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Effects of Word Emotionality and Reader's Emotional States on Word Recognition in L2 Reading: An Eye Tracking Study

Davoud Amini [1*], Kazem Pouralvar [2], Leila Kheiry [1]

[1] *Department of English, Faculty of Literature and Humanities, Azarbaijan Shahid Madani University, Tabriz, Iran*

[2] *Department of English, Faculty of Multimedia, Tabriz Islamic Art University, Tabriz*

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Abstract: The emotional content of words can affect L2 reading in different ways. Meanwhile, this effect does not seem to be independent of the processor's psychological states. The present study examined the complex interplay between word-level emotional features of valence and arousal and reader-level affective states of perceived mood and anxiety on L2 word recognition in the context of L2 reading. Forty-four late English bilinguals read 36 sentences while their eye fixations were recorded with an eye tracker. The results indicated no significant differences in the processing time between high and low arousal words; however, words with positive valence elicited longer gazing time than neutral words, suggesting deeper cognitive engagement with positively-valenced words. Additionally, observation of the interaction between words' valence and arousal levels showed a processing disadvantage for positive low-arousal words. Concerning readers' psychological states, positive mood facilitated faster global word processing regardless of words' emotional properties. However, a high or low level of readers' state anxiety did not make a difference in the processing speed of emotion-laden words. Also, valence and arousal did not interact with the learners' mood or anxiety. The study concludes that the positive valence cost is likely driven by the higher cognitive load and abstractness of positive low-arousal words for L2 learners. Furthermore, positive mood acts as a global cognitive enhancer, reducing processing load, rather than a specific, mood-congruent facilitator. These findings suggest that fostering a positive affective environment and providing explicit instruction for abstract positive words are key to improving reading fluency.

Keywords: L2 Reading, Word Emotionality, Mood, State Anxiety, Positive Valence Cost, Cognitive Load.

[*] **Corresponding Author.**

Authors' Email Address:
[1] **Davoud Amini** (d.amini@azaruniv.ac.ir), [2] **Kazem Pouralvar** (k.pouralvar@gmail.com), [3] **Leila Kheiry** (llkheiry@gmail.com)

Introduction

In L2 reading, emotionally laden words or sentences can elicit emotional reactions, which may impact reading speed, comprehension, and memory encoding (Rączy & Orzechowski, 2021). Some research indicates that encountering emotional words may slow down reading speed as learners pause to process the emotional content and engage in cultural implications (El-Dekhs et al., 2023; Tang & Ding, 2024). However, the bulk of research on the processing of positive emotional words attests to the enhanced reading speed by capturing attention and decreasing cognitive load (Knickerbocker et al., 2015; Kuperman et al., 2014; Scott et al., 2012; Sheikh & Titone, 2013, 2016). Overall, the effect of emotion words on reading comprehension in a second language is complex and can vary among individuals and contexts.

It has been suggested that five dimensions of emotional word processing should be accounted for in order to arrive at an overarching view of the effect of emotional words on the comprehension and speed of second language reading (Amini et al., 2022, p. 117). First, word recognition in a contextualized reading task involves a different cognitive processing compared to recognizing words in such behavioral tasks as lexical decision or categorization because the processing of words in a text requires a larger size of higher-order cognitive processes like syntactic parsing and construction of context-adaptive meaning (Kim et al., 2018; Whitford & Titone, 2015). Therefore, emotional word processing has been demonstrated to be task-dependent (e.g., Liao & Ni, 2022).

Second, the type of emotion words along such dichotomies as emotion-laden vs. emotion-label words needs to be accounted for (e.g., Altarriba & Basnight-Brown, 2011; Knickerbocker et al., 2019). The third factor, which is the most well-investigated one, concerns such word features as valence, arousal, frequency, length, concreteness, distinctiveness, predictability, and age of acquisition (El-Dakhs et al., 2023; Knickerbocker et al., 2015, 2019; Scott et al., 2012; Sereno & Rayner, 2003; Sheikh & Titone, 2016; Wu et al., 2023; Yao et al., 2024).

