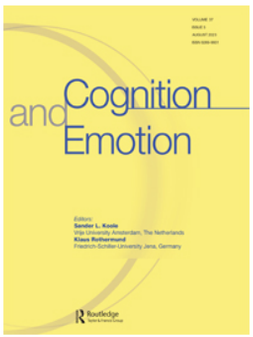

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Fluctuation in cognitive engagement during listening and reading of erotica and horror stories

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ABSTRACT

The present study examined whether emotional text content influences cognitive engagement and transportation during listening (Experiment 1) and reading (Experiment 2) of neutral, horror and erotic stories. In Experiment 1, fluctuation in arousal and cognitive engagement were measured by continuous arousal judgments and head movement recordings during story listening. Participants rated experienced transportation and emotional valence after each story. The results showed that emotional texts were more arousing and induced more transportation than neutral stories. There was less head motion overall and a steeper decrease in head motion across time for erotic than neutral or horror stories. In Experiment 2, participants' head movements and reading times were recorded during reading, and participants rated experienced transportation, arousal, and valence after each text. The results showed that emotional texts were more arousing and induced higher transportation than neutral stories. There was less head motion during reading of erotic than neutral or horror texts. Horror texts were read slower and recalled better than neutral or erotic texts. The present results show that emotional text content impacts cognitive engagement during listening and reading of literary texts and demonstrates the importance of methodological triangulation when examining cognitive engagement.

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emotion; cognitive engagement; reading; listening; transportation

Introduction

We often encounter emotionally arousing content in our daily lives: social media posts, podcasts, radio shows, or literature, either in written form or as audiobooks, may contain information that induces emotional reactions. Some literary texts are written for the purpose of inducing emotions in their receivers – for example, the point of horror stories is to induce negative suspense via descriptions of horrible events, whereas the purpose of erotica is to induce pleasurable arousal (Kneepkens & Zwaan, 1995; Miall & Kuiken, 2002; Oatley, 1995). Emotional texts, such as suspenseful stories, are assumed to increase immersion or transportation to the story world (e.g. Hsu et al., 2014; Jacobs, 2015). When immersed in the story, the receiver's attention and memory processes are fully focused on the narrative (Gerrig, 1993; Green & Brock, 2000; Kuijpers et al., 2014). In other words, when immersed in the story world, the receiver is cognitively engaged with the story (e.g. Kaakinen & Simola, 2020).

Although current research has shown that emotions are an integral part of cognitive functions such as judgment or decision making (Frijda, 2009), attention (Christianson et al., 1991), memorisation (Eich & Metcalfe, 1989), or text comprehension (Bohn-Gettler, 2019; Megalakaki et al., 2019), very few studies have focused on the influence of

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emotional text content on cognitive engagement during literary text reception (see Ballenghein et al., 2019; Kaakinen & Simola, 2020; Usée et al., 2020). Recent reading studies suggest that there is an emotion bias in text processing: eye fixation times are shorter during reading of positively valenced texts than negative or neutral texts (Ballenghein et al., 2019; Usée et al., 2020). Moreover, cognitive engagement, as measured by postural movement during the course of reading (see Ballenghein et al., 2020; Kaakinen et al., 2018), was found to be higher during reading of emotional than neutral texts (Ballenghein et al., 2019). However, Ballenghein et al. (2019) only investigated reading, and they used short narratives that varied in arousal. The influence of texts' valence with a high level of arousal on cognitive engagement during reading and listening needs more examination.

Moreover, there is conflicting evidence about the extent to which negative linguistic stimuli captures attention. Research on negativity bias suggests that there is higher sensitivity to negative than to positive information (Baumeister et al., 2001). Egidi and Gerrig (2009) examined reading times of positively and negatively ending stories and found that reading times were longer for negative than for positive story endings. Nevertheless, the asymmetric effect of valence on cognitive processes remains unclear. For example, Knickerbocker et al. (2015) showed that in reading, there is a processing advantage for emotional words over neutral words, regardless of valence polarity. Also, other studies have found that emotional words are read faster than neutral words (e.g. Kousta et al., 2009; Scott et al., 2012). In a listening task no differences in pupil size fluctuation or blink rates were found between negatively valenced horror stories and neutral stories, indicating that negative text content does not necessarily capture and maintain receivers' attention (Kaakinen & Simola, 2020).

In summary, it is still unclear to what extent positive and negative emotional valence play a role in allocation of attentional resources during text processing, and whether these emotion effects generalise across modalities. In the present study, we aimed to fill up this gap and explore the effects of valence and emotional intensity of literary texts on cognitive engagement by studying postural movements and eye movements. The two experiments presented in this article used highly emotional narrative texts, specifically, horror stories and erotica, and contrasted them with neutral texts to investigate the influence of such content on listening and reading. In Experiment 1, the texts were presented orally to the participants while they judged the emotional intensity in real time. In addition, to have an indicator of the cognitive engagement of the listeners, their head movements were measured during listening. After each story, participants responded to a questionnaire about experienced transportation and recalled the contents of the story. In Experiment 2, participants were asked to read the texts at their own pace while their eye movements and head movement were simultaneously recorded. As in Experiment 1, they filled a transportation questionnaire after each text and recalled the story contents. The results of these two experiments will provide information on the influence of highly emotional information on cognitive engagement during listening and reading of literary texts, allowing comparisons of the emotion effects across modalities.

The two-dimensional view of emotion

The two-dimensional view of emotion describes two components to consider when qualifying an emotion (Citron et al., 2014). The first is the emotional valence which describes to what extent the perceived emotional feeling is pleasant or unpleasant, as measured on a continuum from negative to positive through neutral (Lang et al., 1997). The second component is arousal, which describes arousal or the intensity of activation of the emotional feeling, which varies from weak or calm to strong and exciting (Lang et al., 1997).

Whether valence and arousal are independent dimensions or not has been a topic of scientific controversy (see Moors, 2009). On the one hand, the affective circumplex model of Russell (1980) describes the valence and the arousal as independent components, which form the orthogonal axes of the circumplex. Several empirical studies support this independent conception of emotion (Russell & Barrett, 1999), and neuroimaging studies have also supported this notion by suggesting the existence of two independent neural systems dedicated to the processing of valence and arousal (Anders et al., 2004; Lewis et al., 2006). On the other hand, valence and arousal are linked: very negative or very positive stimuli are also highly arousing (Bradley et al., 1998; Bradley & Lang, 1999). Research shows that these two components are linked by a U-shaped function,

representing an affective space with two dependent dimensions (Bayer et al., 2010). Rating data of emotional words (Bradley & Lang, 1999), pictures (Lang et al., 1999), sounds (Bradley et al., 1998), and short stories (Kaakinen et al., 2022) show that emotional valence and arousal ratings are linked via this U-shaped function. Emotions judged as strongly positive or negative are also judged with a high level of arousal while the neutral stimuli are judged with a low level of arousal.

