Cognition and Emotion

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pcem20

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To cite this article: Anqi Lei, Roel M. Willems & Lynn S. Eekhof (2023) Emotions, fast and slow: processing of emotion words is affected by individual differences in need for affect and narrative absorption, Cognition and Emotion, 37:5, 997-1005, DOI: 10.1080/02699931.2023.2216445

To link to this article: https://doi.org/10.1080/02699931.2023.2216445

Published online: 26 May 2023.

COGNITION AND EMOTION
2023, VOL. 37, NO. 5, 997–1005
https://doi.org/10.1080/02699931.2023.2216445

Routledge
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Emotions, fast and slow: processing of emotion words is affected by individual differences in need for affect and narrative absorption

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ABSTRACT

Emotional words have consistently been shown to be processed differently than neutral words. However, few studies have examined individual variability in emotion word processing with longer, ecologically valid stimuli (beyond isolated words, sentences, or paragraphs). In the current study, we re-analysed eye-tracking data collected during story reading to reveal how individual differences in need for affect and narrative absorption impact the speed of emotion word reading. Word emotionality was indexed by affective-aesthetic potentials (AAP) calculated by a sentiment analysis tool. We found that individuals with higher levels of need for affect and narrative absorption read positive words more slowly. On the other hand, these individual differences did not influence the reading time of more negative words, suggesting that high need for affect and narrative absorption are characterised by a positivity bias only. In general, unlike most previous studies using more isolated emotion word stimuli, we observed a quadratic (U-shaped) effect of word emotionality on reading speed, such that both positive and negative words were processed more slowly than neutral words. Taken together, this study emphasises the importance of taking into account individual differences and task context when studying emotion word processing.

ARTICLE HISTORY
Received 24 October 2022
Revised 25 April 2023
Accepted 15 May 2023

KEYWORDS
Emotion; individual differences; eye-tracking; narratives; language processing

Language is one of the ways in which we can express and understand emotions. Indeed, words denoting emotions are special in that humans react to them differently compared to neutral words. That is, emotional words are consistently shown to be processed faster than neutral words across different tasks (e.g. lexical decision, sentence reading; Gao et al., 2022; Scott et al., 2012). Looking at the effects of emotional valence more specifically, a processing advantage has been robustly observed for positive words (i.e. shorter reaction time/gaze duration; e.g. Goh et al., 2016; Kauschke et al., 2019; Usée et al., 2020), whereas the effects for negative words are more mixed, with some studies reporting a faster reaction to negative verbal stimuli (e.g. Kousta et al., 2009) and some reporting a delayed response (e.g. Kuperman et al., 2014).

From a theoretical perspective, the speed advantage for positive words has been explained in terms of positive stimuli being clustered more densely (i.e. they are more similar to each other) in associative memory than negative stimuli, which results in a faster evaluation of positive words (Unkelbach et al., 2008). On the other hand, it has been proposed that negative words attract more attention due to their evolutionary relevance (e.g. quick detection of threat for survival), resulting in prioritised detection and processing (Kousta et al.,

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2009). However, this prioritisation of negative information could also lead to delayed disengagement of attention (due to its survival significance), resulting in a prolonged processing time for negative words (Estes & Adelman, 2008; Mueller & Kuchinke, 2016).

To date, relatively few studies on emotion word processing examined the role of individual differences, which may have contributed to the heterogeneous findings across studies. Among the studies that have explored individual variability, Mueller and Kuchinke (2016) found that individual variations in goal-directed behaviour and dopamine level predicted reaction times to happy and fear-related words in a lexical decision task. In particular, individuals with higher goal-orientedness reacted more slowly to fear-related words than happy words, whereas individuals with a higher dopamine level showed faster responses to happy words. Regarding individual differences in emotion-specific sensitivity, Silva et al. (2012) found that individuals with high disgust sensitivity responded more slowly to disgust-related words (compared to neutral words) in a lexical decision task, whereas those with low disgust sensitivity showed the opposite effect, i.e. facilitatory processing. In an eye-tracking study for sentence reading, Knickerbocker et al. (2015) reported an association between higher trait anxiety and faster reading times of negative words (compared to neutral words). In sum, these findings highlight the important role of individual differences in emotion word processing.