Above these three sets of factors are the two reader-related variables. The first variable is the affective state of the reader, including anxiety, depression (Tang & Ding, 2024), and mood (e.g., Sereno et al., 2015). The second factor in this category involves such individual differences as the reader's vocabulary knowledge (Alshehri & Zhang, 2022), level of proficiency (El-Dakhs & Altarriba, 2018), L2 experience (Whitford & Titone, 2015), and gender (Amini et al., 2022). The fifth set of variables involves textual features, e.g., authentic vs. simplified texts or the position of a word in a sentence (Kim et al., 2018).

While previous research has explored the influence of various word features on emotional word processing in L2 reading, a less understood area is the interplay between these features and the reader's emotions during reading. Hence, realizing the significance of L2 readers' psychological states during a reading comprehension task, we intended to examine the combined effects of the reader's emotional states (mood and state anxiety) and the emotional content of the word being processed (valence and arousal) on word recognition time using eye-tracking technology. The interaction among these constructs is theorized within embodied cognition and bilingual lexical access frameworks, positing that emotional resonance facilitates or hinders word recognition and integration in L2 reading (Tang et al., 2023).

This research can contribute to a more comprehensive understanding of L2 reading, where learners might grapple with both emotional nuances of words and their own emotional state while reading in a non-native language (Tang & Ding, 2024). Moreover, it can inform pedagogical practices by highlighting how educators can consider the emotional content of materials and potentially tailor instruction to address the interplay between reader emotions and word processing. Finally, the findings could contribute to the broader field of reading research by shedding light on the dynamic relationship between emotional language and the reader's emotional landscape (Leung et al., 2019).

Literature Review

Emotional Word Processing in L2 Reading

Lexical processing is essential for successful L2 reading, influencing speed, comprehension, and overall fluency (Alshehri & Zhang, 2022). According to the Lexical Quality Hypothesis (Perfetti, 2007), inefficient lexical processing increases cognitive load, leaving fewer resources available for comprehension (Perfetti & Stafura, 2014).

A set of well-studied word features that have been considered critical for more efficient and fluent reading includes the word's frequency, length, familiarity, orthographic regularity, semantic transparency, morphological and phonological complexity, cognateness, and contextual predictability (Kim et al., 2018). Word emotionality is a significant lexical feature that can remarkably affect L2 reading speed and comprehension (El-Dakhs et al., 2023). Word emotionality can enhance attention, memory, comprehension, engagement, and motivation in L2 reading (Ballenghein et al., 2019; Leung et al., 2019; Schacht & Sommer, 2009).

Words' emotional content has been commonly studied along the two features of valence (positive, negative or neutral in terms of emotional connotations associated with the word) and arousal (intensity or activation level of the emotional content associated with the word) (Russell, 2003). The bulk of research has indicated an emotionality advantage in word processing whereby positive and negative words are processed faster than neutral words (e.g., Arfé et al., 2023; Knickerbocker et al., 2019; Kuperman et al., 2014; Scott et al., 2012; Sheikh & Titone, 2013, 2016).

Despite this overwhelming empirical evidence for emotionality advantage, some studies have reported no processing advantage for positive or negative words compared to neutral words (El-Dakhs et al., 2023; Tang & Ding, 2024). Therefore, the effect of word valence on word recognition in reading must be nuanced. For instance, processing advantage for emotional words can be stronger for highly proficient L2 learners, who have established emotional associations with the words in the second language (El-Dakhs & Altarriba, 2018; Kim et al., 2018). Additionally, word features like frequency and concreteness interact with valence and arousal, influencing the recognition speed (Yao et al., 2024; Knickerbocker et al., 2015; Scott et al., 2012; Sheikh & Titone, 2013, 2016). These studies have consistently shown that the processing advantage for positive and negative words is witnessed only for low-arousal words. Theoretically, the anxiety level associated with high-arousal words impedes valence effects in the faster processing of positive or negative words over neutral ones. Furthermore, research indicates an interaction between arousal and valence during language processing (El-Dakhs et al., 2023; Citron et al., 2012; Knickerbocker et al., 2015; Scott et al., 2012; Tang & Ding, 2024). However, Kuperman et al. (2014) reported the absence of interaction between valence and arousal.

