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Effects of negative emotional valence on readers' text processing and memory for text: an eye-tracking study

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Abstract

Comprehension of stories requires readers to take the perspective of the story characters and imagine or feel their cognitive and affective states. The study investigated how variations in emotional valence within a literary text affected readers' global text processing, as reflected in their eye movements during the first and second-pass reading, and their memory for text. Processes of reading were also examined in relation to readers' dispositional empathy. Undergraduate students (N = 42) were assigned to an emotionally negative or neutral reading condition. They read a natural text passage from a suspense story while their ocular behavior was registered. After reading, they responded to multiple-choice questions assessing their memory of the text. Results revealed longer first-pass fixation times for content evoking negative emotions than for neutral content, which could be suggestive of a more analytical processing of the former. These effects were however local and did not impact the processing of the text at global level. Memory for the emotionally negative content was more accurate than memory for the neutral content. Dispositional empathy did not contribute to reading processes and outcome. Findings are discussed against the mixed results in the current literature and practical implications are also outlined.

Keywords Emotional valence · Emotion · Narrative text · Reading · Eye-tracking · Memory

Introduction

In real-life situations, attending to stimuli of negative valence has an adaptive value (i.e., faster responses to threats, Estes & Adelman, 2008), thus individuals preferentially attend to negative stimuli in the environment. This attentional preference

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for information of negative valence and its effects on the individuals' processing and memory of events have been widely documented (see Kensinger, 2007, 2009). In contrast, the effects of negative emotional valence on readers' attentional focus or memory for text have been less studied. Content of negative valence may facilitate text processing, via enhancing attention (Brierley et al., 2007; Delatorre et al., 2018), or may in contrast hinder it by narrowing readers' attentional focus to the emotional contents solely (Kensinger, 2009) or reducing the attentional resources available for other levels of text processing (e.g., Algom et al., 2004).

To date, very few studies have explored these effects on text reading (Ballenghein et al., 2019; Burton et al., 2004; Mouw et al., 2019) and of these studies, only a minority have used complex natural (literary) texts (an exception is Hsu et al., 2014). In this eye-tracking study we addressed this literature gap, examining the effects of negative valence on readers' real-time processing of a suspense story passage.

Effects of negative emotional content on attention and memory

Emotions can be defined according to two dimensions (Russell, 1980): (1) valence, that is, the degree of pleasantness or unpleasantness of an affective state, ranging from positive to negative, and (2) arousal, or the intensity of activation due to the emotional state, ranging from calm to excited. In real-life situations, emotional events are more salient and thus capture attention more easily than neutral events; consequently, they are also more likely to be encoded in memory (Kaplan et al., 2012). Negative and positive emotions seem however to have opposite effects on attention and memory of the events. Researchers have indeed found that negative emotions are associated with a narrowing of the attentional focus to the emotional (most salient) elements in the environment (e.g., in a crime scene, the weapon) at the expense of the general memory of an event (i.e., witnesses may not recall the face or clothing of the perpetrator) (Kensinger, 2009). This phenomenon known as "emotional memory narrowing" (Kensinger, 2009) is observed across a wide range of real-world events: Natural disasters (Bahrick et al., 1998), physical injuries (Peterson & Bell, 1996), and crime scenes (Reisberg & Heuer, 2007). Negative stimuli seem also to hold attention longer than positive or neutral stimuli, delaying attentional disengagement (the so called "delayed disengagement hypothesis", Algom et al., 2004; Estes & Adelman, 2008), with further effects on the processing and memory of peripheral information or features of the event. In contrast to negative emotional stimuli, positive emotions drive to broadening the attentional focus (Fiedler & Bless, 2001) and hence benefit memory of the events more generally.

With regard to reading, there is disagreement on how emotional negative content may affect the processing and memory of text. Some studies indeed suggest that negative content in text generate interference in reading, influencing negatively the processing and memory of other information in the text (e.g., Ballenghein et al., 2019; Megalakaki et al., 2019), whereas according to other studies, emotional negative content has positive effects, inducing a greater engagement in reading, more analytical reading, and a better memory for text (Burton et al., 2004; Kensinger, 2007; Mouw et al., 2019).

The first group of studies have produced findings consistent with the "emotional memory narrowing" and "delayed disengagement" phenomena, which show that readers recall more words for positive texts than for negative texts (Megalakaki et al., 2019) and that the delayed disengagement of attentional resources from negative words or sentences in a text can interfer with the processing of the text at other levels. Ballenghein et al. (2019), for example, have found that readers are faster at processing positive than negative texts. Other studies found that negative words induce slower lexical decisions than positive words (Estes & Adelman, 2008), or slow down responses in Stroop tasks (Pratto & John, 1991) and in word naming tasks (Algom et al., 2004). These findings can be interpreted in light of the Process, Emotion, Task (PET) framework (Bohn-Gettler, 2019; Bohn-Gettler & Kaakinen, 2021). High-arousing emotional information, especially negative, easily becomes more salient than neutral information, implying that more cognitive resources are allocated to elaborate the former than the latter. Consequently, when individuals are engaged by negative contents in a text, less cognitive resources may be available to perform other cognitive tasks or attend to other text contents or aspects of the task (Ellis & Ashbrook, 1988).

The second group of studies on emotional negative content show opposite findings, suggesting a facilitating effect of that content on readers' processing and memory for text. For instance, some studies have found that negative emotional words, spontaneously catching the reader's attention, are also associated with enhanced brain activation during early stages of semantic analysis (Citron, 2012; Kissler et al., 2007), and are processed faster than neutral words (Kousta et al., 2009; Scott et al., 2012). This processing advantage has also been observed at sentence level (Mouw et al., 2019). In their study, Mouw et al. asked children and adults to read short emotional or neutral narratives (six sentence stories), presented sentence by sentence on a computer screen. Reading times resulted in both groups faster for negative than for neutral sentences.

Other studies in this group suggest that the advantage for emotionally negative content in text is related to its induction of a more analytical processing of information, which conveys a benefit on memory for details. Slower reading times for negative texts would thus not be a marker of the delayed disengagement of readers' attention, but an expression of this more analytical processing of text. As a consequence, fewer reconstructive-memory errors or distortions are generated than for the processing activated by positive emotions, which relies more on schematic knowledge and less on event details (Kensinger, 2007).

Negative valence has indeed been found to aid memory not only for single words (Kensinger & Corkin, 2003; Kissler et al., 2007) but also for texts (Burton et al., 2004), making the mental representation of the situation described in the text more detailed and stronger, especially when readers assume the agent perspective (Child et al., 2018). Burton et al. (2004), for instance, found that negative stories were processed by readers slower and were recalled better than neutral stories. High-arousing fear-inducing passages and the description of the protagonist's pain or distress induce readers to be more empathic with the story character, and thus may elicit greater attention and enhance engagement in the narration (e.g. Hsu et al., 2014), resulting in a more analytical text processing

(i.e., longer reading times) and stronger fixation of the text content in memory (Burton et al., 2004).

Examining emotional valence effects in complex reading tasks

Until recently, the investigation of the effects of emotional valence on text processing has mainly focused on experimental (ad hoc designed) texts (e.g., Burton et al., 2004; Child et al., 2018; Mouw wt al., 2019). Although experimentally designed materials allow for greater control of text variables, their use limits generalizability of the research results to literary (natural) texts. Unlike experimental texts, literary texts like suspense stories are often less explicit, linguistically more complex, and include more seductive details (Kneepkens & Zwann, 1994). Given these characteristics, they may require greater processing (i.e., cognitive) effort to readers (e.g., Tulis & Fulmer, 2013), but may also involve greater engagement in reading, enhancing the effects of valence on readers' perspective taking and empathic responses (Hsu et al., 2014). These effects may however not be the same for all readers, especially when reading narratives.

The individual sensitivity to a specific emotion (e.g., disgust or sadness) may influence reading more than the general valence or arousal of the words used in the text (Silva et al., 2012). For instance, sad readers could attend more to sad material as they identify with a sad character from a story, and recall more about that character. Being particularly empathetic or anxious can also affect readers' attention to, and perception of, emotional contents in text, especially when reading stories in which perspective taking is a key comprehension process (Komeda et al., 2013). Readers' response to emotional stimuli in a text may also interact with the cognitive characteristics of readers, such as their working memory (Ballenghein et al., 2019). These individual factors have been often neglected in studies that have explored the effects of emotional valence on text processing. In this study we thus examined the effects of emotional valence on readers' processing of a suspense story passage, taking the individual characteristics of readers into account.