However, beyond the level of word recognition and isolated sentence reading, little is known about emotion word processing in a more ecologically valid, contextualised setting (e.g. reading a story). Compared to highly controlled experimental paradigms, naturalistic stimuli have been shown to be more complex, vivid, and emotion-inducing, thus closely capturing the nature of emotion processing in real life (Saarimäki, 2021). In a recent eye-tracking study that examined eye fixation times in the natural context of reading suspenseful stories, Arfé et al. (2022) found that reading times for content that evokes negative emotions were longer than for neutral content. The slower processing of emotional content during story reading possibly reflects a higher level of engagement, which contrasts to the faster processing of emotional words reported by previous research with isolated task contexts (e.g. lexical decision task, single sentence reading). This discrepancy underlines the importance of studying contextualised emotion word processing to capture the nuanced ways in which emotional language is processed in daily life. Similarly, as mentioned previously, examining the role of individual variability would further contribute to a deeper understanding of emotion word processing and the mixed results obtained in previous research.

To address these issues, our current study examines how individual differences in need for affect and narrative absorption affect emotion word processing during naturalistic reading of a journalistic story. Journalistic stories have been described as more engaging and emotional than non-narratives, given their potential to induce a strong feeling of being present in the depicted scenes and identifying with the story characters (van Krieken & Sanders, 2021). We focused on need for affect and narrative absorption because these two measures are associated with sensitivity to emotion-inducing materials and have been shown to reflect different levels of engagement with emotional content during discourse processing in previous studies (Haddock et al., 2008; Song et al., 2021).

As a trait measure of emotional need, the *Need for Affect* (NFA) scale was designed to measure an individual's motivation to approach situations and activities that are emotion-inducing (Maio & Esses, 2001). For instance, individuals with high NFA tend to spend more time consuming emotion-inducing media and report feeling more absorbed in highly emotional materials (Appel & Richter, 2010). As a state measure of narrative absorption, the *Story World Absorption Scale* (SWAS) has been used to measure the experience of feeling "lost" or immersed in a story (Kuijpers et al., 2014). Absorbing reading experiences are characterised by heightened attention, transportation, vivid mental imagery, and emotional engagement with the characters (Kuijpers et al., 2014). In order to measure the effect of these individual differences on emotion word processing in a natural context, we re-analysed an existing large eye-tracking dataset of 90 Dutch participants reading a 5000-word story (Eekhof, van Krieken, et al., 2021).

To compute the emotionality of the words in the story, we used the *aesthetic-affective potentials* (AAPs) calculated by *SentiArt*, a sentiment analysis tool based on publicly available vector space models (Jacobs, 2019; Jacobs & Kinder, 2019). The version of *SentiArt* that we used was trained on a large linguistic corpus with ecologically valid texts (Keuleers et al., 2010), which makes it suitable for our analyses of naturalistic story reading. An AAP value reflects a word's potential in evoking positive or negative emotions (see Methods). Words with high and low AAP values (e.g. "nature" versus "criminal") are more likely to induce positive and negative emotions, respectively, and words with AAP values approaching zero are considered to be more neutral (e.g. "bottle"). AAP has been validated as an accurate predictor of self-reported valence ratings of single words, and has been found to predict emotional states during story reading better than valence ratings from an affective word database (Jacobs & Kinder, 2019).

We hypothesised that individuals with a higher need for affect would display longer reading times for words that induce stronger positive or negative emotions compared to more neutral words, given that individuals with high need for affect are more likely to seek out emotional materials (Maio & Esses, 2001). For narrative absorption, we predicted that higher absorption during reading would be associated with longer reading times for words with more positive or negative emotion-inducing potentials, in line with conceptions of narrative absorption as having a strong emotional component (Kuijpers et al., 2014). Given the mixed findings regarding the general processing advantage of positive and negative words, we did not have any prediction as to whether the relationship between word emotionality and reading time is linear (i.e. faster reading of positive words; Kuperman et al., 2014), non-linear (i.e. faster reading of positive and negative words, compared to neutral words; Kousta et al., 2009), or both (Goh et al., 2016).

