	Positive	5.18	1.03	5.27	1.28	NS
	Dysphoric	5.32	1.02	5.02	1.33	NS
Interest	Positive	3.83	0.88	4.43	1.11	0.02
	Dysphoric	4.72	0.83	4.56	1.29	NS

Note: HD, high depression; MD, minimal depression; NS, not significant; valence ratings range from 1 (sad) to 7 (happy); authenticity ratings range from 1 (not authentic at all) to 7 (very authentic); interest ratings range from 1 (not interesting at all) to 7 (very interesting).

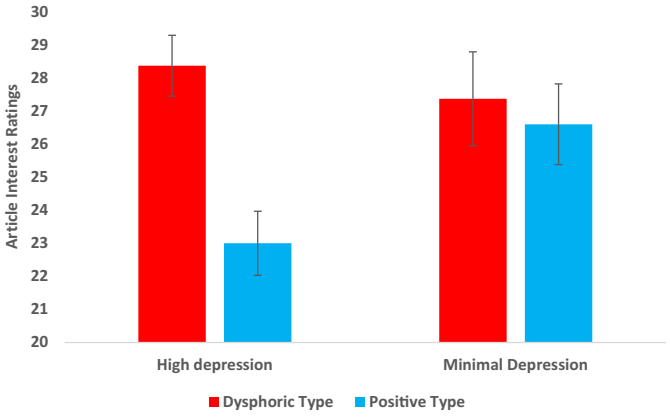

Fig. 3. Mean article interest ratings by Group and Article type. Greater values indicate greater article interest. Error bars denote standard error of the mean.

participants also rated the positive articles as more interesting than HD participants.

Results indicated that compared with MD participants, HD participants allocated more attention to dysphoric information and less attention to positive information, echoing the results of previous RT-based research (for a systematic review and meta-analysis see Gotlib and Joormann, 2010; Peckham et al., 2010) and eye-tracking research (for a review see Suslow et al., 2020), that demonstrated similar findings. However, the present study extends previous research by increasing ecological validity. Specifically, while past research has mainly used prototypical stimuli (i.e., co-presented contrasting emotional faces or pictures), with no real-world contexts for their presentation, lowering the ecological validity of emergent findings (Suslow et al., 2020), here we used a more ecological sound task – using an internet news website, which has been shown to be especially relevant to depression (Ha et al., 2006; Ko et al., 2009; Ko et al., 2012; Young and Rogers, 1998). Indeed, the importance of ecological validity in attentional research has been specifically emphasized (Elias et al., 2021; Richards et al., 2014), highlighting the need to use visual displays better resembling real-world settings. News websites seem like one such setting, as it is less limited by traditional standard laboratory settings, thereby more accurately replicating real-world online environments.

Group differences in time spent viewing the dysphoric AOI are also in line with the only previous eye-tracking study in depression that used multiple cues of contrasting dysphoric and positive valences, as was done in the present study, showing that compared to non-depressed participants, depressed participants (HD participants and patients with MDD) dwelled longer on sad faces (Lazarov et al., 2018). Importantly, in Lazarov et al. (2018) this difference emerged due to HD participants dividing their attention equally between happy and sad faces, while MD participants dwelled significantly longer on happy faces relative to sad faces, avoiding dysphoric content (see also Basel et al., 2021 for a replication). However, here a different results pattern emerged. Specifically, MD participants were the ones to equally allocate their attention between dysphoric and positive articles, while HD participants were inclined to allocate more attention to dysphoric articles over positive ones. One possible explanation for this divergence in dwelling patterns may be related to the context in which attention allocation was assessed (Elias et al., 2021; Garner et al., 2006; Shechner et al., 2012), namely, a realistic news site contacting real-life articles of different valences vs. contrasting static faces with different emotions which are rarely encountered in such a manner in real life. More specifically, the common nature of news websites we encounter every day may contribute to the context effects observed here. As news websites usually contain more dysphoric than positive articles (Garz, 2014; Haskins, 1981), making us all a-priori inclined to "look for" dysphoric content, avoidance of dysphoric stimuli in this context would result in a viewing pattern of equal attention allocation to both types of articles, as exemplified by MD participants. However, for HD participants this inclination is further intensified, leading to attention allocation favoring the dysphoric over the positive.