The eye-tracking methodology to study the real-time effects of emotional valence

The focus of the study was to understand how manipulations of emotional valence within a text could affect the dynamic of reading and readers' global processing of the text. So far, very few studies have attempted to address this research question (exceptions are Child et al., 2018; Mouw et al., 2019).

To achieve this goal we manipulated a natural text passage from a suspense story and used an eye-tracking methodology to capture readers' real-time processing of the text. This methodology relies on the eye-mind hypothesis, which posits that the direction of human gaze is closely linked to the focus of attention, as individuals process the visual information that is currently being observed (Just & Carpenter, 1980). Such perceptual/cognitive analysis may occur very quickly, thus being inaccessible to awareness (van Gog & Scheiter, 2010).

For global text processing, two main indices of eye fixations are relevant and useful (Hyönä et al., 2003): the *first-pass fixation time,* corresponding to the summed duration of all fixations on a target region before exiting from it, and the *second-pass fixation time* or *look-back* fixation time, corresponding to the summed duration of all fixations that return to a target region after the first-pass reading (i.e., the re-reading time of that particular text segment). The first-pass fixation time is assumed to reflect the initial, more immediate, processing of the material. Look-back fixation time is assumed to reflect a more purposeful and strategic processing during reading, that is, when a reader re-processes a region in an attempt to integrate information or solve incoherences (Mason et al., 2017; Hyönä et al., 2003).

Eye-tracking methodology has been experimentally validated for the analysis of language comprehension (Gordon et al., 2006), engagement of attention (Shagass et al., 1976), narrative focus (Hyrskykari, 2006), and global text comprehension (Ariasi et al., 2017; Mason et al., 2020; Hyönä et al., 2002; Shaked et al., 2020; Yeari et al, 2015). However, the research that has exploited eye-tracking technologies to study the effects of emotional valence on readers' real-time engagement in reading and text processing is still very limited (e.g., Ballenghein et al., 2019; Child et al., 2020).

In a recent eye-tracking study, Ballenghein et al. (2019) have examined participants' processing of more or less positively and negatively emotionally charged, or neutral, texts as well as their head motion during reading. Findings showed that readers processed faster only emotionally positive texts as revealed by the mean duration of fixations. No advantage for emotionally negative texts emerged from this study. The authors explained this outcome by speculating that readers' attention may have remained focused on negative emotional cues, making the processing of emotionally negative texts slower; consequently, integration of information was also more laborious. In contrast, faster reading of positively emotional texts may have been due to the gradual activation of positive cues that did not overload the readers' working memory (Ballenghein et al., 2019).

In another study, Child et al. (2020) recorded the eye-movements of undergraduate students reading short experimentally designed passages about a character experiencing either a positive or a negative situation. Texts were narrated in second person (you), encouraging readers to take a personal perspective, or third person (he/she) as an onlooker perspective more typical of literary texts. Unlike Ballenghein et al. (2019), Child et al (2020) separated the text into multiple areas of interest and compared eye-movements across the text. Their findings revealed faster early processing, i.e. shorter gaze durations, for positive than negative texts, and for texts read from a personal perspective (you) than onlooker perspective (he/she). However, for texts narrated in third person (he/she) readers became faster in processing textual information as the text proceeded only when text valence was negative. The authors explain this processing facilitation of negative (but not positive) valence as an effect of the greater engagement, or empathy for the story character, experienced by readers in this condition and speculated that this could support readers' integration of textual information.

The study: research questions and hypotheses

In the present study we used eye-tracking methodology to compare readers' real-time text processing of two versions of a suspense story passage (from *Ghost story* by Peter Straub, 1979), differing only for their central part (paragraph), which was of negative valence in the original story version and of neutral valence in the version experimentally manipulated. Two groups of readers, matched on dispositional empathy and working memory, read either the original passage or the neutral one. Their text processing and memory of the passage was compared.

Two research questions (RQ) guided the study.

RQ1 How does the variation of emotional valence (from negative to neutral) in a literary text affect readers' attentional engagement and real-time text processing? To answer this research question we compared readers' first-pass and second-pass fixation times across three areas of interest (the beginning, central part, and the end) of the negative and neutral (manipulated) story passage. Three hypotheses were formulated.

Hypothesis 1 For RQ1, based on the delayed disengagement hypothesis (Algom et al., 2004) and Burton et al.'s findings (2004), we first expected longer first-pass fixations (greater initial sustained attention) in the central paragraph when the content was negative, as in the original version, compared to neutral, as in the manipulated version.

Hypothesis 2 For RQ1, however, we anticipated that the greater engagement in the narration induced by a negative emotional valence of the central paragraph would facilitate the processing of the subsequent text, thus favoring readers' integration of textual information (Child et al., 2020). We thus hypothesized a decrease of first-pass fixation times from the central part to the end part of the story passage for the negative valence version (original), but not for the neutral valence (manipulated) version. We also predicted longer second-pass fixations (greater integration effort) on the manipulated text of neutral valence than on the original one, of negative valence.

Hypothesis 3 For RQ1, we finally predicted that readers' individual characteristics would modulate their sensitivity to text valence, and thus readers with higher dispositional empathy would show higher sensitivity to the negative emotional valence of the original story passage, that is, longer first-pass fixation times on the central part of the passage.

RQ2 Does negative emotional valence, compared to neutral valence, enhance readers' memory of text content? Are its effects limited to the emotional content of the story, as predicted by the emotional memory narrowing hypothesis?

For RQ2, alternative hypotheses could be formulated. According to the emotional memory narrowing hypothesis, readers in the negative emotional valence reading condition should recall well emotionally negative contents, but compared to readers in the neutral valence reading condition, their memory of other (peripheral) information in the text should be poorer (Kensinger, 2009). Alternatively, as suggested by Burton et al. (2004), negative emotional valence should induce a more analytical processing of the text and, consequently, could benefit text memory more widely, also enhancing readers' memory of peripheral information such as the details of the situation described.

Method

Participants

A power analysis using G*Power 3 software indicated that using an F test (Repeated measures ANOVA, within-between interaction) for valence effect, a total sample of 34 participants was necessary to detect medium effects (d = 0.25) with power (1–β) set at 0.80 and α = 0.05. Participants were 42 students (26 girls, 62%, M_{age} = 24.17, *SD* = 4.91). Initially, 50 undergraduate students had accepted to take part in the eye-tracking experiment. Of these, two did not show up, one was not included in the study because she reported a corneal injury at the preliminary assessment, and one was also excluded after the experimental session for not having completed all tasks. Moreover, the data of two students were excluded from the analysis as outliers in all eye-movement analyses (scores > than 2 standard deviations from the distribution). Participants' characteristics are reported in Table 1. All participants had normal or corrected to normal vision and none of them reported language delays, dyslexia, or reading problems. For three students Italian was the second language (L2). However, they had been exposed to Italian for more than 8 years (range 9–19 years). Their first language was Albanian, Rumanian, and Sinhalese. Two groups of participants were formed, matched on age, gender and first language (i.e., having Italian as

Table 1 Participants' Characteristics with Means, Standard Deviations (in Brackets) and Results of T-Tests and Chi-Square Tests

Variable	Negative valence (*n* = 21)	Neutral valence (*n* = 21)	t/χ^2	*p*	Cohen's *d*
Age	24.62 (5.98)	23.71 (3.65)	.59	.56	0.18
Gender (*n* girls and %)	13 (62%)	13 (62%)	.001	1.00	
Italian as L2 (*n*)	2 (Albanian and Sinhalese)	1 (Romanian)	.34	.55	
LST score	24.76 (5.04)	26.90 (4.94)	− 1.39	.17	− 0.43
IRI score	94.67 (11.06)	95.24 (10.96)	− 0.17	.87	− 0.05
Valence (likert scale 1–5)	3.48 (.60)	3.14 (.57)	1.84	.07	0.57
Empathy (likert scale 1–5)	3.10 (.77)	2.19 (.75)	3.86	.001	1.19

LST = listening span test; IRI = Interpersonal Reactivity Index; Italian L2 = Italian as a second language

L2, see the Measures section). The two groups were randomly assigned to a negative or neutral valence reading condition. The students in the negative valence vs. neutral valence condition did not differ significantly on any of the demographic variables considered. Differences in working memory and dispositional empathy were controlled post hoc, after the students performed the experimental tasks. These differences were too statistically non-significant.