The two experiments presented in this article used highly arousing emotional literary texts, namely erotica and horror, and compared them to neutral texts to investigate the influence of such content on the listening and reading of these texts. These experiments allowed us to examine the fluctuation of cognitive engagement during listening (Experiment 1) and reading (Experiment 2).

Cognitive engagement during reading and listening

Although the notion of cognitive engagement has not been clearly defined in the literature, it can be described as the focusing of cognitive resources (e.g. attention, memory, emotion) on the task of reading (Sinatra et al., 2015) or listening (Herrmann & Johnsrude, 2020). Herrmann and Johnsrude (2020) suggested that engagement is a highly subjective experience, which is influenced by various interrelated factors such as effort needed to perform the task, motivation to engage with the task, and related emotions such as frustration or boredom, which are likely to reduce the experienced engagement (see also Pichora-Fuller et al., 2016).

When considering literary text reception, cognitive engagement is probably linked to experiences of narrative immersion or transportation to the story world (Gerrig, 1993; Green & Brock, 2000; Kuijpers et al., 2014), which is characterised by, for example, focusing attention and memory resources on forming vivid mental imagery of the narrative world and anticipating future events in the story.

In previous studies, cognitive engagement has been operationalised with different measures. Some studies have used increased eye fixation times on the inspected materials as an index of cognitive engagement (see Miller, 2015). The use of eye movement recordings is supported by findings showing that, for example, eye fixation times are longer during reading of task-relevant than task-irrelevant sentences in a text, resulting in better memory for relevant than irrelevant information (e.g. Kaakinen et al., 2002, 2003). Also, postural movements have been used as an indicator of cognitive engagement, reduced motion taken as an indicator of high task engagement, and increased motion indicating low engagement (e.g. Balaban et al., 2004; Ballenghein et al., 2019; Ballenghein & Baccino, 2019; Bonnet et al., 2016; D'Mello et al., 2007; Kaakinen et al., 2018; Witchel et al., 2016). For example, in a learning task, D'Mello et al. (2007) showed that increased postural movement was linked with cognitive disengagement or boredom. Comparing reading of an engaging and a boring text, Witchel et al. (2016) showed that there was less postural movement during the more engaging reading task, suggesting that cognitive engagement reduces movements that are not instrumental for performing the task – a phenomenon they labelled as non-instrumental movement inhibition (NIMI).

A recent reading study suggests that cognitive engagement may fluctuate, and that there are two types of engagement processes: *transient* changes reflected by fast and momentary changes, and *sustained* changes in engagement reflected by slower changes across the reading task (Kaakinen et al., 2018). In this study, readers' eye and postural movements were recorded while they read expository texts containing task-relevant and irrelevant sentences. Results indicated that eye movements reflected *transient* changes in engagement, seen as longer eye fixation times on task-relevant than irrelevant sentences within the text. *Sustained* changes were reflected in reduced head motion during reading of relevant sentences observed across the text.

The influence of emotional text content on cognitive engagement during reading was examined in a study by Ballenghein et al. (2019), who measured readers' eye movements and postural movements while they were reading emotionally positive, negative, and neutral texts. The results showed that eye fixation times were shorter during reading of positive than neutral or negative texts (see also Usée et al., 2020), and that readers made smaller head movements during reading of emotional (positive or negative) than neutral texts. These results suggest that even though positive text content speeds up reading, both negative and positive texts increase cognitive engagement. Recently, Arfé et al. (2022) investigated how variations in emotional valence in a literary text affected text processing by measuring

readers' eye movements. The results revealed longer first-pass fixation times for content evoking negative emotions than for neutral content, which was interpreted by the authors as a greater sustained attention in the case of reading texts with negative valence. In contrast, a listening study by Kaakinen and Simola (2020) failed to find differences between negatively valenced horror stories and neutral texts in pupil size fluctuation or blink rate, which can also be taken as indices of cognitive engagement. However, narrative transportation, as measured after listening to each story, was correlated with these measures. These findings suggest that also emotionally neutral literary text content can induce narrative transportation and cognitive engagement, indicating that it is important to control for the subjective experiences of immersion or transportation when examining literary text reception.

The purpose of the present study was to examine experienced narrative transportation and cognitive engagement during listening (Experiment 1) and reading (Experiment 2) of emotionally positive and negative literary texts, namely horror stories and erotica, and contrast them with neutral stories. We hypothesise that emotional stories are more emotionally arousing and cognitively engaging, and that they induce more narrative transportation than neutral stories. These differences should be reflected as reduced head movements during listening or reading of the emotional stories, and as better recall of the content of the stories.

Experiment 1

In Experiment 1, participants listened to positive (erotica), negative (horror) and neutral text excerpts while they evaluated their arousal with the Arousal Rating Tool, an ad-hoc software (see procedure section). During the listening task, participants' postural movements were measured using a motion capture recording system. Finally, participants responded how much transportation they had experienced, and were asked to briefly describe the main points of the story they had heard.

Materials and methods

Participants

A power analysis using G*Power 3 software (Faul et al., 2007) indicated that a total sample of 28 participants would be needed to detect a medium-sized effect (d = .25) of valence with power (1 – β) set at 0.80 and α = .05 in an F test (repeated measures ANOVA). Participants (n = 41) were recruited via a mailing list consisting of community volunteers that have signed up for a participant pool. All participants were native French speakers, mean age was 25.39 years (SD = 7.65), 9 were male, and 37 right-handed. All participants had a high-school degree, and on average 2.68 years of college education (SD = .96). All tested participants received a voucher for the value of 10 euros for participation.

Apparatus

Advanced Realtime Tracking (ART) motion capture system (for technical details see www.ar-tracking.com) was used to record participants' head movements during reading. The system included six infrared-based cameras (sampling rate 60 Hz) placed around the laboratory space. Participants wore glasses with six 12 mm markers attached to the rims, which were used to track and calculate head movements.

Materials

Text materials consisted of eight horror stories adopted from two Stephen King books (*it* and *Night Shift*), eight erotic stories taken from short stories written by Alina Reyes (*Seven nights*) and Julie Bray (*Erotic Stories*), and eight neutral stories. Neutral stories were emotionally neutral excerpts taken from the same texts that were used to extract the emotional stories (see Appendix for examples).

Audio recordings of the texts were created by running the texts through the *Balabolka* text-to-speech software (LexiMoSoft), at normal speed and female voice. We calculated the Flesch Reading Ease (FRE) for each text as follows: FRE = 206.835 – (1.015 x ASL) – (84.6 x ASW), where ASL = number of words / number of sentences and ASW = number of syllables / number of words. The mean length of the texts (in characters and words), audio file durations, and the FRE score by type of text are presented in Table 1. There were differences between text types in character count ($F(2,21) = 3.50$, $p = .049$), word count ($F(2,21) = 20.20$, $p < .001$) and audio duration ($F(2,21) = 4.30$, $p = .027$). There also were differences in FRE ($F(2,21) = 13.81$, $p < .001$). These differences were taken into account in the statistical analyses.

Table 1. Means and standard deviations of text characteristics as a function of text type.