Exploring the separate contributions of the textual and pictorial parts within each article showed that our findings were mainly driven by articles' textual component. HD participants were found to spend more time fixating on dysphoric text compared with positive text, and compared with the time MD participants spent on dysphoric text. Conversely, no differences were noted for the pictorial component. The results of our sensitivity analysis strengthen the interpretation of this lack of group differences for pictorial content as reflecting actual gazing patterns rather than resulting from a lack of statistical power. This seems a bit surprising at first, considering previous findings in depression using different valenced pictures or faces that consistently show that depressed participants demonstrate attentional biases toward

dysphoric/sad content over positive/happy content (Duque and Vazquez, 2015; Eizenman et al., 2003; Kellough et al., 2008; Lazarov et al., 2018). What could explain this? One viable possibility is the co-presented textual information. In news websites it is common that pictures are presented alongside text, with the text serving as the main source of information. Thus, using news websites one learns over time that the textual section is more relevant for gaining information, considerably reducing the importance of the co-presented pictorial stimuli. Pertaining to the present study, this would suggest that no findings should emerge for the pictorial section because participants were more engaged with the textual component of each article, devoting less attention to the pictorial component. This assumption is supported by the main effect of content type showing that participants across both groups spent significantly more time dwelling on the text than on the picture of presented articles. Future research could further clarify this issue by replicating the current study using only text or only picture stimuli during the free viewing of the news website.

Groups also differed in their rating of how interesting they found the different article types to be. While HD participants rated the positive articles as less interesting than the dysphoric articles, MD participants found both dysphoric and positive articles as equally interesting (replicating the results of the non-selected participants in our pilot study). Interestingly, this results pattern matches the attention allocation of each group. HD participants dwelled more on the dysphoric articles, compared with positive ones, while MD participants allocated their attention equally to both types of articles. Hence, while exploratory, this finding could explain, at least partially, the attentional bias toward dysphoric content shown in HD participants – depressed people allocate more of their attention to dysphoric content, which they also find to be more interesting. This interpretation echoes previous findings in the field of motivation showing that compared to non-depressed individuals, depressed individuals are less motivated to experience happiness and more motivated to experience sadness (Millgram et al., 2019; Millgram et al., 2015), and that depressed people are less likely to use emotion regulation strategies to alter current dysphoric states (Millgram et al., 2019). Our findings are also congruent with studies from the realm of media consumption showing an association between consumption of dysphoric news (e.g., COVID-19; September 11) and depressive symptoms (Bendau et al., 2021; Dutta-Bergman, 2005; Olagoke et al., 2020). Taken together, present and past research may highlight an important association between greater interest in and more consumption of dysphoric news, attention allocation patterns, and depressive symptoms. Yet, the causality and directionality of these associations remain unclear, awaiting further research.