Materials

Two versions of the Ghost story passage, one of negative valence, corresponding to the original text, and the other of neutral valence, the manipulated version, were respectively used in the negative and neutral valence reading condition (see Appendix A). The Italian texts differed for three aspects from the original Ghost story (Peter Straub, 1979): (1) two clauses ("*it was as if he were not merely dreaming*" and "*He was lying in bed in a strange room, waiting for something to happen*") were moved from the beginning to the central part (emotional content area) of the passage; (2) a sentence "*Someone was going up"* was added at the end of the last paragraph; (3) the protagonist was a woman. This methodological decision was based on a pilot testing of the material that showed that readers felt more empathetic in this condition. The texts were divided into three areas of interest (AoI). The first and third AoIs, describing the location and situation of the protagonist were the same in the two story versions, whereas the second and central AoI (AoI2) was manipulated and thus differed between the two conditions. This part described the protagonist's feelings and affective state and was of negative valence in the original story passage, and of neutral valence in the rewritten story version. The experimental manipulation resulted in an original version of the story passage with global negative valence, and a manipulated version of the same story passage with global neutral valence. The emotional valence of the AoIs was assessed by a natural language tool for sentiment analysis, Semantria software (https://www.lexalytics.com/semantria/). Semantria is an artificial intelligent tool based on annotations of linguistic corpora. Semantria's machine learning model is trained on a set of texts that have been scored as negative, neutral or positive by humans. This natural language tool measures sentiment in a scale from −2.0 (negative) to +2.0 (positive) valence. A score between −0.05 and +0.22 is considered neutral. The tool has been used in several studies (e.g., Delatorre et al., 2021; Zucco et al., 2020) and its ecological validity has also been proved. For instance, Delatorre et al. (2020) found that suspense book passages ranged from negative to neutral-negative Semantria scores ($M = 0.189$, $SD = 0.134$), while non-suspense passages ranged from neutral to positive.

The two story passages were equivalent for number of words (in Italian, 148 in text A and 146 in text B) and syllables (306 in text A and 307 in text B), as well as for readability (Gulpease index = 66 for text A and 64 for text B; 100 = maximum readability).

More specifically, AoI1 comprised 50 words and 106 syllables (Gulpease readability = 62). As computed by Semantria, its emotional valence was negative, corresponding to a score of −0.60. AoI2 in the *negative valence* condition corresponded

to the original suspense text. It comprised 57 words and 116 syllables (Gulpease readability = 72). Its emotional valence was also negative, with a Semantria score of − 0.35. In the *neutral valence* condition, this section was manipulated by rewriting the corresponding segment of the negative version to make the original text with an emotionally neutral valence. The resulting section counted 55 words with as many syllables as the original (*negative valence*) segment (117 syllables) and the same readability (Gulpease index = 72). Its emotional valence corresponded to a Semantria score of − 0.02, that is considered as neutral. Semantria scores, therefore, confirmed that the two texts differed for the emotional valence of the second AoI (AoI2). AoI3 was again the same for both texts. It counted 41 words and 84 syllables (Gulpease readability index = 62). Its emotional valence was positive, corresponding to a Semantria score of 0.60.

In synthesis, in the original negative story passage the emotional valence was negative-negative-positive, whereas in the manipulated neutral story passage, it was negative-neutral-positive. Both texts are reported in Appendix A.

Manipulation check

The two text versions (of negative or neutral valence) were selected based on a pilot study run with 34 adult readers who rated on a 5-point Likert scale (from 1 = low to 5 = high) the emotional valence of the passage and their empathy (i.e. apprehension) for the story protagonist. Semantria software was also used for manipulation check. Semantria scores were negative for the overall original negative suspense story passage (score = − 0.26) and neutral for the manipulated version with neutral emotional valence (score = − 0.01) and students' ratings of the emotional valence and empathy for the story character confirmed the differences between the two texts. Students who read the neutral story rated it as less negative, $t(32) = 4.01$, $p < 0.001$, Cohen's $d = 1.38$, and reported less empathy for the character, $t(32) = 5.44$, $p < 0.001$, Cohen's $d = 1.87$, than students who read the negative passage.

Apparatus and eye-tracking indices

Eye movements during reading were registered using the Tobii T120 eye-tracker, manufactured by Tobii Technology (Stockholm, Sweden). The eye tracker is integrated into a 17-inch TFT monitor with a maximum resolution of 1280 × 1024 pixels. Tobii T 120 embeds five near-infrared light emitting diodes (NIR-LEDs) and a high-resolution camera with a charge coupled device (CCD) sensor. The camera samples pupil location and pupil size at the rate of 120 Hz. Data were recorded with Tobii-Studio (1.7) software. The experiment started with a 9-points calibration procedure.

We computed the following indices for each AoI:

- first-pass fixation time: The overall duration of first-pass readers' fixations was considered as an index of readers' initial text processing of each area;

- second-pass fixation time: The overall duration of rereading fixations was considered an index of readers' integration effort.

Measures

Working memory

We used a listening span task (LST, Pazzaglia et al., 2000) to measure working memory. It consists of 40 sentences organized in blocks from 2 to 6 sentences each. After listening to each sentence, participants had to answer comprehension (true/false) questions. At the end of each block they had to recall the final words of the sentences. The final score corresponds to the total number of words correctly recalled. Pazzaglia et al. (2000) reported a significant association between readers' LST and their text recall and comprehension. Split-half reliability of the test is 0.99.

Dispositional empathy

We assessed dispositional empathy using the Interpersonal Reactivity Index (IRI, Davis, 1980) questionnaire. It is a self-report measure that consists of four subscales: Perspective Taking (PT; adopting others' viewpoints); Fantasy (FS; the tendency to identify with fictional characters in books or movies); Empathic Concern (EC; the tendency to experience feelings of sympathy or concern for others in need) and Personal Distress (PD; the tendency to discomfort or distress when witnessing others' negative experiences). Validated versions of the scale exist for several languages (e.g., DeCorte et al., 2007; Lucas-Molina et al., 2017), including Italian (Albiero et al., 2006). The Italian version has been validated on a population of 888 adolescents and young adults (range 10 to 20 years), reporting a Cronbach's alpha of 0.75.

Memory for text

Memory scores were computed separately for each of the three AoIs of the story, based on 12 multiple-choice recognition memory questions (see Appendix B). Each question required participants to identify among four alternatives the sentence drawn from the text. Sentences from each AoI were selected. Eight memory questions referred to peripheral and descriptive details (location, characteristics of the room, etc.) provided in AoI1 (four questions) and AoI3 (four questions). Four questions focused on the manipulated AoI2 which described the affective and physical states of the protagonist.

Procedure

All participants preliminarily completed a demographic questionnaire, the interpersonal reactivity index questionnaire and the listening span task. The reading session was carried out in a quiet room. Students were asked to read the short suspense story passage while their eye-movements were recorded. After reading the passage,

they rated its emotional valence on a 5-point likert-type scale (from 1 = very good to 5 = very bad) in response to the following request: "Please, assess how good/bad this story makes you feel", and their empathy for the protagonist ("Please, assess how much worried are you for the protagonist") on a 5-point likert-type scale ranging from 1 = very little worried to 5 = very much worried. Participants then performed a categorization span task from an Italian battery for memory assessment in adults (BAC; De Beni et al., 2008). This task was aimed at diverting participants' attention from the content of the text just read. After this interfering task, they responded to the 12-items questionnaire assessing their memory for the story read.

Results

Preliminary t-tests and chi-square analyses confirmed that the two groups, assigned to the two (negative valence and neutral valence) reading conditions, did not differ significantly on age, gender or on other characteristics relevant to the study (i.e., IRI and working memory scores, see Table 1). The only statistically significant difference between the two reading groups was found in their empathy for the story character. As expected, the group assigned to the neutral valence reading condition reported lower empathy than the negative valence group. As shown in Table 1, the negative valence group also rated story valence more negatively than the neutral valence group. However, the difference between the two conditions (negative versus neutral valence) did not reach statistical significance ($p = 0.07$).