	Text type					
	Erotic		Horror		Neutral	
Measure	M	SD	M	SD	M	SD
Character count	1098.37	42.65	1066.5	40.37	1049.75	27.13
Word count	201.12	10.95	175.75	6.61	177.75	8.55
Audio duration (s)	91	4.63	88.12	5.57	84.5	2.62
Flesch Reading Ease	67.57	6.24	53.64	4.98	53.22	7.21

Arousal rating

Throughout listening to the stories, participants were asked to rate the level of arousal in real time using the Arousal Rating Tool (see Figure 1). The participant's task was to move an image of an emoji along a line to match their current arousal level. The left end of the line depicted low arousal and the right end extremely high arousal, and this was visualised by the size of the eyes (big eyes = high arousal, small eyes = low arousal). The ratings were recorded in real time with a Matlab software running on a Macbook Air mi-2012 computer using the computer's touchpad at the sampling rate of 20 Hz. The rating could have any value from −1 (low arousal) to +1 (high arousal).

Valence rating

Valence ratings were collected using SAM scale (Bradley & Lang, 1994), which is a visual rating scale consisting of nine manikins representing a continuum of valence from extremely negative to extremely positive emotion. Participants' task was to select the image that best represents the emotion induced by the text, and the responses were coded on a 9-point scale (1 = extremely negative, 9 = extremely positive).

Transportation scale short form

Transportation ratings were collected using the Transportation Scale Short-Form (TS-SF) (Appel et al., 2015), which consisted of six items tapping into different aspects of transportation. Participants respond to the items (e.g. "I could picture myself in the scene of the events described in the narrative.") on scale from 1 to 7 (1 = not at all, 7 = very much).

Recalls

After listening to a text, participants were asked to recall the main contents of the story. In order to code the recalls, we identified main ideas or propositions included in each experimental story, and the recalls were coded for the number of correctly recalled propositions, with one point for each proposition included in the recall.

Procedure

The study protocol was approved by the Ethics Committee for Human Sciences at the University of Turku. After arriving in the laboratory, the participants signed an informed consent form. They were then given the motion capture glasses and the headphones, and instructions for the experiment were presented in written form. Participants were told that: "You will hear different texts through headphones. Some texts may contain emotional elements, and your task is to judge the level of arousal in real time using the computer in front of you. The level of arousal can also be seen as a level of excitability or the level of emotional activation. A horizontal line with a central cross is displayed on the screen. When you start listening, a face figure appears on the cursor. Move the figure to the right if the text is highly excitable. The more you move the figure to the right, the stronger your feeling of arousal. Instead, move the figure to the left if the text is low

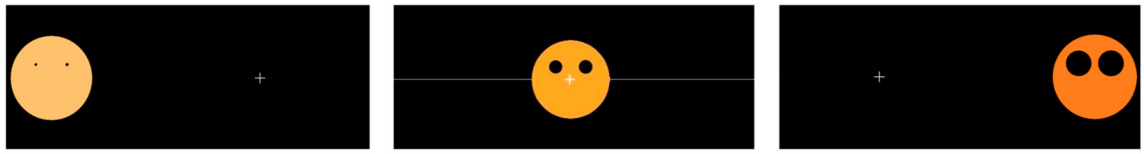

Figure 1. Arousal rating tool. Low arousal (a), medium arousal (b) and high arousal (c).

in excitability. The more you move the figure to the left, the weaker your feeling of arousal is. Before each text, place the mouse cursor on the cross in the center of the screen."

All 24 stories were presented aurally using *Bose QuietComfort 35* headphones with active noise cancelling mode enabled. After each text, participants rated the valence of the text with the SAM scale (Bradley & Lang, 1994). Then, participants were asked to rate their degree of transportation to the story with the TS-SF (Appel et al., 2015). Finally, they were asked to briefly describe the main points of the story they had heard.

Stories were presented in random order for each participant and replaying a story was not possible. A training phase with an *ad-hoc* neutral story was done before starting the experiment. The total duration of the experimental session was about 50-60 min.

Results

Data preparation and analysis

Rating data was missing for one participant due to technical problems with the recording software, resulting in n = 40 for arousal, valence, and transportation ratings. Moreover, one participant had misunderstood the valence rating task and was excluded from the analyses of valence, resulting in n = 39 for valence ratings.

For arousal rating data, we computed means across the samples for every second of the audio file. From motion capture data, we computed the head motion (mm/s) by computing the Euclidean distance of the head marker coordinates of two consecutive samples and dividing that by the time lag between the samples. We then computed a mean across the samples for every second of the audio file. Before the statistical analyses, outliers in the motion capture data were detected in two steps. First, in order to identify abnormal motion (e.g. wide movements due to the participant moving around) we identified observations that exceeded 2.5 SD of the grand mean and excluded them from the data (.70% of the data). Second, we examined the distribution of the head motion variable with the *checkdistr* function in the *fitdistrplus* -package for R. The distribution was skewed (skewness = 7.96), and examination of the Cullen and Frey graph indicated that logarithmic transformation would be suitable. Thus, we log-transformed the mean head motion per second and identified observations exceeding 2.5 SD of the grand mean of the log-transformed measure (2.95% of the observations). In order to check the impact of removing outliers on the second step, we also ran the model with the outliers, and the results were almost identical.

Recall data was missing for one participant and the hand-writing incomprehensible for one participant, resulting in n = 39 for the recall data.

The data were analysed with cumulative link, linear and generalised linear mixed effects models using the *ordinal* (version 2019.12.10; Christensen, 2019) and *lme4* packages (version 1.1-19; Bates et al., 2015) for R (version 4.0.3; R Core Team, 2020). Text type (neutral, erotic, horror) was entered to the models as a treatment coded fixed factor, using neutral texts as a baseline.

As valence was measured on an ordinal scale, it was analysed with a cumulative link mixed model fitted with Laplace approximation. The model was of the form: Valence ~Text type + (Text type | Participant) + (1 | Text), in which text type was a fixed factor, and a random intercept and random slope of text type for participants and a random intercept for texts were entered to the random part of the model.

Transportation was analysed with a linear mixed effect model of the form: Transportation ~Text type + (Text type | Participant) + (1 | Text), in which text type was a fixed factor and a random intercept and a random slope of text for participants, and a random intercept for texts were included in the random part of the model.

For models of arousal and head motion, which have continuous data across the text, time from the start of the text was entered as a centred fixed effect to the models. We included both linear and quadratic terms of time to the models. The models were of the form: Arousal / Head motion ~ Text type*(Time + Time ^2)+ (Text type*(Time + Time^2) | Participant) + (Time + Time^2| Text). Participants and texts were entered into the models as random effects. At the participant level we included a random intercept and random slopes for text type, linear and quadratic terms of time, and interactions between text type and linear and quadratic terms of time. At the text level a random intercept and random slopes for linear and quadratic terms of time were included. For arousal, the initial full model did not converge. The random structure of the model was then trimmed by removing the random slopes that showed the smallest estimated variance

one at a time until the model converged. The final model for arousal was of the form: Arousal ~ Text type * (Time + Time^2) + (Type*Time + Time^2 | Participants) + (1 | Text). Confidence intervals for the model estimates of fixed effects were computed using the Wald method. Differences between text types were examined by fitting the model at different levels of text type.