The results of studies focusing on emotion word processing in contextualized reading tasks have been varied (Amini et al., 2022; El-Dakhs & Altarriba, 2019; El-Dakhs et al., 2023; Knickerbocker et al., 2015; Scott et al., 2012; Tang & Ding, 2024). These studies provide empirical support for the notion that emotion words can have both positive and negative effects on L2 reading, depending on other word features, the nature of the task, the type of text, the emotional state of the reader, and other individual difference factors (Amini et al., 2022; Kim et al., 2018; Liao & Ni, 2022).

Effect of Reader's Emotional State on Emotional Word Processing

Readers' Emotional states can influence the cognitive resources available for reading. Positive emotions can reduce cognitive load, making it easier to process and understand the

text (Fredrickson, 2001; Leung et al., 2019), while negative emotions can increase cognitive load, making it harder to concentrate and process information (MacIntyre & Gardner, 1994). Mood influences such cognitive processes as attention, memory, and comprehension, which, in turn, affect language processing. Neuroscientific evidence from ERP studies attests to distinctive neural correlates involved in the processing of positive, negative, and neutral words during positively and negatively induced mood (Citron, 2012; Kissler & Bromberek-Dyzman, 2021). Studies generally find minimal or inconsistent correlations between mood or state anxiety and eye-tracking indices during L2 reading of emotional words (El-Dakhs et al., 2023; Tang & Ding, 2024). The emotional facilitation effect appears independent of anxiety or depression status in L1 but less so in L2 (Knickerbocker et al., 2015; El-Dakhs et al., 2023). Some findings suggest that individual affective states can modulate reading strategies or emotional word processing, especially positive mood-enhancing self-efficacy and global reading strategies (Leung et al., 2019).

Interaction Between Word Emotionality and Reader's Affective State

One of the earliest attempts to address the interactive relationship between word emotionality and the subjects' induced mood in lexical perception was Small (1985). The study intended to substantiate Gerrig and Bower's theory of Mood Congruency Effect (Gerrig & Bower, 1982), according to which there is a speed-up in perception when the emotional stimulus is congruent with the processor's mood state. The results of this pioneering research indicated no difference between participants with depressive symptoms and those with a neutral depression state. However, subjects with induced depression recognized congruent depressing words more rapidly than neutral words. Although this finding was in line with Gerrig and Bower (1982), it must be noted that the study simply measured low-level perception thresholds in recognizing the stimulus words. The succeeding research focusing on higher-level cognitive word processing came up with different results.

Sereno et al. (2015) examined the effects of induced mood on emotional and neutral language perception. Although positive and negative moods facilitated the processing of emotion words, they did not function in accordance with mood congruency. In a recent study, Naranowicz et al. (2023) studied the interaction between word valence, induced mood, and gender in an emotive decision task in L1 and L2. The results indicated that L1 neutral words and L2 positive words were processed faster only when the participants were in a positive mood. Positive and negative words were processed faster compared to neutral words, regardless of gender and language of operation.

Kissler and Bromberek-Dyzman (2021) demonstrated that the interaction between mood and valence/arousal depends on the stage of word processing: Mood-congruent effects were found at the early perceptual processing, while mood incongruent effects were witnessed during higher-order evaluative processing.

Knickerbocker et al. (2015) measured their participants' depression and anxiety with BDI and STAI, respectively, to probe into any possible relationship between word valence and learners' psychological states. They were unable to demonstrate an interaction effect between positive valence and learners' level of depression or anxiety. Nevertheless, an interaction was found between negative valence and anxiety. Learners with higher anxiety appeared to process negative words faster. No interaction was witnessed between negative valence and depression. Surprisingly, in a similar research design, El-Dakhs et al. (2023) studied the interplay between word valence and arousal on the one hand, and depression and anxiety of the processor, on the other, coming up with absolutely contrasting results from Knickerbocker et al.'s. They showed an interaction effect between positive valence and depression but no main or interaction effect between positive valence and anxiety. They also reported the absence of interaction between negative words and depression or anxiety.

In a recent study, Tang and Ding (2024) followed Knickerbocker et al. (2015) and El-Dakhs et al. (2023) in probing into word emotionality and the processor's emotionality in natural sentence reading. They were unable to demonstrate any robust effect for the anxious and depressive states of the participants in processing emotional words. These studies suggest that both emotional states of the reader and emotional content of words can play a critical role in L2 reading dynamics. The findings support the idea that emotional states can significantly impact L2 reading processes.