RQ1: Effects of emotional valence on readers' engagement and text processing

Hypotheses 1 and 2 predicted a greater engagement, signaled by longer first-pass fixations in AoI2 for the negative valence than the neutral valence condition (Hypothesis 1), and a facilitative effect of the negative valence condition on the processing of the subsequent text, that is, a decrease of first-pass fixation times from AoI2 to AoI3 and shorter second-pass fixations (less integration effort) for the negative valence version of the story passage (Hypothesis 2). A first set of analyses thus compared first-pass fixations duration of the two reading groups (negative vs. neutral valence condition) across AoI2 and AoI3. AoI1 first-pass fixations time was covaried to control for readers' initial inter-individual variability in reading speed. A two (negative valence vs. neutral valence condition) x two (AoI2 vs. AoI3) mixed analysis of covariance (ANCOVA) was run, followed by univariate analyses of variance investigating between and within group effects separately. For these follow-up analyses, Bonferroni corrections were applied and alpha was adjusted to 0.025 (0.05/2).

A second set of analyses compared second-pass fixation durations (i.e., time for extra-processing or re-reading) of the two reading groups across the three AoIs. As second-pass fixations tap extra-processing rather than reading speed, in this case AoI1 first-pass fixation time was not covaried. A two (negative valence vs. neutral valence) x three (AoI1, AoI2, and AoI3) mixed analysis of variance (ANOVA) was run. Within and between group effects were explored through t-tests with corrections

for multiple testing. Alpha was adjusted to 0.016 (0.05/3) for both between group and within group comparisons (AoI1-AoI2; AoI2-AoI3; AoI-AoI3). Log-linear transformed first-pass and second-pass fixation durations per syllable were the dependent variables. Means and standard deviations for first-pass and second-pass fixations are displayed in Table 2.

First-pass fixation duration

The main effect of the within subject factor (AoI) was not significant. Reading condition approached statistical significance, $F(1, 39) = 3.62$, $p = 0.06$, $\eta^2_p = 0.09$ and also the effect of the covariate AoI1 first-pass fixation duration was significant, $F(1, 39) = 90.57$, $p < 0.001$, $\eta^2_p = 0.70$. The interaction between reading condition and AoI was also statistically significant, $F(1, 39) = 17.72$, $p < 0.001$, $\eta^2_p = 0.31$. Parameter estimates showed that reading condition was significant for AoI2 first-pass fixation duration, $B = 0.38$, $t = 3.36$, $p = 0.001$, $\eta^2_p = 0.25$, but not for AoI3 first-pass fixation duration, $B = -0.02$ $t = -0.20$, $p = 0.84$.

Subsequent between-conditions ANCOVAs run separately for AoI2 and AoI3 (with AoI first-pass fixation duration as covariate) showed significantly longer first-pass fixation times in AoI2 for the group in the negative valence reading condition than for the other (neutral reading condition) group, $F(1, 39) = 13.19$, $p < 0.001$, $\eta^2_p = 0.25$. The effect of the covariate was also statistically significant, $F(1, 39) = 86.86$, $p < 0.001$, $\eta^2_p = 0.69$. For AoI3, only the covariate was significant, $F(1, 39) = 58.92$, $p < 0.001$, $\eta^2_p = 0.60$, as reading condition did not differentiate the first-pass fixation times of the two groups, $F(1, 39) = 0.40$, $p = 0.84$ (see also Fig. 1).

Within group ANCOVAs comparing first-pass fixation times across AoI2 and AoI3 separately for the negative and neutral valence reading condition, did not show significant differences between AoI2 and AoI3 in either of the two conditions, $F(1, 19) = 3.23$, $p = 0.09$ (negative valence) and $F < 1 =$, $p = 0.76$ (neutral valence). Only the effect of the covariate was statistically significant, for the negative valence reading group $F(1, 19) = 41.20$, $p < 0.001$, $\eta^2_p = 0.68$, and for the neutral valence reading group, $F(1, 19) = 49.92$, $p < 0.001$, $\eta^2_p = 0.72$. That is, in both groups of readers, individual variability in reading speed was associated with first-pass fixation times across the two AoIs.

Summing up, the reading group in the negative valence condition showed greater attentional engagement (longer first-pass fixations) during reading AoI2 than the matched group in the neutral reading condition. The negative content in this area seemed to capture their attention and hold it longer. Hypothesis 1 was thus supported by the findings. This greater immersion in the narration did not seem however facilitating to a significant level the processing of the subsequent text (i.e., increase the processing speed of AoI3, Hypothesis 2). Hence, the findings did not support the second hypothesis of the study. Remarkably, however, readers' delayed disengagement from AoI2 in the negative valence condition did not either slow text processing down.

Table 2 Emotional Valence Effects on Readers' Text Processing for First-Pass Fixation Duration and Second-Pass Fixation Duration Across AoIs by Reading Condition

Variable	Negative valence condition			Neutral valence condition			Within and between reading condition effects		
	AoI1	AoI2	AoI3	AoI1	AoI2	AoI3	*F* (AoI)	*F* (RC)	*F* (AoI *RC)
First-pass fixation times *M* (SD)	5.02 (.45)	4.57 (.60)	4.43 (.51)	5.21 (.40)	4.40 (.58)	4.63 (.55)	2.99	$3.62^{\#}$	17.72^{***}
Second-pass fixation times *M* (SD)	1.14 (.59)	1.04 (.77)	.05 (.17)	1.09 (.85)	.97 (.66)	.21 (.48)	31.16^{***}	.89	.44

RC = reading condition; AoI1 first-pass fixations are covaried in the within and between conditions analyses of first-pass fixations duration. $p^{\#} = .06$; $^{*} < .05$; $^{**} < .01$ $^{***} < .001$

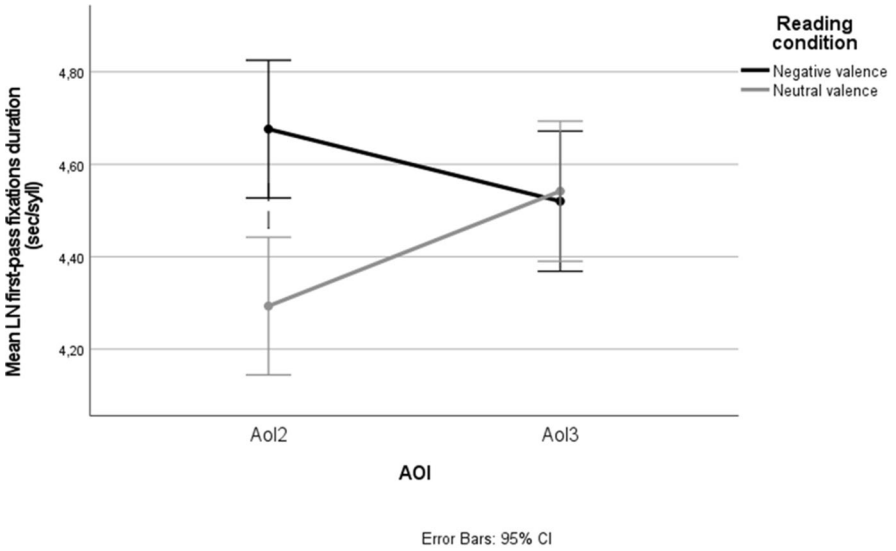

Fig. 1 First-Pass Fixation Times on AoI2 and AoI3 by Reading Condition

Second-pass fixation times

The main effect of the reading condition was not significant, $F < 1$, $p = 0.89$, and the interaction reading condition x AoI was also not significant, $F < 1$, $p = 0.64$ (see Table 2). A main effect of AoI was instead found, F (2, 80) = 31.16, $p < 0.001$, $\eta^2_p = 0.44$. Follow-up paired t-tests showed that for both groups second-pass fixations were longer on AoI1 and AoI2 than on AoI3 (see Fig. 2). For the negative valence reading group, the difference between AoI1 and AoI3 was $t(20) = 8.31$, $p < 0.001$, $d = 1.83$, and the difference between AoI2 and AoI3 was $t(20) = 5.87$, $p < 0.001$, $d = 1.\ 28$. In both cases the effect size was large. Second-pass fixations on AoI1 and AoI2 did not differ significantly, $t(20) = 0.42$, $p = .\ 68$.

For the neutral valence reading group, the difference between AoI1 and AoI3 was $t(20) = 4.88$, $p < 0.001$, $d = 1.06$ and the difference between AoI2 and AoI3 was $t(20) = 4.08$, $p = 0.001$, $d = 0.89$. The effect size was again large. No statistically significant differences were found between AoI1 and AoI2, $t(20) = 0.49$, $p = 0.63$.

