Short Communication

Eye movement evidence for defocused attention in dysphoria — A perceptual span analysis

Aneta Brzezicka a,⁎, Izabela Krejtz a, Ulrich von Hecker b, Jochen Laubrock c

a Interdisciplinary Center for Applied Cognitive Studies, Warsaw School of Social Sciences and Humanities, Warsaw, Poland
b School of Psychology, Cardiff University, Cardiff, UK
c Department of Psychology, University of Potsdam, Potsdam, Germany

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A B S T R A C T

The defocused attention hypothesis (von Hecker and Meiser, 2005) assumes that negative mood broadens attention, whereas the analytical rumination hypothesis (Andrews and Thompson, 2009) suggests a narrowing of the attentional focus with depression. We tested these conflicting hypotheses by directly measuring the perceptual span in groups of dysphoric and control subjects, using eye tracking. In the moving window paradigm, information outside of a variable-width gaze-contingent window was masked during reading of sentences. In measures of sentence reading time and mean fixation duration, dysphoric subjects were more pronouncedly affected than controls by a reduced window size. This difference supports the defocused attention hypothesis and seems hard to reconcile with a narrowing of attentional focus.

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1. Introduction

Classical views on the influence of mood on information processing claim that negative affective states are associated with a narrowing of attention, a more systematic and analytical style of information processing, in which greater attention is paid to details, and the tendency to focus on one single thought or activity — most often negative and self-relevant — (e.g. Edwards and Weary, 1993; Gasper and Clore, 2002; Yost and Weary, 1996; review in: Andrews and Thomson, 2009). Some authors see a possible adaptive function of emotional states in general, and depressed mood in particular. According to these approaches, negative mood and depression itself is an adaptive mechanism that has evolved to face complex problems. Its assumed function is to minimize disruption and to sustain a subsequent analysis of those problems, thereby reducing the desire to engage in other activities that could be potentially be distracting from the perspective of the current problem. This approach to information processing in depression has been labeled as the analytical rumination theory (AR, Andrews and Thomson, 2009).

In contrast, there is also evidence to show that depressed individuals may sometimes attend to task-irrelevant information (von Hecker and Meiser, 2005), as they also often find it difficult to inhibit such information (Hertel, 1997, 1998; Hertel and Rude, 1991; Joormann, 2010). Such a defocused mode of attention is sometimes regarded as reflecting an adaptive mechanism which allows for seeking new opportunities or ways of problem solving, even if these may appear irrelevant or perceptually peripheral at the time. For example, according to the functional theory of emotion, experiencing sadness may be associated with a “do nothing and/or search for new plan” state which promotes an open, unselective and low-effort mode of attention (Oatley and Johnson-Laird, 1987) which then allows to perceive and process a greater variety of stimuli. If depressed mood is associated with defocused attention (DA), then one should be able to elicit even superior cognitive performance in the depressed as compared to nondepressed people when asking them about irrelevant aspects of a task that is being processed.

To examine this prediction with respect to memory performance, von Hecker and Meiser (2005) used a source monitoring paradigm that allows for separating various components of memory performance, relating to relevant and irrelevant aspects of the materials learnt. In their study participants had to learn 64 nouns that were presented individually on a computer screen, on either the left or the right side of the screen, and each surrounded by either a red or green frame. Participants were told that they later would be asked to recognize these 64 words as “old” when randomly presented amongst 64 distractors. Participants were also instructed to remember the location of each word for later identification. Importantly, participants were not told about remembering the frame color. In the test stage, however, participants were not only queried about old/new decisions for each presented test word and, if participants responded “old,” about the side on which that word had been presented on the screen, but they were also asked, additionally, what the color of its frame had been. This way, for each word they had...
classified as "old," participants attempted to recall one source dimension that had been relevant (location), and one that had been irrelevant (frame color) at the time of encoding. Results showed that nondepressed participants' memory for frame color (irrelevant contextual information) was virtually nil. The depressed group, on the other hand, showed above-chance memory for this irrelevant stimulus feature. A possible mechanism underlying better performance in the depressed group on tasks such as this may be connected with a different characteristic of the perceptual processes in the latter group. Maybe depressed people scan the environment in a way that results in perceiving a wider range of stimuli within the visual field, but do it rather superficially, as if searching for "something" new, that is, without any particular purpose — and without paying much attention to details. Hence, a less effective attentional filter could cause, e.g., more intrusions by irrelevant material into working memory. In any case, this approach is opposite to the traditional view holding that cognition in depressed mood is often operating in a local rather than global mode (e.g., Gasper and Clore, 2002).