Based on the reviewed research, the present study investigated how mood can modulate the cognitive processes involved in reading and processing emotional lexicon. The following seven research questions guided the research:

1. Does a word's emotional valence have any effect on word recognition time in L2 reading?
2. Does a word's arousal have any effect on word recognition time in L2 reading?
3. Is there any interaction between word valence and arousal in affecting word recognition time in L2 reading?
4. Does the reader's perceived mood have any effect on the word recognition time in L2 reading?

5. Is there any interaction between an L2 reader's mood and word valence/arousal in affecting word recognition time in L2 reading?

6. Does the reader's perceived state anxiety have any effect on the word recognition time in L2 reading?

7. Is there any interaction between an L2 reader's state anxiety and word valence/arousal in affecting word recognition time in L2 reading?

Methods

Design

The study employed a mixed Between-Within-Subjects experimental design to examine the processing of emotion-laden words in natural L2 reading. Simultaneous effects of two features of emotional words (valence and arousal) as the within-subject variables and two variables indicating L2 readers' emotional state (state anxiety and perceived mood) as the between-subject variables on the time assumed to be allotted for recognizing the target words (total eye fixation time) were investigated. Eye-tracking technology was utilized to capture real-time data on gaze durations during reading tasks.

Participants

Forty-four intermediate-level English learners (21 males, 23 females; age range: 20–30 years), selected from among the students of Arts and Engineering at the Multimedia Faculty of Tabriz Islamic Art University on a convenience sampling basis, participated in the study. The participants met the following criteria:

- Intermediate proficiency level (verified through PET scores).
- Normal or corrected-to-normal vision.
- No history of neurological or psychological disorders.

An initial sample of 68 students took a Preliminary English Test (PET), the aim of which was to assess their reading proficiency and ensure homogeneity. Based on the results of PET, a sample of 48 students with scores of 1 SD above and below the mean was selected for the experiment. The data from the eye movements of four participants (1 male and 3 females) were left out of the analysis because they lost track during the experiment. Thus, the number of participants was reduced to 44.

Apparatus

A Tobii TX300 eye-tracker recorded participants' eye movements at a sampling rate of 300 Hz. In this research, the readers' gaze duration (Total eye fixation time on each word) made up the main data. The eye-tracking device employed in this study did not use glasses or a chinrest to attach to the participants; therefore, the experiment ran as a natural reading activity. The device was calibrated for each participant to ensure accuracy. Calibration indicated that an average of 1000 frames reported as the outlet equaled 1 second. Therefore, the collective sum of frames for each target word was considered as the total Gazing Time (GT) in milliseconds for that word.

Instruments and Materials

Preliminary English Test: The reading section of a PET archive test was used to measure the participants' general reading proficiency. The test, which consisted of 5 comprehension passages with a total of 35 comprehension questions, was considered appropriate for the purpose of this study as the stimulus here involved reading comprehension.

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) measured the participants' perceived mood. The scale was rated on a 7-point Likert scale. The cut point for determining positive/negative mood states was set at 3.5.

State-Trait Anxiety Inventory: The participants' state anxiety was gauged by the State part of Spielberger's (1989) Y-Form of State-Trait Anxiety Inventory (STAI). The scale has been used not only for clinical purposes but also for other research situations as an indicator of distress (Spielberger et al., 1983). It contains 40 items in a 4-point Likert scale, 20 of which are for state anxiety. The scores ranged from 20 to 80 for each participant, with higher scores indicating a higher level of anxiety.

Target Words: The emotion-laden words selected for the purpose of this research needed to be categorized based on their emotional valence (positive, negative, or neutral) and arousal (high vs. low). Therefore, 36 words, i.e., (6+6+6) ×2, were selected from the list of ANEW (*Affective Norms for English Words*, Bradley & Lang, 1999). Arousal values in ANEW range from 1 (low) to 9 (high) in accordance with the British National Corpus (http://www.natcorp.ox.ac.uk/). The valence values of the selected words ranged from 1-3 (negative), 3-6 (neutral), and 6-9 (positive). The valence and arousal attributions of the target words have been displayed in Table 1.