In synthesis, the pattern of second-pass fixations (rereading behavior) did not differ between the two reading groups, which again conflicted with Hypothesis 2. The readers in the neutral and negative valence condition did show exactly the same rereading and extra-processing of the text, as shown in Fig. 2.

The role of readers' dispositional empathy

To test the role played by readers' dispositional empathy (Hypothesis 3), we run the same analyses also covarying readers' IRI scores. These analyses did not

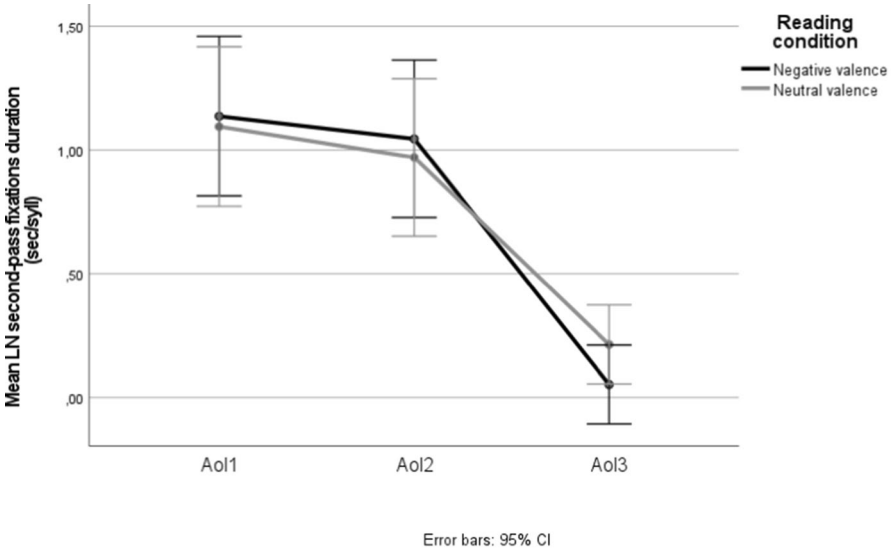

Fig. 2 Second-Pass Fixation Times in the Three AoIs by Reading Condition

yield different findings and the covariate did not result as significant in any of the ANCOVAs run.

RQ2: Effects of emotional valence on memory for text

The effects of valence on readers' memory were tested by examining between group (negative vs. neutral reading condition) differences in memory scores for AoI2 (describing the character's emotional and physical states), and for the other two areas of interest (AoI1 and AoI3, that provided peripheral information on the location and situation of the narrated events). Three between group univariate analyses of variance were run to test the alternative hypotheses of the study, that is, an emotional memory narrowing or a wider memory enhancement effect of negative emotional valence on readers' memory for text. Memory scores for AoI1, AoI2, and AoI3 were the dependent variables. As expected, we found a statistically significant difference across the two groups for memory of AoI2, $F(1, 40) = 5.54$, $p < 0.05$, $\eta^2_p = 0.12$. Memory scores for this area were significantly higher for the negative valence reading condition (see Table 3). In contrast, memory of AoI1 and AoI3 did not differ significantly between the two groups, $F < 1$, $p = 0.87$, and $F < 1$, $p = 0.39$, respectively. The same findings were obtained when participants' LST scores were covaried in the analyses: $F(1, 40) = 4.59$, $p < 0.05$, $\eta^2_p = 0.11$ for AoI2; $F < 1$ and $p = 0.46$ for AoI1; $F < 1$ and $p = 0.57$ for AoI3.

Similar results were also obtained when readers' IRI scores were a covariate in the analyses: $F(1, 40) = 5{,}7$, $p < 0.05$, $\eta^2_p = 0.13$ for AoI2, $F < 1$ and $p = 0.86$ for AoI1

Table 3 Effects of Emotional Valence on Readers' Memory for Text by Reading Condition

Area of Interest	Negative valence condition *M* (SD)	Neutral valence condition *M* (SD)	*F*	*p*	η^2
AoI1 (score range 0–4)	2.90 (.70)	2.95 (1.16)	0.03	.87	.00
AoI2 (score range 0–4)	3.09 (.77)	2.48 (.93)	5.54	.02	.12
AoI3 (score range 0–4)	2.67 (.86)	2.95 (1.24)	0.75	.39	.02

and $F < 1$, $p = 0.39$ for AoI3. In synthesis, the participants who read the passage of negative valence showed better memory for AoI2 (i.e., the emotional content of the story), compared to the group in the neutral reading condition, but similar memory for peripheral information and story details (i.e., AoI1 and AoI3). Thus, neither the emotional memory narrowing hypothesis nor the alternative hypothesis were confirmed.Readers' dispositional empathy did not seem to influence their memory of the story content.

Discussion

The specific mechanisms through which emotional valence dynamically influences reading and memory for texts are still a dilemma for researchers. In this study, we conducted an in-depth analysis of a complex reading task, comparing the eye-movements and memory for texts of adult readers who read two versions of the same story passage. Interindividual differences between readers in working memory and dispositional empathy were controlled. The two versions of the story passage varied only for the emotional valence of the central part of the story (AoI2), which was negative in the original story and neutral in a manipulated story version. The beginning (AoI1) and end (AoI3) of the story passage were the same in the two story versions. Readers' first-pass and second-pass fixation times were recorded to examine differences in readers' text processing in the two reading conditions, and their memory of the passage was assessed through multiple-choice questions, focused on the three areas of interest (AoI1, AoI2 and AoI3).

Effects of emotional valence on text processing

The first hypothesis of this study was that the manipulation of the emotional valence of AoI2 would induce differences in readers' processing of that area: More specifically, in the negative emotional valence condition readers would show longer first-pass fixations (greater sustained attention) than in the neutral valence condition.

This hypothesis was confirmed by the results of the study. Readers spent longer processing times (first-pass fixations) on the negative AoI2 than on the neutral AoI2. Other authors (e.g., Mouw et al., 2019) have found faster processing times for sentences/texts of negative valence, compared to sentences/texts of neutral valence, and such processing speed has been interpreted as a processing advantage. Consistently,

it was posited that longer processing times reveal a disadvantage in reading. For instance, Ballenghein et al. (2019), who found faster processing of emotionally positive, but not emotionally negative, texts compared to neutral texts, interpreted the finding as proof of a disadvantage induced by emotionally negative valence in text processing. When readers' attention remains anchored on negative emotional cues, integration of information in the text is hypothesized to be more laborious, and text processing is slowed down. As we will discuss next, the findings of the present study suggest a different interpretation, more in line with Burton et al.'s (2004) hypothesis of a positive effect of negative valence in reading.

Methodological differences between this and prior studies (e.g., Ballenghein et al., 2019; Mouw et al., 2019), such as the use of experimental texts (Mouw et al., 2019) versus literary texts (as in this study) and the different sensitivity of the measures used (reading times based on self-paced presentation of the text in Mouw et al. versus eye-movement measures in this study, or different eye-movement measures considered in this and Ballenghein et al.'s study) could account for the diverging findings. Literary texts can for example induce a greater immersion in the story compared to ad hoc experimentally designed narratives (see Hsu et al., 2014). Eye-tracking measures, on the other hand, may be more sensitive to the emotional responses of the reader. Eye-movements are automatic and unconscious responses to stimuli, and hence, compared to measures that require explicit control (e.g., when text presentation is self-paced, Mouw et al., 2019), they are more helpful when the goal is to examine reading processes that are in part under the threshold of readers' consciousness, as it is for readers' response to emotional valence examined in this study.

Like in this study, also in Ballenghein et al.'s study (2019) eye-tracking measures were used. A difference between Ballenghein et al.'s and the present study relies however in the type of eye-movement measures considered. Ballenghein et al. computed the total fixation time for the whole text, without differentiating between first-pass (early processing) and second-pass (rereading) fixation times, whereas in the present study we computed first-pass and second-pass fixations separately. This allowed us to capture early text processing, which could explain the difference in findings between the two studies.

Hypothesis 2 predicted that the greater immersion in the narration induced by negative emotional valence would facilitate the subsequent processing of the text and readers' integration of textual information. We thus predicted a decrease of first-pass fixation times from the central part to the end part of the text for the original (negative valence) story passage, and longer second-pass fixations across the AoIs (i.e., greater integration effort) for the manipulated (neutral) story passage. The results did not confirm this second hypothesis. The seemingly greater engagement of the readers in reading the central part of the text in the negative valence condition did not facilitate, or speed up, to a significant extent the processing of the subsequent text (AoI3). It is however important to note that it did not either slow it down.