Methods

We used an eye-tracking data set collected by Eekhof, van Krieken, et al. (2021). This data set has been published and is available online (see Data Availability). Ninety native Dutch speakers aged between 18 and 48 years old ($M = 23.30$, $SD = 5.49$, 67 females, 23 males) read a 5077-word non-fictional story about a missing person case published in a Dutch news magazine while their eye movements were being recorded (for more details, see Eekhof, van Krieken, et al., 2021). Participants were instructed to read the narrative naturally at their own pace and were not informed about being tested about reading comprehension or engagement after the experimental session. The data set includes eye-tracking measures (e.g. gaze durations), stimulus characteristics for each word (e.g. word frequency), and various measures of individual differences (see below).

Individual differences measures

Need for affect

The 10-item short version of the Need for Affect (NFA) scale (Appel et al., 2012) includes 5 items that measure the motivation to approach emotions (e.g. *I feel that I need to experience strong emotions regularly*) and 5 items that assess the motivation to avoid emotions (e.g. *I would prefer not to experience either the lows or highs of emotion*). The NFA items were presented with a 7-point scale (1 = *strongly disagree*, 7 = *strongly agree*), and the 5 avoidance items were reverse coded for analysis. An aggregate mean score was used to index the need for affect ($\alpha = .79$). The short form of the NFA scale has been validated and shows high reliability as well as high correlations with relevant personality constructs that capture a tendency to engage with others emotionally (e.g. openness to experience, extraversion; Appel et al., 2012).

Story World Absorption Scale

The 18-item Story World Absorption Scale (SWAS; Kuijpers et al., 2014) includes 4 different subscales: Attention (e.g. *I felt absorbed in the story*), Transportation (e.g. *when I was finished with reading the story it felt like I had taken a trip to the world of the story*), Mental Imagery (e.g. *I could imagine what the world in which the story took place looked like*), and Emotional Engagement (e.g. *I felt how the main character was feeling*). The SWAS items were presented with a 7-point scale (1 = *disagree*, 7 = *agree*). Because we did not have any specific hypotheses about the subscales of the SWAS, an aggregate mean score across all subscales was used as a measure of narrative absorption ($\alpha = 0.93$). The SWAS scale shows high convergent validity with existing scales that measure transportation and narrative engagement, and it has strong predictive validity in predicting both enjoyment and emotional impact during reading (Kuijpers et al., 2014).

Aesthetic-affective potentials

The aesthetic-affective potentials (AAPs) were computed by *SentiArt* to index a word's potential to elicit affective responses (Jacobs & Kinder, 2019). More specifically, the AAP is calculated based on the semantic association between a target word and each token from a list containing positive and negative labels (Jacobs & Kinder, 2019). In other words, the AAP value for a target word is the mean semantic relatedness between the word and each of the positive labels minus the mean relatedness between the word and each of the negative labels. As a result, positive AAP values are given to words that have a high potential to elicit positive emotions, AAP values around zero are given to neutral words, and negative AAP values are given to words that have a high potential to elicit negative emotions.

The AAP of each word in the current data set was obtained from the Dutch *SentiArt* table (available via Github: https://github.com/matinho13/SentiArt), which contains AAP values for more than one hundred thousand Dutch words. The Dutch *SentiArt* table covers 97.14% of the words (4932 words) in the current eye-tracking data set. The distribution of AAP values in the data set is shown in Figure 1.

Data pre-processing

We opted to use gaze durations as our dependent variable, because this measure has been shown to be sensitive to high-level individual differences during story reading before (e.g. Eekhof, Kuijpers, et al., 2021). Gaze durations more than 3 standard deviations away from the participant-specific mean were excluded from the analysis. Data for the first word of each page was also removed, considering the potential spill-over from looking at the fixation cross at the beginning of each page of the narrative. For more details on the pre-processing of the eye-tracking data, see Eekhof, van Krieken, et al. (2021).