To test the hypothesis about a wider scope of attention as a characteristic feature of mildly depressed people we directly measured the perceptual span during reading, using eye tracking. We were specifically interested in investigating defocused attention during reading. Using a moving window paradigm (McConkie and Rayner, 1975; Rayner, 1998) we assessed the size of the perceptual span, which in turn informed us about how dysphoric people acquire information during reading tasks.

1.1. Perceptual span

Useful information during reading is probed from a limited region around the fovea and the term perceptual span is used to denote this region. Perceptual span is defined as the width of the window of characters which one is able to attend to at each fixation during text reading (Rayner, 1975; Rayner et al., 1981; Bullimore and Bailey, 1995). In contrast to visual span, not all of the characters need to be identifiable within the perceptual span, but their characteristics (word length, spacing) influence planning and execution of the next eye movement. The perceptual span is asymmetric (Pollatsek et al., 1981), and as the decline in visual acuity away from the fovea is roughly symmetrical, the existence of asymmetry shows that the perceptual span is determined by attentional, in addition to structural, factors. Moreover, this asymmetry is functional as the area covered by the perceptual span is wider on the right side of the fovea for people whose reading direction is right to left, and wider on the left side for people whose reading direction is left to right (Pollatsek et al., 1981). Additionally, Miellet et al. (2009) showed that the perceptual span in reading is governed mainly by attentional factors. The size of the perceptual span (in characters) is typically smaller in languages such as Chinese with greater information content per character (1 character to the left, 3 characters to the right for readers of Chinese, compared to 3–4 characters to the left and 14–15 characters to the right for readers of English), but is roughly equal in terms of information conveyed, again suggesting that it is also limited by cognitive factors (Inhoff and Liu, 1998). Finally, the perceptual span can be dynamically modulated according to local processing difficulty. For example, the span gets smaller when more difficult words are processed (Henderson and Ferreira, 1990) or when visual search is performed under conditions with high attentional demands (Pomplun et al., 2001).

1.2. Moving window paradigm

The technique most commonly used to assess the perceptual span is the moving window paradigm as devised by McConkie and Rayner (1975), in which a region around a fixation point is designated as a "window" through which one can see the presented text or picture. As the eyes move, the display is modified so that all material within the window is seen normally whereas all material outside the window is masked. During reading participants can freely move their eyes, but the amount of useful information available on each fixation is thus controlled by the experimental program. The moving window technique is gaze-contingent, meaning that each time the eyes move, a new region of text is exposed, while the previously fixated region is masked. In our experiment, window size was defined in terms of characters, and characters as well as inter-word spaces outside of the window were filled with a mask (see Fig. 1 for details).

The logic underlying the moving window technique is that behavioral indicators related to eye movement, such as sentence reading time (longer), fixation duration (longer), and number of fixations (more), indicate the degree of processing difficulty. When the window is as large as, or larger than, the region from which the reader can obtain information, there should be no difference with regards to the above indices between the moving-window and a normal, unmasked control condition (Rayner, 1998). The aim of the present study was to test conflicting predictions of the DA and AR theories about cognitive functioning of depressed individuals. On this basis, perceptual/attentional level. Predictions of the DA theory concerning perceptual span size are quite straightforward: Attention in depressed individuals works in a defocused mode, allowing for gathering of information from a wider area in comparison to healthy controls. Consequently, in terms of reading times and fixations, depressed individuals should find the reading task more difficult than nondepressed individuals when spontaneous reading is constrained by the moving window; and particularly so when the size of that window is narrow.

In contrast, AR theory claims that depressed or dysphoric people are characterized by more systematic information processing, implying more focused attention. If this were true we should observe no differences between dysphoric and control participants, or a narrower perceptual span in the group with depressive symptoms. In terms of reading times and fixations, dysphoric individuals should find the reading task less difficult than individuals from the control group when spontaneous reading is constrained by the moving window, especially when the window is narrow.