Table 1. Target words by Valence and Arousal

Valence	High Arousal	Low Arousal
Positive	famous (6.98, 5.73)/ desire (7.69, 7.35) joyful (8.22, 5.98)/ (health (6.81, 5.13) cheer (8.1, 6.12)/ inspired (7.5, 6.02)	dream (6.73, 4.53)/ truth (7.80, 5) idol (6.12, 4.95)/ easygoing (7.2, 4.3) adult (6.49, 4.76)/ bliss (6.95, 4.41)
Negative	tense (3.56, 6.53)/ insecure (2.36, 5.56) fights (3.76, 7.15)/ troubles (3.3, 6.85) crisis (2.74, 5.44)/ pain (2.13, 6.5)	alone (2.41, 4.83)/ slow (3.93, 3.39) hinder (3.81, 4.12)/ idiot (3.16, 4.21) loser (2.25, 4.51)/ moody (3.20, 4.18)
Neutral	chance (6.02, 5.38) / news (5.30, 5.17) rough (4.74, 5.33) / anxious (4.81, 6.92) noisy (5.02, 6.38) / highway (5.92, 5.16)	quiet (5.58, 2.94) / methods (5.56, 3.85) gender (5.73, 4.38) / modest (5.76, 3.98) customs (5.83, 4.65) / detail (5.55, 4.1)

1-4: Negative valence, 4.01-6: Neutral Valence, 6.01-9: Positive valence

5>Low arousal, 5.01< High arousal,

Reading Materials

The study utilized 36 sentences, each embedding a target word with varied emotional valence (positive, negative, neutral) and arousal (high, low). The sentences were controlled for length, complexity, and word frequency to ensure uniformity. The stimulus reading task involved two short texts, each made up of 18 sentences, each including one of the target words. The reading task involved reading 8 slides (4 slides for each text). The target words appeared in the middle of the sentences on each slide to control the sentence location effect (Conklin & Pellicer-Sánchez, 2016).

Procedure

In this experiment, initially, an announcement was circulated at the university to attract volunteers for the study. Following the administration of the reading proficiency test, a sample of 44 students made up the ultimate participants. The participants were tested individually. The participants completed the PANAS and STAI to establish baseline mood

and anxiety levels before the reading task. Then the participants were asked to read the two reading passages within the given time and answer the 5 comprehension questions following each reading passage. During reading, their eye fixations were recorded. The participants were kept naïve to the purpose of the research in order to prevent emotional interference. Following the reading task, participants rated the emotional intensity and valence of target words, which was used to ensure alignment with intended valence and arousal categorizations.

Data Analysis

The design involved 3 (Valence: Positive, Negative, Neutral) × 2 (Arousal: LA, HA) × 2 (Mood: Positive, Negative; or Anxiety: High and Low) between-within factorial design. The data were analyzed by conducting 1) a two-way repeated-measures ANOVA to investigate the main and interaction effects of word arousal and valence, and 2) two separate three-way between-within-subjects repeated measures ANOVA on SPSS in order to determine the main and interaction effects of readers' mood and anxiety, on the one hand, and word valence and arousal, on the other. While the type of target words along the two variables of valence and arousal made up the within-subject factors, the participants' anxiety and mood were considered as the between-subject variables.

Results

Descriptive Statistics and Preliminary Analyses

The mean Gazing Time (GT) and standard deviations (SD) for all 36 target words, aggregated across the 44 participants, were calculated for each word-level independent variable, i.e., positive valence (PV), negative valence (NV), neutral (NeutV) as well as arousal features of high arousal (HA) and low arousal (LA) are displayed in Table 2 below.

Table 2. Eye-Fixation Time Across Valence and Arousal Properties of Target Words

	N	Minimum	Maximum	Mean	SD
Positive Words' Gazing Time	44	80	540	248.14	106.471
Negative Words' Gazing Time	44	50	640	240.00	113.895
Neutral Words' Gazing Time	44	40	460	213.36	89.305
High Arousal Gazing Time	44	80	450	229.32	96.939
Low Arousal Gazing Time	44	40	550	250.45	106.857
Valid N (listwise)	44				

Overall, neutral words elicited the shortest mean GT (213.36 ms), indicating the fastest processing time. In comparison, both positive words and negative words received comparatively longer GTs. For the arousal dimension, high arousal words (229.32 ms) received descriptively shorter mean GTs than low arousal words (250.45 ms).

Table 3 presents the descriptive statistics (M, SD) for GTs disaggregated by the reader's mood and the six word-type combinations (Valence*Arousal).