Statistical analysis

All the analyses were performed in RStudio (Version 1.3.959). In line with Eekhof, van Krieken, et al. (2021), we controlled for potential confounding factors that could influence reading time, including word length (number of letters), word frequency (lemma frequency), and participants' print exposure, as indexed by scores on the Dutch version of the Author Recognition Test (ART; Koopman, 2015). For this test, participants select the names of fiction authors they know from a list of real and made-up author names. The ART score is calculated by summing the correctly selected author names and subtracting the number of selected foils, with scores ranging between −12 (only foils selected) to 30 (only real names selected).

The mean scores for the individual difference measures (NFA scores, SWAS scores) and the control measure (ART scores) are summarised in Table 1. Participants were on average quite highly absorbed in the story, as indicated by the mean SWAS score ($M = 4.48$, $SD = 1.04$), which is comparable to absorption levels reported by previous narrative reading studies (e.g. Eekhof, Kuijpers, et al., 2021). SWAS and NFA scores are weakly, but statistically significantly correlated ($r = 0.15$, $p < 0.001$).

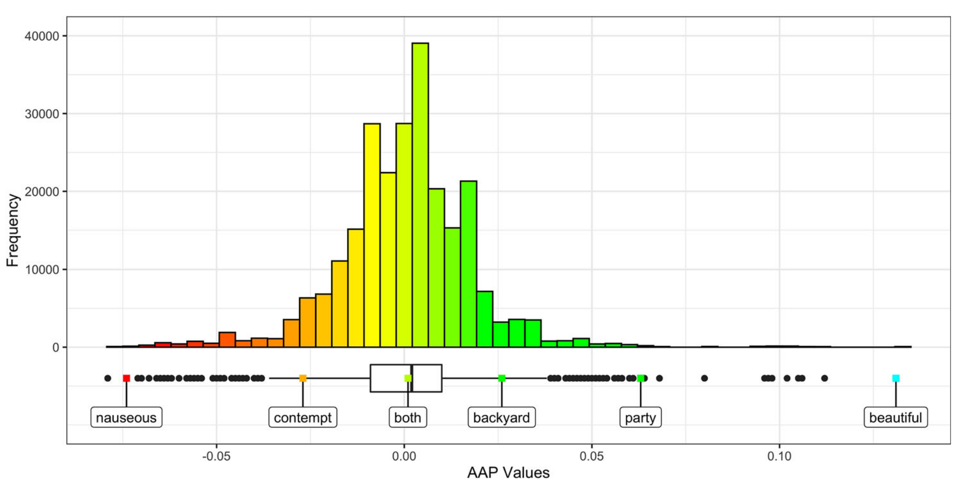

Figure 1. Distribution of AAP values for words in the text that was used in the experiment. Examples of words with different AAP values are included. Words with lower AAP values (e.g. *nauseous*, *contempt*) tend to elicit more negative emotions, words with more positive AAP values (e.g. *backyard*, *party*, *beautiful*) elicit more positive emotions, and words with AAP values close to zero (e.g. *both*) are considered neutral.

Table 1. Descriptive statistics for the predictors in the model.

Measure	*M* (SD)	Cronbach's *α*
Need for Affect	5.07 (0.86)	0.79
Story World Absorption Scale	4.48 (1.04)	0.93
Author Recognition Test	6.60 (3.27)	–

Notes: Scores on need for affect and Story World Absorption Scale could vary between 1 and 7. Scores on Author Recognition Test could vary between −12 to 30. Note that these variables were centred for our analyses.

Using the *lme4* and *lmerTest* packages (Bates et al., 2015; Kuznetsova et al., 2017), we fit a linear mixed model for gaze duration with by-subject random intercepts. The fixed effects included word length, log-transformed word frequency, ART scores, NFA scores, SWAS scores, AAP values, as well as interactions between the two individual difference measures and AAP values. We also included squared AAP values (in addition to non-squared AAP values) and their interaction with the two individual difference measures to capture the potential non-linear relationship between AAP and gaze duration, as described in the introduction. All predictors were centred for analysis, in line with previous studies (Eekhof, van Krieken, et al., 2021; Usée et al., 2020). The model formula is shown below:

$$\begin{aligned} &\textit{Gaze duration} \sim \textit{word length} + \textit{log word frequency} \\ &\quad + \textit{ART scores} + \textit{NFA scores} * (\textit{AAP} + \textit{AAP}^2) \\ &\quad + \textit{SWAS scores} * (\textit{AAP} + \textit{AAP}^2) + (1|\textit{subject}) \end{aligned}$$