2. Method

2.1. Subjects

60 healthy university students (32 women, 28 men, 18–29 years old) took part in a reading experiment employing the moving window paradigm, after giving informed consent. Participants were assigned to two groups, control and dysphoric students, according to their scores on the Beck Depression Inventory (BDI, Beck, 1967). Target groups were selected from the initial, larger sample (over 100 participants) according to the following criteria: Nondepressed group — 1 to 5 points in BDI-I, dysphoric group — above 10 points (these criteria were previously used in, e.g., Hertel and Rude, 1991; Edwards and Weary, 1993; von Hecker and Sedek, 1999). Characteristics of each group are presented in Table 1. Groups did not differ in age, but in indicators of depression (besides BDI-I we measured...
the intensity of ruminative thoughts using the Automatic Thoughts Questionnaire (ATQ, Hollon and Kendall, 1980).

2.2. Apparatus

Sentences were displayed on an LCD monitor running at a resolution of 1024×768 pixels at a refresh rate of 60 Hz. Eye movements were recorded monocularly with an SR Research EyeLink 1000 eye tracker at a sampling rate of 1000 Hz.

2.3. Design and procedure

Participants read 120 sentences randomly assigned to four blocks of trials differing in window size. The order of blocks was counterbalanced between participants. Three different window sizes (6, 12, and 18 characters) were used in addition to a no-window (unrestricted reading) control condition. Thus, the design was mixed factorial, with a quasi-experimental grouping factor (dysphoric vs. control) and a 4-level within-subjects factor (window type).

2.4. Materials

120 easy sentences in Polish were read, 30 per experimental condition. The mean sentence length was 10.4 words (ranging from 7 to 13 words) and 74.1 characters (ranging from 56 to 94 characters per sentence, including inter-word spaces).

Total sentence reading time, average fixation duration, number of fixations and average saccade size (amplitude) were treated as dependent variables (for a more comprehensive definition of eye movement measures, see Inhoff and Radach, 1998). Reading time together with fixations count and average saccade amplitude allowed us to make inferences about sentence reading strategies. A fixation can be defined as the period of time between two consecutive rapid eye movements (saccades). Previous research found that our eyes usually stop for about 200–300 ms during reading, although fixations from under 100 ms to over 500 ms may occur (see Rayner, 1998). Fixation duration as well as fixation count can be treated as indexes of information processing difficulty. By summing up all fixations within one given sentence, we obtained a total dwelling time, referred to as the total sentence reading time. Saccade amplitude was measured in degrees of visual angle. Data were preprocessed using SR Research Data Viewer, then exported to Microsoft Excel for further processing (merging and averaging) and finally analyzed with PASW Statistics (SPSS) software.

3. Results

The data were analyzed using two separate, 2 (mood: dysphoric vs. control)×4 (window size: no window vs. small vs. medium vs. large) two-way mixed ANOVAs, one conducted for each dependent measure. All reported effects use Greenhouse–Geisser correction in the case of violated assumption of sphericity. Subsequent planned comparisons were used to assess differences between groups or levels.
small-window condition, but significant differences between all window size conditions were only found in the dysphoric group (p < .05 for all differences, with Bonferroni correction), whereas there was no difference between the large-window and no-window conditions in the control group.

3.3. Mean saccade size, number of fixations

There were no statistically significant effects involving the mood factor in either the mean saccade size or the number of fixations during reading of the sentences.

In summary, we obtained clear differences between dysphoric and control participants on two temporal indices of the perceptual span: Both sentence reading time and mean fixation duration indicated that dysphoric participants were more sensitive to a reduced window size, in turn suggesting a wider perceptual span for dysphorics than for controls. We did not observe statistically significant differences between the two groups for saccade size or number of fixations.

4. Discussion

In this research, we used eye tracking in order to test contrary predictions deriving from two theories of information processing in depression — defocused attention and analytical rumination. By applying the moving window paradigm we showed that dysphoric and control individuals differ in the sizes of their perceptual span. Results regarding two temporal measures of perceptual span, sentence reading time and mean fixation duration, showed a pattern supporting the predictions of the defocused attention hypothesis. The dysphoric group was more pronouncedly affected by a reduction in visible window size (minor decreases in the visible area influenced their behavior) than was the control group for which only one difference (i.e., between the small-window and no-window conditions) was statistically significant. Furthermore, we observed significant differences between the dysphoric and control groups for the smallest window condition in terms of both measures, but no such differences for the no-window or large-window conditions. This implies that dysphoric participants do not exhibit a general deterioration of task performance, but that they are especially sensitive to shrinkage of the available visual field.