Recall data, for which the response was a binary variable (0 = not recalled, 1 = recalled) was analysed with a generalised linear mixed model using binomial distribution and Laplace approximation. The initial model was of the form: Recall ~ Text type + (Text type | Participant) + (1 | Text). However, the initial model produced singular fit, and the random slope was removed from the model. The final model included only random intercepts for participant and text: Recall ~ Text type + (1 | Participant) + (1 | Text).

As the Flesch Reading Ease scores and the mean length differed between texts, the models for transportation, arousal and head motion were conducted both with and without the Flesch Reading Ease score and text length as fixed factors. Of the different text length measures, we chose character count as it correlated highly with both word count ($r = .69$) and audio duration ($r = .70$). However, Flesch Reading Ease score and word count correlated only modestly with the outcome measures ($|r|$´s = .01 – .19) and adding them to the models did not influence the pattern of results. Thus, in the following, we report the models without the Flesch Reading Ease score or word count. Final models are presented in the Appendix.

Valence ratings

The mean valence ratings for neutral, erotic and horror texts are presented in Table 1. The analysis of the valence ratings showed that erotic texts induced more positive emotion than neutral texts ($\beta = 2.59$, *95%CI* = [1.39, 3.80], $z = 4.23$), whereas horror texts induced more negative emotion than the neutral texts ($\beta = -3.44$, *95%CI* = [−4.53, −2.35], $z = -6.18$).

Arousal during listening

Mean arousal ratings during listening of neutral, erotic and horror texts are presented in Table 1. The model estimates for arousal ratings across time for different texts are presented in Figure 2. Overall, arousal ratings were higher during erotic (β = .36, SE = .05, 95%CI = [.26,.47], t = 6.75) and horror texts (β = .32, SE = .06, 95%CI = [.21, .43], t = 5.60) than during neutral texts. There was no evidence of a difference between erotic and horror texts (β = .04, SE = .05, 95%CI = [-.15,.06], t = .84).

Moreover, there were interactions between text type and linear and quadratic terms of time (Text type erotic * Time: β = .16, SE = .02, 95%CI = [.13,.20], t = 10.30; Text type erotic * Time ^2: β = -.05, SE = .002, 95%CI = [-.05,.-.04], t = −20.06; Text type horror * Time: β = .13, SE = .02, 95%CI = [.09,.17], t = 6.62; Text type horror * Time^2: β = -.03, SE = .002, 95%CI = [-.04,-.03], t = −14.13), indicating that arousal changed differently during listening of erotic and horror texts than during neutral texts (see Figure 2). For neutral texts, there was a linear decrease in arousal across time (β = -.07, SE = .01, 95%CI = [-.09,-.05], t = −7.66), as well as a slight positive curve (β = .013, SE = .005, 95%CI = [.003, .022], t = 2.69). In contrast, during erotic texts there was a clear linear increase in arousal (β = .09, SE = .01, 95% CI = [.06,.12], t = 6.49) and a negative quadratic trend (β = -.03, SE = .005, 95%CI = [-.04,-.02], t = −7.17) indicating that the increase in arousal levels was not purely linear but there was a slight curve. Also for horror texts there was a clear linear increase in arousal (β = .06, SE = .02, 95%CI = [.03,.10], t = 3.43) with a negative quadratic term (β = -.02, SE = .005, 95%CI = [-.03,-.01], t = −4.33), even though the curve was flatter than for the erotic texts. In summary, as can be seen in Figure 2, arousal during listening of erotica and horror rapidly increased until it reached the peak level, whereas arousal during neutral stories decreased relatively steadily across time.

Head motion during listening

Mean head motion during listening of neutral, erotic and horror texts are presented in Table 1. Model estimates for head motion across the time for different text types are presented in Figure 3. The analyses revealed that there was overall less head motion during listening of erotic than neutral (β = -.12, SE = .04, 95%CI = [-.19, -.05], t = −3.27) or horror texts (β = .10, SE = .04, 95%CI = [.02, .18], t = 2.35). There was no evidence for a difference between neutral and horror texts (β = -.02, SE = .03, 95%CI = [-.08,.04], t = −0.69).

Head motion linearly decreased across time for all texts (β = -.21, SE = .02, 95%CI = [-.24,-.18], $t = -13.83$), and there was a slight positive curve (β = .19, SE = .02, 95%CI = [.16,.22], $t = 11.04$). However, the decrease was steeper for erotic than for neutral or horror texts, as indicated by interactions between text type and time (neutral vs. erotic: β = -.06, SE = .02, 95%CI