Results

The estimates for the linear mixed effects model predicting gaze duration can be found in Table 2. As expected, there were significant main effects of word length, word frequency, and ART scores on gaze duration. An increase in word length increased gaze duration, whereas higher word frequency and ART scores (i.e. more print exposure) decreased gaze duration. NFA and SWAS scores did not significantly affect gaze duration.

There was no significant main effect of AAP values (see Figure 2(a)). However, there was a significant main effect of squared AAP values, such that there was a positive U-shaped relationship between word emotionality and gaze duration (see Figure 2(b)). In other words, there was a non-linear relationship between AAP values and gaze durations such that words with extreme emotional potentials, i.e. both negative and positive words, were read more slowly compared to neutral words.

Finally, the model showed a significant interaction between NFA scores and AAP values, and between SWAS scores and AAP values. We visualised the interactions using the R package *sjPlot* (version 2.8.11; Lüdecke, 2018). As depicted in Figure 2(c), when reading words with higher AAP values (i.e. positive words), people with higher NFA scores slowed down (longer gaze durations), whereas those with lower NFA scores sped up (shorter gaze durations). On the other hand, no effect of NFA scores was visible for negative words.

Similarly, people with higher SWAS scores slowed down (longer gaze durations) when reading words with high AAP values (i.e. positive words), whereas those with lower SWAS scores sped up (shorter gaze durations; see Figure 2(d)). Again, there seems to be no effect of SWAS scores on gaze

Table 2. Estimates for the linear mixed effects model predicting gaze duration.

Predictors	Estimates	*SE*	*CI*	*t*	*p*
(Intercept)	236.62	3.09	230.56–242.69	76.47	**<0.001*** **
SWAS Score	1.68	3.05	−4.30–7.65	0.55	0.582
AAP	3.49	10.92	−17.92–24.89	0.32	0.749
AAP^2	1365.19	244.81	885.36–1845.01	5.58	**<0.001*** **
NFA Score	2.57	3.63	−4.55–9.68	0.71	0.480
ART Score	−3.12	0.96	−4.99 – −1.24	−3.26	**0.001** **
Word frequency	−5.15	0.19	−5.53 – −4.78	−26.98	**<0.001*** **
Word length	3.97	0.11	3.75–4.18	35.77	**<0.001*** **
SWAS Score * AAP	28.11	10.40	7.72–48.50	2.70	**0.007** **
SWAS Score * AAP^2	−255.57	229.74	−705.86–194.72	−1.11	0.266
NFA Score * AAP	29.59	12.54	5.01–54.17	2.36	**0.018** *
NFA Score * AAP^2	−259.05	277.16	−802.28–284.18	−0.93	0.350

Notes: All predictors were centred for analysis. In addition, word frequency scores were log-transformed.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