The defocused attention hypothesis proposed by von Hecker and Meiser (2005) claims that people in a depressed mood have a specific mode of attention, that is, a mode which is unfocused and unselective but allows to acquire more information from outside, or from the periphery of the ongoing task. In contrast, the analytical rumination hypothesis by Andrews and Thomson (2009) states that a tendency to focus attention and a systematic way of information processing are key features of a depressive person’s cognitive system. Although the analytical rumination hypothesis addresses a much wider scope than we covered here (in our study only one variety of attention, namely, visuospatial attention, was tested), its core assumption is that the depressive state elicits rumination and related internal cognitive processes. If a depressive state elicits rumination, then less capacity should be available for processing of the reading material, resulting in a reduction of the perceptual span. A wider perceptual span within dysphoric subjects, however, seems to indicate more, not less attentional capacity, contradicting the AR hypothesis. Our results are especially interesting when we consider not only the valence dimension of the investigated affect but also its motivational direction, namely, the motivation to approach or avoid a stimulus or situation. Recent studies suggest that affects low in approach-related motivational intensity broaden the scope of attention whereas affects high in approach-related motivational intensity narrow the attentional span (Gable and Harmon-Jones, 2010). Sadness or dysphoria, as these are affective states low in approach-related motivational intensity, may promote broadened attention because they assist with disengagement from terminally blocked goals and cause the organism to become open to new, perhaps previously irrelevant possibilities (Klinger, 1975). As von Hecker and Meiser showed (2005), such an unfocused and unselective mode of attention may be beneficial in terms of memory performance. It is also in agreement with the assumption that after fruitless cognitive effort, motivation will plummet as part of the ensuing state of cognitive “exhaustion”, leading to the occurrence of depressive symptoms (Kofka and Sędek, 1997).

Interestingly, both the “analytical rumination” and the “defocused attention” hypotheses point out that depression may have a positive influence on cognition, although they predict quite opposite ways in which such influences might happen. Whereas AR postulates a focusing of attention on specific task-relevant information, predictions of DA are that mainly task-irrelevant elements are processed more thoroughly in depression. The present results seem to favor the DA hypothesis. Depressed people are characterized by a wider perceptual span, which seems difficult to reconcile with a more focused processing strategy. Attentional focusing should lead to a narrower span, but actually depressed subjects showed a deviation from normal reading already at a window size of 12 characters, where control subjects were unaffected by peripheral masking. Instead, the results suggest that visual attention in depressed individuals may be spread out over a wider spatial range, supporting the defocused attention hypothesis.

By using the moving window paradigm, we only tested one variety of attention, namely, visuospatial attention. Attention is a multifaceted construct, and the analytical rumination hypothesis mainly deals with internal attentional processes. However, it is not unlikely that the perceptual span during reading is at least partly affected by endogenous processes. Considering, for example, the resource metaphor of attention (Kahneman, 1973), we think that a reduction of general attentional capacity should cause a reduction of the perceptual span. If a depressive state elicits rumination, then less capacity should be available for the processing of materials to be read. A wider perceptual span, however, seems to indicate more, not less attentional capacity.

However, there might also be an alternative explanation of our results, which is, in principle, compatible with both DA and AR hypotheses. The task used in our study did not require any kind of deeper, analytical thinking (not to mention solving social problems to which depressive states should predispose, according to AR theory). Instead, participants were asked to just read simple sentences, and it is possible that the current data reflect a processing mode outside the scope of AR theory. If so, the present results are nevertheless important because they (a) delineate the scope of AR theory, and (b) show a group difference that needs explanation, which DA can easily provide.

With more depressogenic material or a more demanding task, however, the pattern postulated by AR theory might still be obtained. Such a speculation is supported by data in Joormann (2010) indicating that depression is associated with increased interference from irrelevant negative material and that depressed have difficulties removing irrelevant negative material from short-term memory. It is also possible that the experimentally induced narrowing of the perceptual span had detrimental effects in the dysphoric group because of perceived difficulty. For dysphoric individuals hiding information within a sentence might make the sentence reading harder to do, and thus more annoying, than for controls. In order to answer the question whether the perceptual span in depressed people will still be found wider when more negative materials or a more difficult task were used, more research needs to be done.

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References