In addition, readers' second-pass fixations did not differ significantly in duration between the two reading conditions and the pattern of second-pass fixations was similar between the two groups. These findings suggest that in this study the effects of emotional valence were local, restricted to the manipulated area, and mainly associated to the first processing of text, whereas strategic reading behaviors, like

rereading, were less influenced by emotional valence. Second-pass fixations (rereading) were probably more strictly related to cognitive factors (Scrimin & Mason, 2015), such as the perceived coherence or difficulty of the text, which was probably perceived similar in the two reading conditions.

Effects of emotional valence on memory for text

The emotional memory narrowing hypothesis predicts that while sustained attention to negative valence in a text can fix memory for the emotional details of the story, in contrast, it is detrimental to the processing and memory of peripheral (non-emotional) information (Kensinger, 2009). An alternative hypothesis, based on preliminary findings of Burton et al. (2004), is that by inducing a more analytical processing of the text, negative emotional valence could benefit text memory more widely, that is, may also enhance readers' memory for peripheral information, such as the details of the situation described. The results of this study did not support either of these two hypotheses. The negative emotional valence of the central part (AoI2) of the story passage induced a memory enhancement for the negative emotional content only (AoI2), without interfering with readers' memory of other (peripheral) information (in AoI1 and AoI3) or, alternatively, enhancing memory for the text at a general level. The implications of this finding for the design and adaptation of textual material will be discussed later.

The role of readers' dispositional empathy

The participants in the negative valence condition reported to be more empathetic with the character when reading the story. This group spent longer time processing AoI2 and showed better memory of the emotional content of the story (AoI2). In contrast, readers in the neutral valence condition, who reported less empathy for the story character were also faster at processing AoI2 (i.e., showed shorter first-pass fixations) and demonstrated poorer memory of this part of the text. Remarkably, these differences cannot be attributed to individual differences in dispositional empathy, as the two groups were matched on interpersonal reactivity (IRI scores). In line with other research (Johnson, 2012; Hsu et al., 2014), these findings suggest that feeling empathic responses during reading is an important component of the cognitive processing of texts. On the other hand, these results also help explain why negative valence could be associated with longer text processing and stronger memory for text (Burton et al., 2004): Inducing more empathic responses, negative content may cause a greater immersion in reading, with beneficial effects for the cognitive elaboration of the text (Hsu et al., 2014).

Hypothesis 3 anticipated that readers' dispositional empathy would modulate their sensitivity to text valence, and thus their processing of the story read. However, we found no evidence of a relationship between readers' personal dispositional empathy and their text processing or memory for text. This finding is inconsistent with what found by Silva et al. (2012), who showed that readers' individual

sensitivity to a specific emotion (disgust) influenced their speed in a lexical decision task more than word valence. In this study we considered a more general disposition (the interpersonal reactivity index) and a more complex linguistic task, i.e., story reading, than in Silva et al.'s study. These two factors may account for the differences between the studies. In story reading, mirroring the character's emotions is an important part of the reader's comprehension process (Child et al., 2020), consequently negative emotional valence could have an impact on readers' text processing that is less dependent of their individual disposition.

Practical implications

The practical implications of these findings may be several, from informing decisions about the design of intelligent tutoring systems (D'Mello et al., 2012), or the adaptation of instructional texts, to the design of persuasive texts for public health campaigns or other social purposes (Trevors & Kendeou, 2020). In the digital era, intelligent tutoring systems capable to detect readers' engagement during reading and respond to readers' boredom and disengagement are already available (D'Mello et al., 2012). Studies on the effects of emotional valence in reading can help develop more sophisticated and interactive tutoring systems and digital tools for reading.

Our findings suggest that adaptations of the emotional valence of texts could modulate readers' text processing. Learning from texts is cognitively demanding for most readers. Enhancing reader's immersion in the task by manipulating the emotional content of text segments may improve readers' processing of specific parts of the text and is thus a potential important target of reading interventions. Similar adaptations should not be limited to fictional narratives. A strategic use of negative valence in texts can indeed improve also the processing and memory of historical, persuasive or refutation texts (Trevors & Kendeou, 2020).

Limitations of the study and future directions

In the present study, we conducted a fine-grained analysis of readers' real-time responses to valence variations within a literary text, controlling not only for relevant text characteristics (e.g., length, readability), but also for interindividual differences in dispositional empathy and working memory. The use of a single text passage represents however an important limitation of this study. Its findings show that negative content induces more analytical text processing and better memory for details. However, these effects seem locally restricted to the surroundings of the emotional content in the text. Replicating the experiment with other narrative passages, or even different genres, could help establish the extent to which these results generalize to other texts.

Future studies should also explore further the subject variables that can modulate readers' response to text valence. In the present study we considered readers' dispositional empathy. Readers' engagement in a narration could however depend on other factors too, like their similarity to the character (e.g., being of same gender, ethnicity, or age), or familiarity with the situation narrated. For instance, readers who share

characteristics with the story protagonist (e.g., gender, ethnicity, age, or personality traits) seem to experience greater empathy for her/him and, consequently, greater engagement in the narration (Komeda et al., 2013). Similarly, being familiar or not with the situation narrated or the narrative scenario could also modulate readers' transportation and individual sensitivity to text valence. Taking into consideration these variables can be important for a deeper understanding of the influence of emotional valence in reading.

A further limitation of the study relates to the experimental conditions tested. In the present study we were interested in the effects of negative valence on text processing. We thus compared two experimental reading conditions: a negative versus a neutral valence condition. Previous research has shown that positive valence too can influence readers' engagement and text processing (Ballenghein et al., 2019; Child et al., 2020). A more complete experimental design would be one in which also a positive valence experimental condition is considered. A comparison between neutral, positive and negative valence conditions could indeed help explore the selective contribution of arousal and valence in reading (e.g., Ballenghein et al., 2019).

Conclusion

Despite these limitations, the study contributes to the current literature by providing evidence that in text processing, like in real-life situations, contents evoking negative emotions engage readers' attention and induce a more analytical processing and memory encoding of emotionally negative information. As a consequence, negative contents are remembered more accurately and more vividly than neutral contents. Differently from what predicted by the emotional memory narrowing hypothesis, in fictional situations like story reading the emotional focus does not seem to interfere with the encoding of textual information at other levels, or with readers' memory of peripheral details. On the contrary, as also noted by other authors (Hsu et al., 2014; Kneepkens & Zwann, 1994), negative emotional content may enhance readers' immersion in the task and analytical processing of the information surrounding the emotional content, that is an important part of the comprehension of stories, as well as of other text genres. Studying readers' real-time responses to literary texts can be a challenging enterprise, but our auspice is that in the future more studies will address this challenge, focusing on natural (literary) texts to increase our understanding of the role of emotional valence in real-life reading situations.

Appendix A

The Two Texts in English (manipulated text in the neutral version in bold; The personal pronoun *he* is replaced by *she* as in the Italian versions).

Negative emotional valence

[When *she* woke up..] she felt like if she had in fact been lifted bodily and still awake into another room in another building. The room seemed deserted, part of an abandoned house. Its walls and floor were bare planks; the window was only an empty frame, sunlight leaked in through a dozen cracks. **[AoI1]** It was as if she were not merely dreaming. She did not know how she knew it, but she knew that something horrible was going to happen. She was unable to leave the bed; but even if her muscles were working, she knew with the same knowledge that she would not be able to escape whatever was coming and she was afraid of it. Her body was covered with an old quilt so faded that some of its squares were white. Beneath it, her legs lay paralyzed. **[AoI2]** The room was on an upper floor of the building: through the window she saw only gray clouds and a pale blue sky. From down at the bottom of the house, she heard a crash-it was the noise of a door being thrown open, a heavy cellar door banging against a wall. Someone was going up **[AoI3].**

Neutral emotional valence

[When she woke up..] she felt like if she had in fact been lifted bodily and still awake into another room in another building. The room seemed deserted, part of an abandoned house. Its walls and floor were bare planks; the window was only an empty frame, sunlight leaked in through a dozen cracks. **[AoI1]** It was as if she were not merely dreaming. She did not know how she knew it, but she felt like **something was familiar in that place**. She knew that the room **belonged to someone she had met several years ago and she was calm**. She was unable to leave the bed; but even if her muscles were working, she knew with the same knowledge that she could not stand up. Her body was covered with **a soft quilt**. Beneath it, her legs **lay numb**. **[AoI2]** The room was on an upper floor of the building: through the window she saw only gray clouds and a pale blue sky. From down at the bottom of the house, she heard a crash-it was the noise of a door being thrown open, a heavy cellar door banging against a wall. Someone was going up **[AoI3].**

Appendix B

Multiple Choice Questions for the Memory Test (literal translation from Italian).