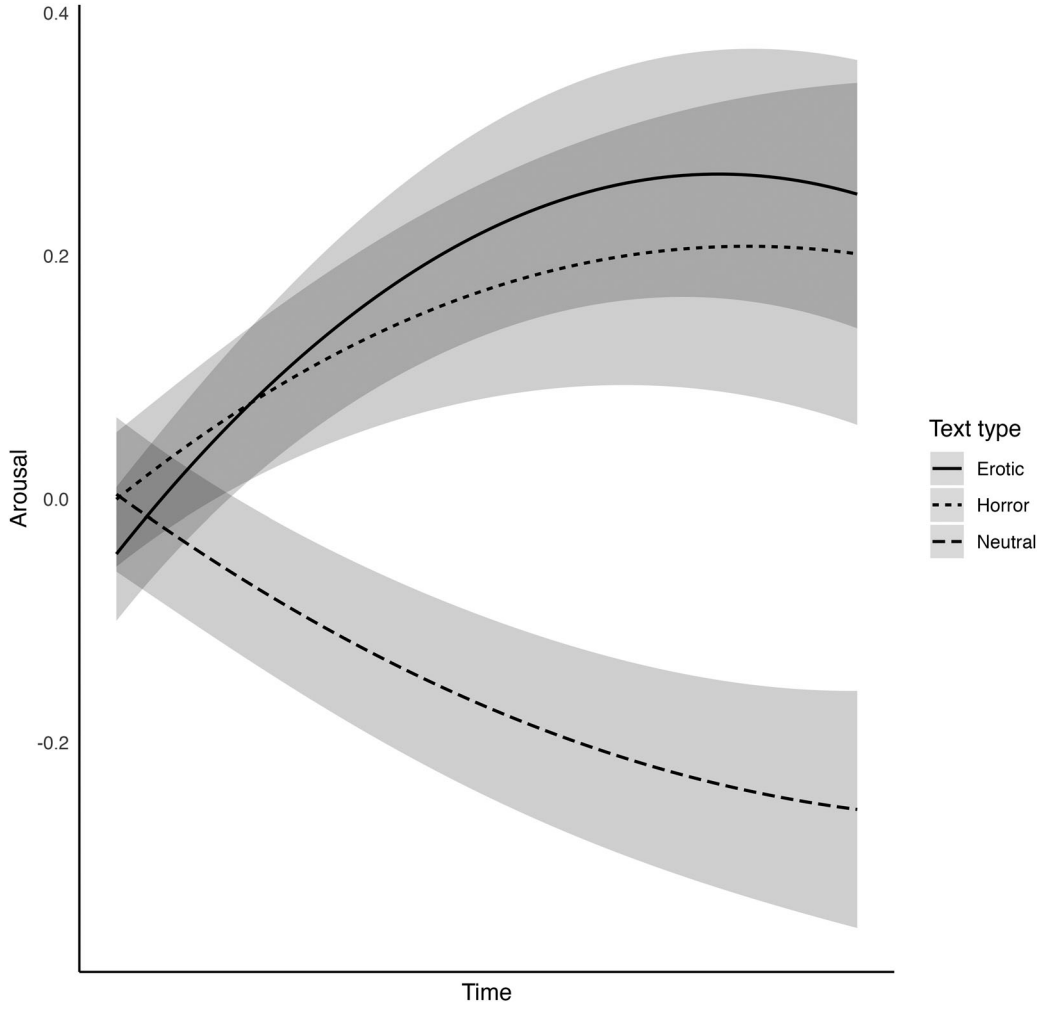

Figure 2. Model estimates of arousal as a function of time for erotic, horror, and neutral texts.

= [-.10,-.01], $t = -2.62$; erotic vs. horror: β = .04, SE = .02, 95%CI = [.01,.08], $t = 2.55$).

Transportation

Transportation ratings were higher for erotic ($\beta = 1.38$, SE = .30, 95%CI = [.78,1.97], $t = 4.52$) and horror texts ($\beta = 1.36$, SE = .28, 95%CI = [.81, 1.92], $t = 4.81$) than for neutral texts. Erotic and horror texts induced very similar levels of transportation ($\beta = .01$, SE = .31, 95%CI = [-.59,.61], $t = .05$).

Recall

There was no evidence for differences between text types in recall, (neutral vs. erotic: $\beta = .05$, SE = .13, 95%CI = [-.20, .30], $z = .39$; neutral vs. horror: $\beta = .20$, SE = .13, 95%CI = [-.04, .46], $z = 1.59$).

Discussion

Experiment 1 examined fluctuation in cognitive engagement and transportation during listening of emotional stories (horror and erotica) versus neutral ones. We expected that emotional texts would be more arousing, more engaging (as indexed by reduced head motion) and that they would induce more narrative transportation than neutral texts. Recall performance was expected to reflect engagement during listening, such that higher engagement would result in better recall of the text content.

The results on valence ratings revealed that erotic stories induced more positive and horror stories more negative emotion than neutral stories. In addition, arousal ratings were higher during listening to erotic

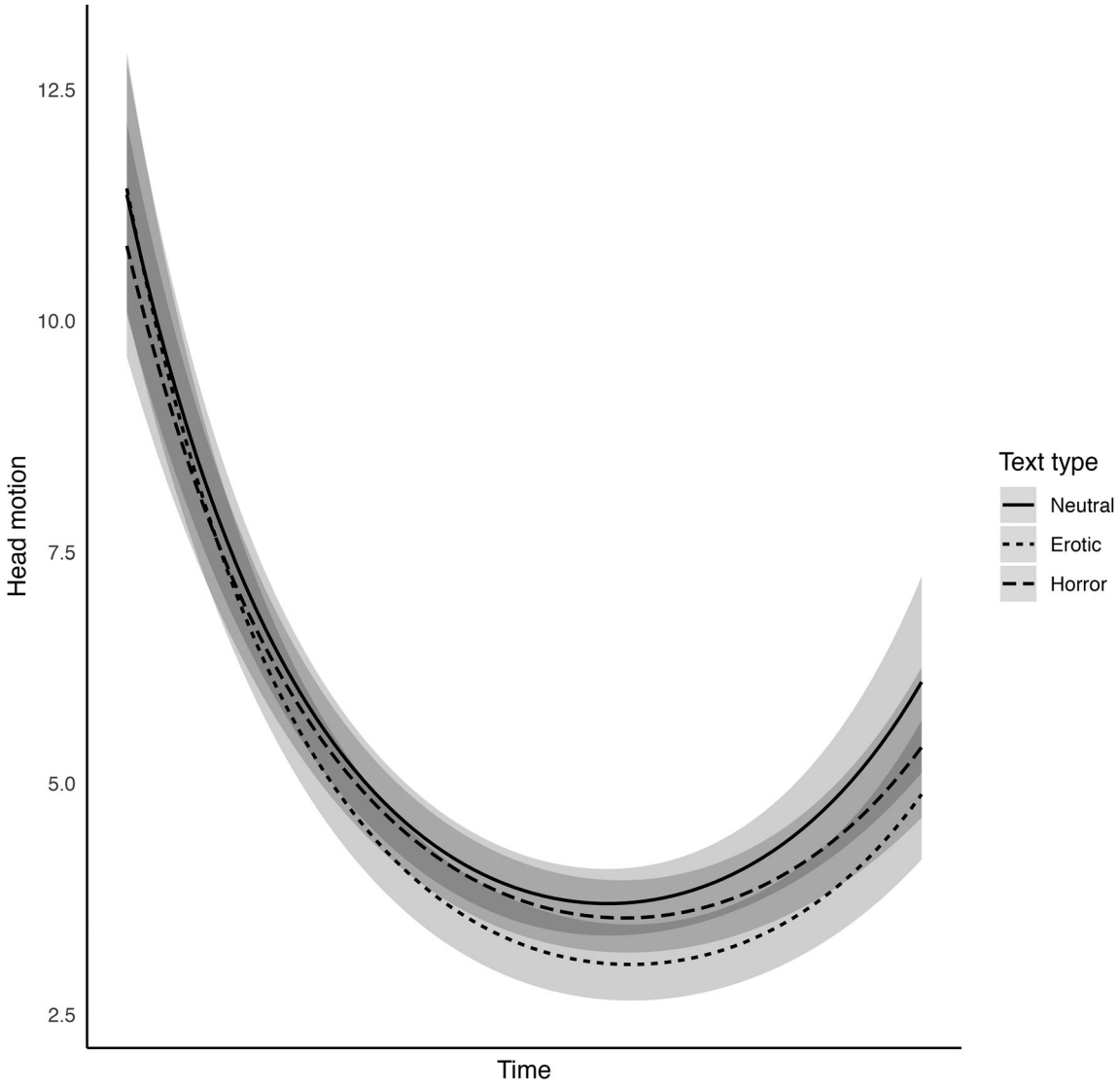

Figure 3. Model estimates of head motion as a function of time during listening of erotic, horror and neutral texts.

and horror stories than neutral stories. Moreover, arousal changed differently during listening of erotic and horror stories than during neutral stories. During listening to neutral stories, there was a linear decrease in arousal across time, whereas there was a linear increase in arousal during listening to erotic and horror stories. Erotic and horror stories also induced more transportation than neutral texts.