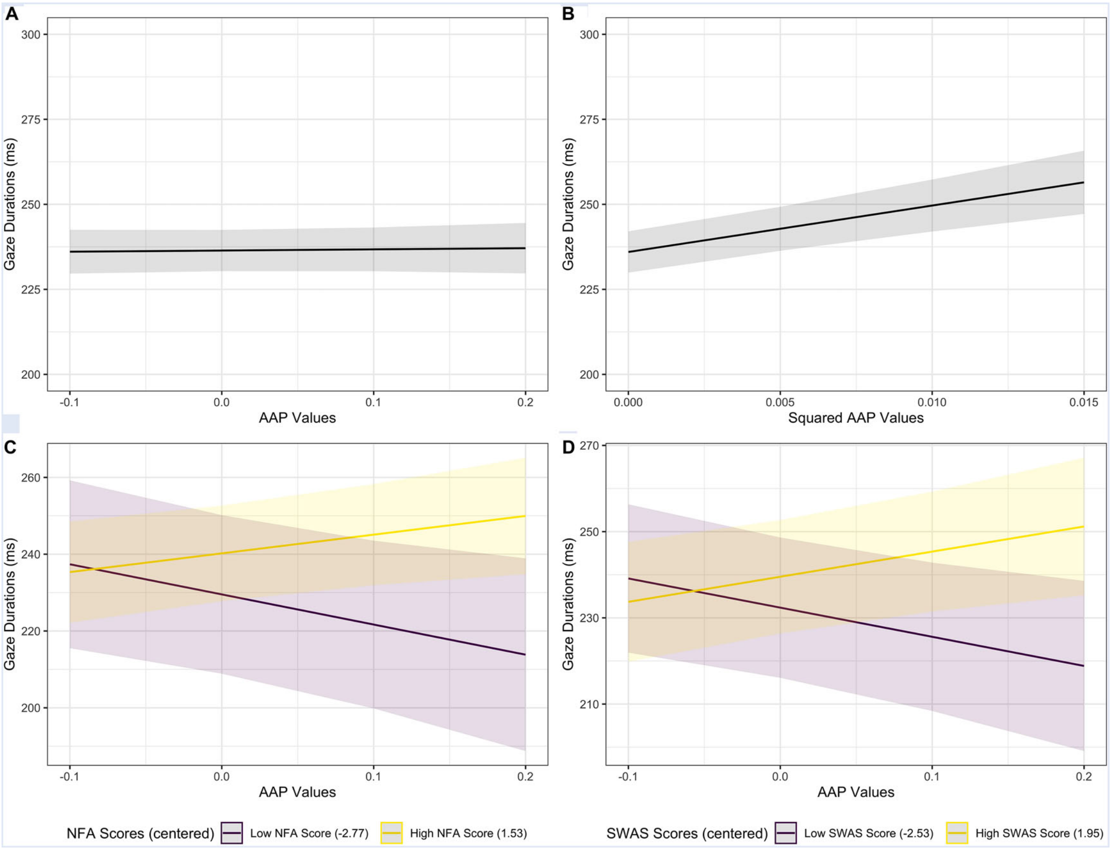

Figure 2. (A) Prediction plot for the main effect of AAP values on gaze durations. AAP values did not significantly predict gaze durations. (B) Prediction plot for the main effect of squared AAP values on gaze durations. Higher squared AAP values (i.e. more emotional words) were significantly associated with longer gaze durations. (C) Prediction plot for the significant interaction between NFA scores and AAP values on gaze durations. (D) Prediction plot for the significant interaction between SWAS scores and AAP values on gaze durations.

durations for words with lower AAP values (i.e. negative words).

There was no significant interaction between NFA scores and the squared AAP term, nor between SWAS scores and the squared AAP term.

Discussion

In the current study, we investigated how individual differences in need for affect and narrative absorption affected the relationship between the emotion-inducing potential of words and reading times. First of all, we found evidence of a non-linear relationship between the emotion-inducing potential of words and gaze durations. In particular, AAP values had a U-shaped effect on reading time, with both positive and negative words (higher and lower AAP values) being processed more slowly than neutral words. Previous studies have also observed non-linear word valence effects for reaction times in a lexical decision paradigm (Goh et al., 2016; Kousta et al., 2009). However, contrary to our finding, these studies observed an inverted U-shaped relationship between valence and reaction time, suggestive of a speed advantage for both positive and negative words.

The discrepancy between our result and previous findings might be explained by the differences in stimuli and tasks. That is, word emotionality might impact processing speed differently in the context of a complex and vivid narrative as in our study (Lüdtke et al., 2021), where participants were instructed to read naturally at their own pace. In contrast, the words in a lexical decision task are presented without context and require very fast reactions from participants. Indeed, our finding is consistent with

Arfé et al. (2022), who also adopted a naturalistic story reading paradigm and reported slower processing of emotional content compared to neutral content. Since our stimulus narrative featured the emotional quest of a brother who spends years to find his missing brother (Eekhof, van Krieken, et al., 2021), it is possible that readers' overarching emotions evoked by the plot affected the more low-level processing of emotion words. More research is needed to study how these so-called fiction feelings affect emotion word processing. Another explanation could be that word emotionality was operationalised differently in our study. We used AAP values calculated by a sentiment analysis tool to capture a word's potential to induce positive or negative emotions, whereas previous studies mostly relied on human ratings of valence to index word emotionality (e.g. Scott et al., 2012) and some exclusively selected words that indicate specific emotional states (e.g. *happy*, *distressed*; Knickerbocker et al., 2015).