You will now be presented with some sentences. You are asked to recognize which sentences are included in the text you have just read.

- Sara felt like if she had never fallen asleep in that room
- **Sara felt like if she had been carried awake to another building [AoI1]**
- Sara felt like if she was not fully awake
- Sara felt like if she was dreamin

- **The room seemed deserted [AoI1]**
- The room seemed poor
- The room seemed clean
- The room seemed cozy

- The room was on the ground floor of the building
- The room was adjacent to the cellar
- **The room was on the upper floor of the building [AoI3]**
- The room was in the basement

- Its walls were covered with fabrics
- **Its walls were made of bare planks. [AoI1]**
- Its walls were bare
- Its walls were bright

- **The window was an empty frame. [AoI1]**
- The window was a dark frame
- The window was a bright frame
- The window was a frame on an avenue

- **She was calm [AoI2, Neutral]**
- **She was afraid [AoI2, Negative]**
- She was concerned
- She was serene

- Her arms lay paralyzed
- **Her legs rested numb. [AoI2, Neutral]**
- Her body lay numb
- **Her legs lay paralyzed. [AoI2, Negative]**

- She felt that the place belonged to the past
- **She felt that something was familiar in that place**. **[AoI2, Neutral]**
- **She felt that in that place something horrible was going to happen [AoI2, Negative]**
- **Her body was covered with a quilt. [AoI2, Negative, Neutral].**

- She felt that in that place something was going to happen
- Her body was covered with an old cloth
- Her body was covered with a blanket
- Her body was covered with a sheet

- Through the window she could see the sun rays
- Through the window she could see a garden
- **Through the window she could see a pale blue sky. [AoI3]**
- Through the window she could see a street

- She heard the upstairs door banging against a wall
- **She heard the cellar door banging against a wall. [AoI3]**
- She heard the cellar door open
- She heard the upstairs door open

- Somebody was going in
- **Somebody was going up. [AoI3]**
- Somebody was going down
- Somebody was going out

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Declarations

Conflict of interest We have no conflicts of interest to disclose.

References

Albiero, P., Ingoglia, S., & Lo Coco, A. (2006). Contributo all'adattamento italiano dell'Interpersonal reactivity index [Contribution to the Italian adapation of the interpersonal reactivity index]. *TPM. Testing Psicometria Metodologia, 13*(2), 107–125. [in Italian].

Algom, D., Chajut, E., & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: A generic slowdown, not a Stroop effect. *Journal of Experimental Psychology: General, 133*, 323–338. https://doi.org/10.1037/0096-3445.133.3.323

Ariasi, N., Hyönä, J., Kaakinen, J., & Mason, L. (2017). An eye-movement analysis of the refutation effect in reading science text. *Journal of Computer Assisted Learning*, *33*(3), 202−221. https://doi.org/10.1111/jcal.12151

Bahrick, L. E., Parker, J. F., Fivush, R., & Levitt, M. (1998). The effects of stress on young children's memory for a natural disaster. *Journal of Experimental Psychology: Applied, 4*(4), 308–331. https://doi.org/10.1037/1076-898X.4.4.308

Ballenghein, U., Megalakaki, O., & Baccino, T. (2019). Cognitive engagement in emotional text reading: Concurrent recordings of eye movements and head motion. *Cognition and Emotion, 33*(7), 1448–14460. https://doi.org/10.1080/02699931.2019.1574718

Bohn-Gettler, C. M. (2019). Getting a grip: the PET framework for studying how reader emotions influence comprehension. *Discourse Processes, 56*, 386–401. https://doi.org/10.1080/0163853X.2019.1611174

Bohn-Gettler, C. M., & Kaakinen, J. (2021) Introduction to the Special Issue on Emotions in reading, learning, and communication. *Discourse Processes*. https://doi.org/10.1080/0163853X.2021.1899369

Brierley, B., Medford, N., Shaw, P., & David, A. (2007). Emotional memory for words: Separating content and context. *Cognition and Emotion, 21*, 495–521. https://doi.org/10.1080/02699930600684963

Burton, L. A., Rabin, L., Vardy, S. B., Frohlich, J., Wyatt, G., Dimitri, D., Constante, S., & Guterman, E. (2004). Gender differences in implicit and explicit memory for affective passages. *Brain and Cognition, 54*(3), 218–224. https://doi.org/10.1016/j.bandc.2004.02.01

Citron, F. M. M. (2012). Neural correlates of written emotion word processing: A review of recent electrophysiological and hemodynamic neuroimaging studies. *Brain and Language*, *122*(3), 211–226. https://doi.org/10.1016/j.bandl.2011.12.007

Child, S., Oakhill, J., & Garnham, A. (2018). You're the emotional one: The role of perspective for emotion processing in reading comprehension. *Language, Cognition and Neuroscience, 33*(7), 878–889. https://doi.org/10.1080/23273798.2018.143139

Child, S., Oakhill, J., & Garnham, A. (2020). Tracking your emotions: An eye-tracking study on reader's engagement with perspective taking during text comprehension. *Quarterly Journal of Experimental Psychology, 73*(6), 929–940. https://doi.org/10.1177/1747021820905561

De Beni, R., Borella, E., Carretti, B., Marigo, C., & Nava, L. A. (2008). BAC. Portfolio per la valutazione del benessere e delle abilità cognitive nell'età adulta e avanzata [*The assesment of well-being and cognitive abilities in adulthood and aging*]. Giunti OS [in Italian].

De Corte, K., Buysse, A., Verhofstadt, L. L., Roeyers, H., Ponnet, K., & Davis, M. H. (2007). Measuring empathic tendencies: reliability and validity of the dutch version of the interpersonal reactivity index. *Psychologica Belgica, 47*(4), 235–260. https://doi.org/10.5334/pb-47-4-235

Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *JSAS Catalog of Selected Documents in Psychology*, *10*, 85

Delatorre, P., León, C., & Salguero, A. (2021). Improving the fitness function of an evolutionary suspense generator through sentiment analysis. *IEEE Access, 9*, 39626–39635. https://doi.org/10.1109/ACCESS.2021.3064242

Delatorre, P., León, C., Salguero, A., Palomo-Duarte, M., & Gervás, P. (2018). Confronting a paradox: a new perspective of the impact of uncertainty in suspense. *Frontiers in Psychology, 9*, e1392. https://doi.org/10.3389/fpsyg.2018.01392

Delatorre, P., León, C., Salguero, A. G., & Tapscott, A. (2020). Predicting the effects of suspenseful outcome for automatic storytelling. *Knowledge-Based Systems, 209*, 106450. https://doi.org/10.1016/j.knosys.2020.106450

D'Mello, S., Olney, A., Williams, C., & Hays, P. (2012). Gaze tutor: A gaze-reactive intelligent tutoring system. *International Journal of Human-Computer Studies*, *70*(5), 377–398. https://doi.org/10.1016/j.ijhcs.2012.01.004

Ellis, H. C., & Ashbrook, P. W. (1988). Resource allocation model of the effects of depressed mood states on memory. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition, and social behavior: new evidence and integrative attempts* (pp. 25–43). Hogrefe.

Estes, Z., & Adelman, S. J. (2008). Automatic vigilance for negative words is categorical and general. *Emotion, 8*(4), 453–457. https://doi.org/10.1037/a0012887

Fiedler, K., & Bless, H. (2001). The formation of beliefs in the interface of affective and cognitive processes. In N. Frijda, A. Manstead, & E. Bem (Eds.), *The influence of emotions on beliefs* (pp. 144–170). Cambridge University Press.