These findings indicate that emotional stories with high arousal level are more likely to promote transportation and immersion in the story than neutral stories. Arousal has been defined as the degree to which one is excited, alert or stimulated when reading or listening to a story. In previous studies (Kaakinen & Simola, 2020), increased arousal during listening of emotional stories, and specifically horror, has been linked to higher narrative transportation (Kaakinen & Simola, 2020). Our results add to these findings by showing that emotional texts that induce arousal, whether caused by positive or negative text content, increase experiences of narrative transportation.

As for our measure of cognitive engagement, head motion, we found that there was a steeper decrease in head motion during listening of erotic than neutral or horror stories. However, we found no evidence for a difference between neutral and horror stories. More

generally, head motion linearly decreased across time for all stories regardless of their emotional status. In a previous reading study, Ballenghein et al. (2019) found overall smaller head movements during reading of positive and negative texts compared to reading of neutral texts, indicating that emotional text content, whether positive or negative, induced higher cognitive engagement. The present results replicate the finding of higher engagement for emotional texts, but only for the erotic stories. The lack of a difference between horror and neutral stories is in line with the results of a listening study by Kaakinen and Simola (2020), who found no differences between horror and neutral stories in pupil fluctuation or blink rate. All in all, these findings indicate that especially positive text content, in this case erotica, may increase cognitive engagement during a listening task.

As for recall of the text content, we failed to find differences between text types. One potential reason is that the listening task does not allow slowing down processing and thus rehearsing the text contents, which impacts later recall of text information. Moreover, the recall task was completed immediately after each text when the text contents were still fresh in memory.

In summary, the results of Experiment 1 showed that even though emotional stories were more arousing and produced higher transportation to the story world than neutral texts, only erotic stories induced higher cognitive engagement during listening, as measured by head motion. These differences were not reflected in the recall performance measured immediately after presentation of the text.

Experiment 2

The purpose of Experiment 2 was to examine the impact of emotional text content on cognitive engagement during reading. Participants read the same texts as in Experiment 1 while their postural movements and eye movements were recorded. After reading, they responded to the same transportation questionnaire as in Experiment 1, and recalled the main points of the story.

Materials and methods

Participants

A power analysis using G*Power 3 software (Faul et al., 2007) indicated that a total sample of 28 people would be needed to detect an effect size of $d = .25$ for the main effect of valence with power $(1 - \beta)$ set at 0.80 and $\alpha = .05$ in an F test (repeated measures ANOVA). Participants ($n = 40$) were recruited via a mailing list consisting of community volunteers that have signed up for a participant pool. Four participants had to be excluded because of excessive data loss during recording, and the final data set consisted of 36 participants. All participants were native French speakers, mean age was 27.25 years ($SD = 6.38$), 9 were male, and 37 right-handed. All participants had a high-school degree, and on average 3.35 years of college education ($SD = 1.61$). All tested participants received a voucher for the value of 10 euros for participation.

Apparatus

Eye movements were recorded with an infrared-based SMI RED 500 eye-tracking system allowing free head movements. Sampling rate was set to 500 Hz. Stimuli were presented on a Dell P2210 22″ LCD monitor, using $1,680 \times 1,050$ resolution and 59 Hz screen refresh rate.

As for recording readers' head movements, the same motion capture system was used as for Experiment 1. Motion capture data and the eye-tracking data were temporally aligned by a parallel port trigger sent by the stimulus presentation computer to the Matlab software recording the motion capture data.

Materials

Same texts as in Experiment 1 were used, with the exception that the texts were in written form. Each text was presented on one screen page with 18-point Arial font using triple line spacing.

Valence and arousal ratings

Valence and arousal ratings were collected using SAM scales (Bradley & Lang, 1994), which are pictorial scales in which the participant responds by choosing a manikin that best represents their level of arousal and valence. The responses were coded into 9-point scales (1 = low arousal / negative valence, 9 = high arousal / positive valence).

Transportation rating

Transportation was measured with the TS-SF (Appel et al., 2015) as in Experiment 1.

Recall

After each text, participants were asked to briefly describe the main points of the story they had read. Recalls were scored as in Experiment 1.

Procedure

The study protocol was approved by the Ethics Committee for Human Sciences at the University of Turku. After arriving in the laboratory, the participants signed an informed consent form. They were then given the motion capture goggles and instructions for the experiment were presented in written form. Participants were seated at about 60–70 cm away from the screen. Participants were told that: "You will read texts on the computer screen. Some texts may contain emotional elements. Read each text at a natural reading speed. Before each text, look at the cross that will appear at the top left of the screen. Then read the text. When you have finished reading, press the spacebar." The eye tracker was then calibrated using a 9-point calibration scheme. A fixation cross appeared at the location of the first word on the page for 1,500 ms before each text page. Participants could read the text at their own pace. Returning to previous screens was not possible. A training phase with an *ad-hoc* neutral story was done before starting the experiment.

Stories were presented in random order for each participant. After each text, participants were asked to complete a paper questionnaire to judge the valence and arousal of the stories using a SAM scale (Bradley & Lang, 1994), and to provide recall of the main points of the story. The total duration of the experimental session was about 50-60 min.

Results

Data preparation and analysis

Data for all variables was available from 36 participants.

For the text reading times, we first identified abnormally long or short reading times by excluding observations that were 2.5SD away (i.e. shorter or longer) from the grand mean (.97% of the data). The reading times included in the data (after outlier removal) varied between 22 and 90 s (these criteria will be used for the analyses of the head motion data). In order to account for length differences between texts, we converted text reading times (measured in seconds) to reading speed (words per minute) by dividing the length of the text by its reading time. To prepare the data for statistical analyses, reading speed was log-transformed and observations deviating more than 2.5SD from the grand mean were excluded (1.22% of the data).

Table 2. Means and standard deviations of different measures as a function of text type in Experiment 1.

	Text type					
	Erotic		Horror		Neutral	
Measure	M	SD	M	SD	M	SD
Valence	6.33	1.33	3.00	1.10	5.00	.62
Arousal	.18	.19	.15	.21	-.14	.15
Head motion	6.28	2.10	6.53	1.85	6.98	1.85
Transportation	4.59	1.13	4.58	1.02	3.22	.84
Recall	.11	.05	.13	.04	.11	.04

Note. Means and standard deviations are computed across per-participant means.

Measure for head motion was computed as in Experiment 1. Only trials for which reading time was between 22 and 90 s were included in the analysis (see above). First, in order to identify abnormal motion (e.g. wide movements due to participant moving around) we identified observations that deviated 2.5 SD of the grand mean, and excluded them from the data (2.30% of the data). Second, in order to prepare the data for statistical analysis, we log-transformed the measure to account for skewness, and excluded observations exceeding 2.5 SD of the grand mean of the log-transformed measure (3.22% of the observations).