We also showed that individual differences in need for affect and narrative absorption did not impact reading times in general, given the lack of main effects of NFA scores and SWAS scores on gaze duration. Importantly, however, the significant interaction between NFA scores and AAP values does indicate that individual variability in the willingness to approach emotions had an impact on reading words of different valences. Specifically, compared to low need for affect readers, people with a higher need for affect slowed down when reading words that tend to induce positive emotions, but there was no effect of need for affect on gaze durations for more neutral or negative words. This suggests that readers with high need for affect specifically linger on parts of the text that induce positive emotions, whereas those with low need for affect sped up their reading of positive words. This resonates with Silva et al. (2012), who showed that individuals with high disgust sensitivity reacted more slowly to disgust-related words, whereas low disgust sensitivity led to facilitated processing of disgust-related words.

Similarly, we found that compared to low-absorption readers, participants who reported to be highly absorbed in the story slowed down when reading positive words. On the other hand, there was no effect of narrative absorption on gaze durations for neutral or negative words. In the case of the narrative used in this study, it is possible that readers who are highly absorbed in the emotional turmoil of the story characters become more sensitive to positive parts of the text. Alternatively, it could also be that lingering on positive content increases narrative absorption. More research is needed to shed light on the directionality of this effect.

In sum, it seems that reading behaviour for positive words, but not negative words, is susceptible to individual differences. One possible explanation for this is that negative stimuli are particularly difficult to disengage from due to their evolutionary significance (Estes & Adelman, 2008), and thus are less affected by individual differences. Alternatively, it is possible that reading behaviour of negative words is affected by other kinds of individual variability unexamined in the current study (e.g. trait anxiety; Knickerbocker et al., 2015).

One limitation of our study is that we did not quantify word emotionality based on the narrative context in which the words were embedded. As a result, it is possible that some neutral words could in fact be considered emotional given the context of the story. However, we emphasise that *SentiArt* has been validated to show significantly high accuracy in predicting human-rated emotionality of text content during naturalistic story reading across different contexts (Jacobs & Kinder, 2019), so we consider AAP a proper index of word emotionality for our narrative material and the purposes of this study.

To conclude, we are among the first studies to show that individual differences affect emotion word processing in the naturalistic context of narrative reading. Individual variability in need for affect and narrative absorption were both found to impact the reading times of words that tend to induce positive emotions. In particular, individuals with a higher need for affect and higher narrative absorption slowed down when reading positive words. Additionally, we found that the processing of emotion words is generally slower than the processing of neutral words in the context of narrative reading. Combined, these findings stress the importance of taking into account the effects of individual differences and context in emotion word processing. Particularly, our study supports the idea that emotion word processing varies across individuals, which might explain the mixed findings in previous literature (Mueller & Kuchinke, 2016). That is, if individual differences in sensitivity to emotions and emotional engagement with the experimental task are not controlled for, main effects of word emotionality might be obscured or modulated. Secondly, our study supports the idea that different task contexts elicit different patterns of emotion word processing. This highlights the importance of taking into account the ecological validity of the task context when making generalisations about emotion word processing. Future studies could examine emotion word processing across more text genres (e.g. poetry) and other naturalistic contexts (e.g. processing of song lyrics) to establish the generalisability of our finding that emotion words slow down processing during narrative reading.

Acknowledgements

We thank Arthur Jacobs for providing us with the Dutch *SentiArt* table.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

Data availability statement

The data supporting the results of this study are publicly available: https://doi.org/10.34973/zb8x-xe75. The analysis script and data files supporting the results of this study are available as well: https://osf.io/64mdz/.

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