Gordon, P. C., Hendrick, R., Johnson, M., & Lee, Y. (2006). Similarity-based interference during language comprehension: Evidence from eye tracking during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*(6), 1304–1321. https://doi.org/10.1037/0278-7393.32.6.1304

Hsu, C-T., Conrad, M., & Jacobs, A. M. (2014). Fiction feelings in Harry Potter: Haemodynamic response in the mid-cingulate cortex correlates with immersive reading experience. *NeuroReport for Rapid Communication of Neuroscience Research, 25*(17), 1356–1361. https://doi.org/10.1097/WNR.0000000000000272

Hyönä, J., Lorch, R. F., & Kaakinen, J. K. (2002). Individual differences in reading to summarize expository text: Evidence from eye fixation patterns. *Journal of Educational Psychology, 94*(1), 44–55. https://doi.org/10.1037/0022-0663.94.1.44

Hyönä, J., Lorch, R. F., & Rinck, M. (2003). Eye movement measures to study global text processing. In J. Hyönä, R. Radach, & H. Deubel (Eds.), *The mind's eye: cognitive and applied aspects of eye movement research* (pp. 313–334). Elsevier Science.

Hyrskykari, A. (2006). Utilizing eye movements: overcoming inaccuracy while tracking the focus of attention during reading. *Computers in Human Behavior, 22*(4), 657–671. https://doi.org/10.1016/j.chb.2005.12.013

Johnson, D. R. (2012). Transportation into a story increases empathy, prosocial behavior, and perceptual bias toward fearful expressions. *Personality and Individual Differences, 52*(2), 150–155. https://doi.org/10.1016/j.paid.2011.10.005

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review, 87*(4), 329–354. https://doi.org/10.1037/0033-295X.87.4.329

Kaplan, R. L., Van Damme, I., & Levine, L. J. (2012). Motivation matters: Differing effects of pre-goal and post-goal emotions on attention and memory. *Frontiers in Psychology, 3*, e404. https://doi.org/10.3389/fpsyg.2012.00404

Kensinger, E. A. (2007). Negative emotion enhances memory accuracy. Behavioral and neuroimaging evidence. *Current Directions in Psychological Science, 16*(4), 213–218. https://doi.org/10.1111/j.1467-8721.2007.00506.x

Kensinger, E. A. (2009). Remembering the details: effects of emotion. *Emotion Review, 1*, 99–113. https://doi.org/10.1177/1754073908100432

Kensinger, E. A., & Corkin, S. (2003). Memory enhancement for emotional words: Are emotional words more vividly remembered than neutral words? *Memory & Cognition*, *31*(8), 1169–1180. https://doi.org/10.3758/bf03195800

Kissler, J., Herbert, C., Peyk, P., & Junghofer, M. (2007). Buzzwords - Early cortical responses to emotional words during reading. *Psychological Science*, *18*(6), 475–480. https://doi.org/10.1111/j.1467-9280.2007.01924.x

Kneepkens, E. W. E. M., & Zwann, R. A. (1994). Emotions and literaly text comprehension. *Poetics, 23*(1–2), 125–138. https://doi.org/10.1016/0304-422X(94)00021-W

Komeda, H., Tsunemi, K., Inohara, K., Kusumi, T., & Rapp, D. N. (2013). Beyond disposition: The processing consequences of explicit and implicit invocations of empathy. *Acta Psychologica, 142*(3), 349–355. https://doi.org/10.1016/j.actpsy.2013.01.002

Kousta, S. T., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition, 112*(3), 473–481. https://doi.org/10.1016/j.cognition.2009.06.007

Lucas-Molina, B., Pérez-Albéniz, A., Ortuño-Sierra, J., & Fonseca-Pedrero, E. (2017). Dimensional structure and measurement invariance of the Interpersonal Reactivity Index (IRI) across gender. *Psicothema, 29*, 590–595. https://doi.org/10.7334/psicothema2017.19

Mason, L., Tornatora, M. C., & Pluchino, P. (2015). Integrative processing of verbal and graphical information during rereading predicts learning from illustrated text: an eye-movement study. *Reading and Writing*, *28*, 851–872. https://doi.org/10.1007/s11145-015-9552-5

Mason, L., Scheiter, K, & Tornatora, M. C. (2017). Using eye movements to model the sequence of text-picture processing for multimedia comprehension. *Journal of Computer Assisted Learning*, *33*, 443–460. https://doi.org/10.1111/jcal.12191

Mason, L., Zaccoletti, S., Scrimin, S., Tornatora, M. C., Florit, E., & Goetz, T. (2020). Reading with the eyes and under the skin: Comprehending conflicting digital texts. *Journal of Computer Assisted Learning*, *36*, 89−101. https://doi.org/10.1111/jcal.12399

Megalakaki, O., Ballenghein, U., & Baccino, T. (2019). Effects of valence and emotional intensity on the comprehension and memorization of texts. *Frontiers in Psychology, 10*, 179. https://doi.org/10.3389/fpsyg.2019.00179

Mouw, J. M., Van Leijenhorst, L., Saab, N., Danel, M. S., & van den Broek, P. (2019). Contributions of emotion understanding to narrative comprehension in children and adults. *European Journal of Developmental Psychology*, *16*(1), 66–81. https://doi.org/10.1080/17405629.2017.1334548

Pazzaglia, F., Palladino, P., & De Beni, R. (2000). Presentazione di uno strumento per la valutazione della memoria di lavoro verbale e sua relazione con i disturbi della comprensione [*A tool for the assessment of working memory and its relation with reading comprehension problems*]. *Psicologia Clinica Dello Sviluppo, 4*(3), 465–486.

Peterson, C., & Bell, M. (1996). Children's memory for traumatic injury. *Child Development, 67*(6), 3045–3070. https://doi.org/10.1111/j.1467-8624.1996.tb01902.x

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61*(3), 380–391. https://doi.org/10.1037/0022-3514.61.3.380

Reisberg, D., & Heuer, F. (2007). The influence of emotion on memory in forensic settings. In M. P. Toglia, J. D. Read, D. F. Ross, & R. C. L. Lindsay (Eds.), *The handbook of eyewitness psychology memory for eevents* (Vol. 1, pp. 81–116). Lawrence Erlbaum Associates Publishers.

Russell, J. A. (1980). A circumplex model affect. *Journal of Personality and Social Psychology, 39*, 1161–1178. https://doi.org/10.1037/h0077714

Scott, G. G., O'Donnell, P. J., & Sereno, S. C. (2012). Emotion words affect eye fixations during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*(3), 783–792. https://doi.org/10.1037/a0027209

Shagass, C., Roemer, R. A., & Marco, A. (1976). Eye-tracking performance and engagement of attention. *Archives of General Psychiatry, 33*(1), 121–125. https://doi.org/10.1001/archpsyc.1976.01770010077015

Shaked, K. B. Z., Shamir, A., & Vakil, E. (2020). An eye tracking study of digital text reading: A comparison between poor and typical readers. *Reading and Writing, 33*(8), 1925–1944. https://doi.org/10.1007/s11145-020-10021-9

Silva, C., Montant, M., Ponz, A., & Ziegler, J. C. (2012). Emotions in reading: Disgust, empathy and the contextual learning hypothesis. *Cognition, 125*, 333–338. https://doi.org/10.1016/j.cognition.2012.07.013

Straub, P. (1979). *Ghost story*. New York: G. P. Putnam's Sons.

Trevors, G., & Kendeou, P. (2020). The effects of positive and negative emotional text content on knowledge revision. *Quarterly Journal of Experimental Psychology*. https://doi.org/10.1177/1747021820913816

Tulis, M., & Fulmer, S. M. (2013). Students' motivational and emotional experiences and their relationship to persistence during academic challenge in mathematics and reading. *Learning and Individual Differences, 27*, 35–46. https://doi.org/10.1016/j.lindif.2013.06.003

van Gog, T., & Scheiter, K. (2010). Eye tracking as a tool to study and enhance multimedia learning [Editorial]. *Learning and Instruction, 20*(2), 95–99. https://doi.org/10.1016/j.learninstruc.2009.02.009

Yeari, M., van den Broek, P., & Oudega, M. (2015). Processing and memory of central versus peripheral information as a function of reading goals: Evidence from eye-movements. *Reading and Writing, 28*(8), 1071–1097. https://doi.org/10.1007/s11145-015-9561-4

Zucco, C., Calabrese, B., Agapito, G., Guzzi, P. A., & Cannataro, M. (2020). Sentiment analysis for mining texts and social networks data: Methods and tools. *Wires Data Mining and Knowledge Discovery, 10*(1), e1333. https://doi.org/10.1002/widm.1333