Statistical analyses were conducted as in Experiment 1. As there were differences between texts in Flesch Reading Ease scores and length, we examined whether they influenced the observed pattern of results. Flesch Reading Ease score and text length (character count) correlated only modestly with the outcomes ($|r|$´s = .02 – .22). Adding them to the models as covariates changed the pattern of results for reading speed. Thus, we report the models without the Flesch Reading Ease score and character count for arousal, immersion, and head motion. For reading speed, Flesch Reading Ease and character count are included in the model as fixed effects. All models are presented in the Appendix.

Valence ratings

Mean valence ratings for erotic, horror and neutral texts are presented in Table 2. Erotic texts were rated as more positive than neutral texts ($\beta = .1.71$, SE = .45, 95%CI = [.82,2.60], z = 3.76), and horror texts as more negative than neutral texts ($\beta = -2.54$, SE = .53, 95%CI = [−3.58,−1.51], z = −4.83).

Table 3. Means and standard deviations of different measures as a function of text type in Experiment 2.

	Text type					
	Erotic		Horror		Neutral	
Measure	M	SD	M	SD	M	SD
Valence	5.94	1.25	3.31	1.16	5.05	.92
Arousal	5.28	1.66	4.84	1.51	3.04	1.18
Transportation	4.45	1.20	4.33	.99	3.42	.96
Reading speed	252.90	60.97	210.66	60.05	234.25	61.96
Head motion	3.21	1.22	3.62	1.49	3.62	1.38
Recall	.10	.04	.13	.05	.08	.03

Arousal ratings

Mean arousal ratings for erotic, horror and neutral texts are presented in Table 2. Erotic texts ($\beta = 3.11$, SE = .51, 95%CI = [2.10,4.11], z = 6.06) and horror texts ($\beta = 2.57$, SE = .47, 95%CI = [1.65, 3.49], z = 5.47) induced higher arousal than neutral texts. There was no evidence for

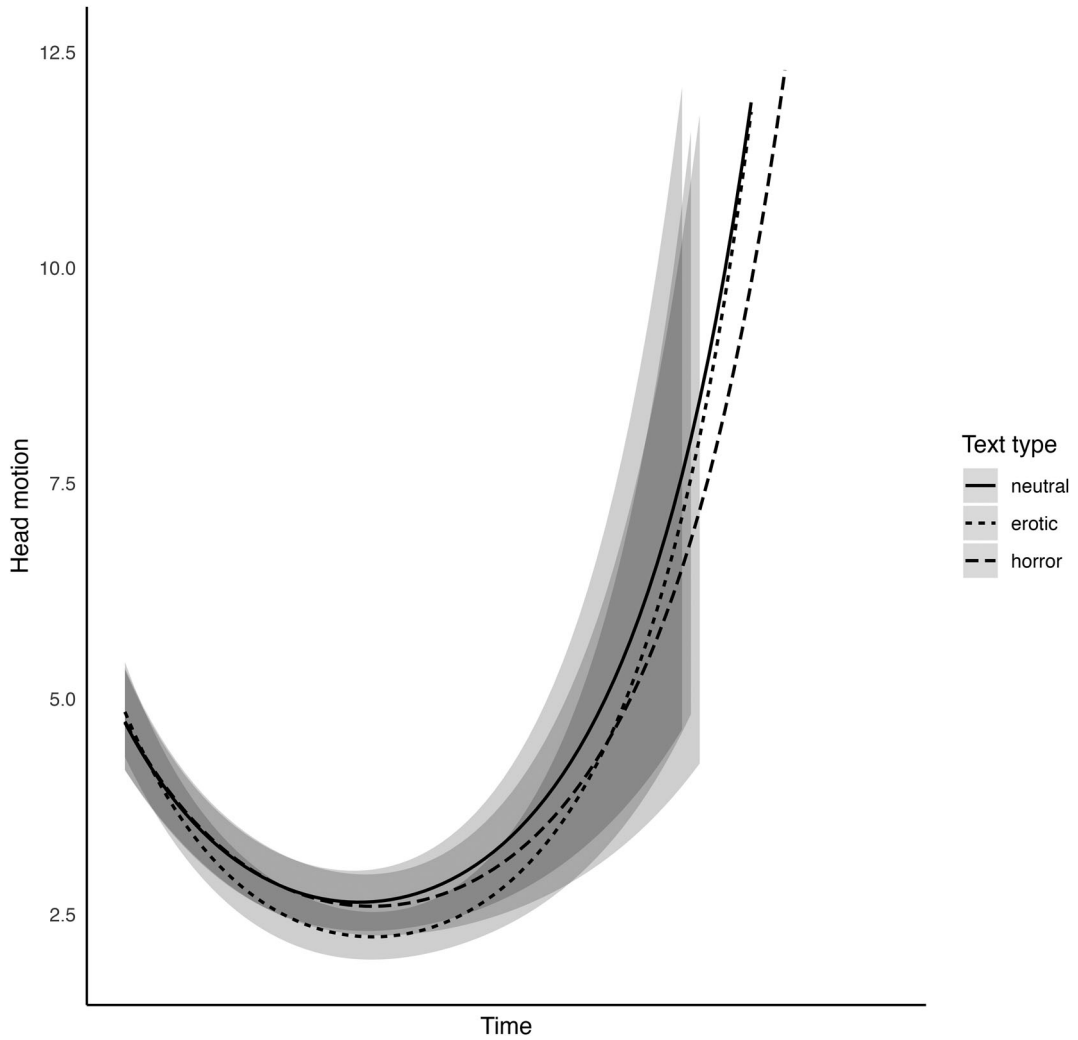

Figure 4. Predicted values of head motion during reading of erotic, horror and neutral texts as a function of time. The y-axis is limited to values < 12.5 for the sake of readability and comparability to the results from Experiment 1.

a difference between erotic and horror texts, β = -.54, SE = .46, 95%CI = [−1.44, .36], z = −1.17.

Transportation

Mean transportation ratings for erotic, horror and neutral texts are presented in Table 3. Both erotic (β = 1.05, SE = .30, 95%CI = [.47,1.63], t = 3.54) and horror texts (β = .95, SE = .28, 95%CI = [.40,1.51], t = 3.35) induced higher transportation than neutral texts. There was no evidence for a difference between erotic and horror texts in transportation, β = -.09, SE = .30, 95%CI = [-.68, .49], t = -.32.

Reading speed

As there were differences in text length, a measure of reading speed (words per minute, WPM) rather than reading time was used in the analyses. There were differences between text types in reading speed: horror texts were read slower than neutral (β = -.11, SE = .03, 95%CI = [-.17,-.06], $t = -4.00$) or erotic texts (β = -.15, SE = .04, 95%CI = [-.24,-.07], $t = -3.61$).

Head motion

Predicted values of head motion across time for different text types are presented in Figure 4. There was overall less head motion during reading of erotic than neutral (β = -.11, SE = .03, 95%CI = [-.18,-.05], t = −3.48) or horror texts (β = .10, SE = .03, 95% CI = [.05, .16], $t = 3.52$). There was no evidence for a difference between horror and neutral texts (β = -.01, SE = .02, 95%CI = [-.05,.03], $t = -.50$).