The current study has several limitations that should be acknowledged. First, the study examined college students with high and minimal levels of depression symptoms, not patients with clinical depression. Still, we used a BDI-II cutoff score of 14, representing mild depression (Beck et al., 1996; Dozois et al., 1998), coupled with a PHQ-9 cutoff score of 10, representing moderate depressive symptoms (Kroenke et al., 2001; Manea et al., 2012), as our inclusion criterion for the HD group. Moreover, individuals with sub-clinical mild depression have been shown to suffer from a wide range of symptoms that affect their quality of life and their immediate environment (Naismith et al., 2010; Swallow and Kuiper, 1992). Finally, internet news consumption is increasingly rising in the general population (Gentzkow, 2007; George, 2008). Hence, we believe that understanding the attentional allocation patterns of mildly depressed people has important clinical implications. Still, further studies should replicate the present one recruiting clinically diagnosed patients with MDD, comparing their performance on the task to non-depressed control participants. Future research could also explore the specificity of present finding to depression, by comparing task performance of MDD patients to that of patients diagnosed with other psychopathologies characterized by attention biases, such as PTSD (Lazarov et al., 2019), social anxiety disorder (Chen and Clarke, 2017; Elias et al., 2021; Lazarov et al., 2016; Lazarov et al., 2021), and generalized anxiety disorder (Goodwin et al., 2017). Second, the present study did not assess participants' daily internet consumption and habits. As discussed earlier, depressed people tend to use the internet more frequently and for longer durations than the general population, which may have affected some of the observed results. Future research should rectify this limitation by explicitly assessing daily internet consumption and exploring its associations with attention allocation patterns. Third, we employed a relatively small sample size. However, this sample size was determined following a formal power analysis based on previous similar research in the field. Furthermore, we also conducted a sensitivity analysis to ensure sufficient statistical power, especially where we suspected a possible type II error (i.e., regarding the null interaction in the pictorial content model). Also, despite this small sample size significant results emerged, demonstrating different gaze patterns between groups. Yet, future research could employ larger samples to increase the power and possibly detect additional group differences. Finally, in line with previous attentional studies in depression (Lazarov et al., 2018), the present study included dysphoric and positive articles. However, popular news websites also include other negatively-valenced articles, such as articles provoking fear or anger, which were not included in the present study, limiting the generalizability of obtained results. While previous research has shown that the attention allocation patterns of depressed individuals is more affected by the relativity of the presented stimuli's valence (i.e., depressed individuals lack of a general bias toward *relatively* positive stimuli over *relatively* negative stimuli) and less by the specific valence of contrasting stimuli (Basel et al., 2021), future research can replicate the present one while incorporating news articles of varying emotional content, such as fear-provoking or anger-provoking articles, to examine the specificity of obtained results to dysphoric vs. positive articles.

The aim of our study was to examine attentional allocation patterns in depression using a more ecologically valid environment – when using a news website. Our results suggest that depressed individuals may be biased toward dysphoric articles which they also find to be more interesting. These findings are important for understanding the mechanisms that preserve depressive symptoms, considering the association between internet usage, the consumption of dysphoric content, and depression. Moreover, while our website contained an equal proportion of dysphoric and positive articles, common news websites are usually a-priori negatively biased, containing more dysphoric and tragic events than positive stories (Van der Meer et al., 2020; van der Meer et al., 2019). This strengthens the importance of present findings, which may be even more pronounced when considering “real-world” news websites. The present work can be extended in the future by exploring attention patterns as these unfold when using real-world genuine news websites. Our findings may also suggest to address attention allocation patterns in depression when using news websites in extant treatment for depression, such as cognitive-behavioral therapy (CBT; Butler et al., 2006; Lopez-Lopez et al., 2019). Future work can explore the potential added therapeutic effect of addressing depression-related behaviors as they manifest not only in the “real” external world, but also in online internet-based environments. The present task may be also used as an additional platform for novel gaze-contingent attentional bias modification procedures designed to modify one's attention allocation away from dysphoric cues and toward more positive ones (Shamai-Leshem et al., 2021). Future work could address this possibility by, for example, implementing gaze-contingent reward feedback protocols while using the task, aiming to modify attention allocation away from dysphoric and toward positive content.

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CRediT authorship contribution statement

Anat Rudich-Strassler: Conceptualization, Investigation, Project administration, Data curation, Formal analysis, Writing - original draft

Nimrod Hertz-Palmor: Formal analysis, Writing - review & editing
Amit LAzarov: Conceptualization, Funding acquisition, Investigation, Resources, Supervision, Writing - review & editing

Authors' declaration

We declare that this manuscript is original and that it has not been published before or has been posted on a web site and that it is not currently being considered for publication elsewhere.

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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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Institutional board review

The authors assert that all procedures contributing to this work comply with APA ethical standards and with the Helsinki Declaration of 1975, as revised in 2008. All procedures were approved by the committees on human experimentation in Tel Aviv University.

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