In general, head motion showed a positive curve, as indicated by a significant quadratic term (β = .18, SE = .03, 95%CI = [.12, .23], $t = 6.52$). The erotic texts showed greater positive curvature than horror texts, as indicated by a significant interaction (β = .04, SE = .02, 95%CI = [.01,.08], $t = 2.23$). Moreover, there was a steeper negative linear trend for erotic than for neutral texts (β = -.04, SE = .03, 95%CI = [-.08, -.01], $t = -2.32$), although this effect is hard to interpret considering the curvature in head motion across time for all text types.

It is worth noting that, as is evident in the Figure 4, there was an overall increase in head motion towards the end of the texts. However, as there were individual differences in reading times, there were few observations with longer reading times and thus the confidence intervals are relatively long for the longer reading times.

Recall

Participants recalled more contents from the horror than neutral (β = .56, SE = .16, 95%CI = [.25, .87], t = 3.54) or erotic stories (β = .31, SE = .16, 95%CI = [.001, .61], t = 1.97). There was no evidence for a difference between erotic and neutral stories (β = .25, SE = .16, 95%CI = [-.06, .57], t = 1.60).

Discussion

The Experiment 2 examined fluctuation in cognitive engagement and transportation to the story world during reading of emotional texts versus neutral ones. We expected that readers would become more aroused and more immersed with emotional texts than neutral ones. This was expected to be reflected as reduced head motion during reading, and better recall of the text contents. Based on previous research (e.g. Ballenghein et al., 2019), we expected to see faster reading times for erotic texts compared to neutral and horror texts.

The results revealed that erotic texts were rated as more positive than neutral texts, and horror texts were rated as more negative than neutral texts. Moreover, erotic and horror stories induced higher arousal and more transportation to the story world than neutral texts. These results are in line with the results of Experiment 1, which used exactly the same text materials but examined listening.

Results about the reading speed revealed differences between text types: horror texts were read slower than neutral texts. The present results suggest that negative text content captures readers' attention for a longer time than neutral content (see, e.g. Egidi & Gerrig, 2009; Fox, Russo, Bowles, & Dutton, 2001). Similarly, Arfé et al. (2022) found longer first-pass fixation times for content evoking negative emotions than for neutral content. The recall results of the present study support this notion: readers showed better memory for the contents of the horror stories than erotic or neutral stories.

Finally, results on head motion indicated that there was less head motion during reading of erotic than neutral or horror texts, but we found no difference between horror stories and neutral texts. The erotic stories showed a deeper curve in head motion across time than horror stories. These findings partly replicate the results of Experiment 1 by demonstrating smaller head motion during reading of erotic

than neutral or horror texts. As for changes in head motion across time, in Experiment 1 erotic stories showed a steeper decrease in head motion across time, whereas in Experiment 2, we observed a greater dip in the curvature for head motion for erotic stories. Even though the overall pattern of head motion was different in the experiments, in both experiments the minimum level of head motion was reached faster during exposure to erotic in comparison to horror texts.

General discussion and conclusions

The purpose of the present study was to examine how emotional text content, particularly horror and erotica, impact cognitive engagement during listening and reading of literary texts. The results of the two experiments reported here showed that erotic and horror stories were more arousing and induced higher transportation to the story world than neutral texts. These findings are in line with previous research suggesting that emotionally arousing text content induces transportation or immersion (Hsu et al., 2014; Jacobs, 2015), which has been linked with focused attention on the story contents. We expected that if emotionally arousing texts increase transportation to the story world, then emotionally arousing texts should also increase cognitive engagement with the text. In order to track changes in cognitive engagement, we measured postural sway and specifically, head movements, during listening and reading of erotica and horror.

The results showed that positive and negative text content had different effects on cognitive engagement as the literary stories unfold. During a listening task, head motion decreased across all texts, and this decrease was steeper for erotic than horror or neutral stories. During reading, head motion first decreased, and then again increased towards the end of the reading task for all texts. The drop in head motion was steeper for erotic than for horror or neutral texts. Thus, in both tasks erotic stories showed a faster drop in head motion, even though the overall pattern on head motion was slightly different in the two tasks. This indicates that positive texts boost the build-up of cognitive engagement as the text and the story progresses. However, in contrast to previous findings of positive bias in text processing (e.g. Ballenghein et al., 2019; Usée et al., 2020), we did not observe facilitation in the processing of positively valenced erotic stories.

Even though horror stories presenting negative emotional content induced higher arousal and transportation than neutral texts, we failed to observe differences between these text types in cognitive engagement as measured by head motion. Moreover, the results of Experiment 2 showed that horror stories were read slower, and their content was recalled better than that of neutral texts. We suggest that these results reflect the characteristics of horror: negative stimuli capture attention (e.g. Carretié et al., 2009; Smith et al., 2003) and improve memory (e.g. Arfé et al., 2022; Kensinger, 2009). These results are in line with the research on negativity bias that suggests higher sensitivity to negative than to positive information (Baumeister et al., 2001). Previous research also shows that reading times are longer for negative than for positive story endings (Egidi & Gerrig, 2009). It has been suggested that reading times reflect momentary, transient changes in cognitive engagement, whereas head motion shows sustained changes in engagement (Kaakinen et al., 2018). Our results are in line with previous research showing that negative text content attracts longer reading times than positive content (Egidi & Gerrig, 2009), and suggest that negativity bias mainly impacts transient changes in cognitive engagement.

As for the differences between listening and reading, the effects of text type were overall very consistent across modalities. The results differed only in the recall performance. There were no differences between text types in recall of aurally presented stories, whereas horror stories were recalled better than neutral or erotic stories when they were presented in written form. This difference can be explained by the differences in cognitive demands of the listening and reading tasks. In a listening task, the rate of incoming information is not in the control of the receiver, prohibiting slowing down of processing or rehearsing, as new information is constantly coming in. During reading it is possible to slow down reading or return to previously read parts of the story in order to rehearse it in memory. Our results showed that horror stories were read slower than neutral stories, indicating that negative text content attracts longer processing time.

The present study demonstrates the importance of methodological triangulation when examining cognitive engagement: different measures tap into different aspects of processing. Eye movements and reading times reflect the time invested in processing text information, whereas head motion shows how

engagement might change across time (Kaakinen et al., 2018). By combining different measures to study cognitive engagement during listening and reading of erotica and horror, the present results shed light on associations between emotional arousal, cognitive engagement and experienced transportation to the story world, which seem to depend on the emotional valence of the text contents. These results show that different types of literary texts trigger different emotional responses (Kneepkens & Zwaan, 1995; Miall & Kuiken, 2002; Oatley, 1995) and engage readers to different degrees (Kaakinen & Simola, 2020), while inducing immersion or transportation to the story world (Gerrig, 1993; Green & Brock, 2000; Kuijpers et al., 2014).

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement

The data that support the findings of this study are openly available in osf.io at http://doi.org/10.17605/OSF.IO/Y4VRQ, reference number Y4VRQ.

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