Table 3. Eye-Fixation Time of Target Words Across Readers' Perceived Mood States, and the Target Words' Valence and Arousal

	Reader's Mood	Mean	Std. Deviation	N
Positive High Arousal	Positive Mood	172.50	70.103	20
	Negative Mood	253.46	111.909	24
	Total	216.66	102.630	44
Positive Low Arousal	Positive Mood	248.00	133.164	20
	Negative Mood	332.58	131.090	24
	Total	294.14	137.267	44
Negative High Arousal	Positive Mood	230.45	161.008	20
	Negative Mood	265.50	205.035	24
	Total	249.57	185.074	44
Negative Low Arousal	Positive Mood	210.50	137.515	20
	Negative Mood	267.50	112.143	24
	Total	241.59	126.122	44
Neutral High Arousal	Positive Mood	186.00	77.283	20
	Negative Mood	276.25	115.751	24
	Total	235.23	108.959	44
Neutral Low Arousal	Positive Mood	158.55	84.137	20
	Negative Mood	242.13	120.841	24
	Total	204.14	112.741	44

As visualized in Figure 1, a consistent trend emerges from the data in Table 3. The mean GTs for the positive mood group are consistently lower across all six word types compared to the negative mood group, strongly suggesting a potential main effect of mood.

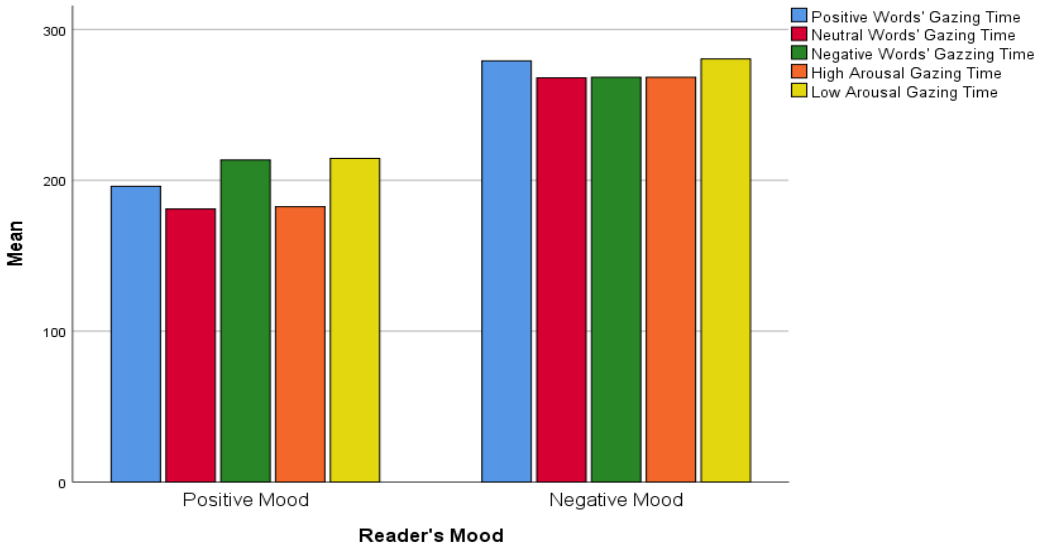

Figure 1. Comparing Means of Eye Fixation Time of 5 Types of Emotional Words in relation to Mood State

Similarly, the descriptives of the gazing time of the target words disaggregated by state anxiety levels of participants are shown in Table 4 and Figure 2.

Table 4. Eye-Fixation Time of Target Words Across Readers' Perceived State Anxiety and Words' Valence and Arousal

	Reader's State Anxiety	Mean	Std. Deviation	N
Positive High Arousal	Low	208.85	102.813	26
	High	227.94	104.254	18
	Total	216.66	102.630	44
Positive Low Arousal	Low	285.85	142.241	26
	High	306.11	132.848	18
	Total	294.14	137.267	44
Negative High Arousal	Low	225.12	173.244	26
	High	284.89	200.662	18
	Total	249.57	185.074	44
Negative Low Arousal	Low	240.38	145.175	26
	High	243.33	96.100	18
	Total	241.59	126.122	44
Neutral High Arousal	Low	218.46	105.932	26
	High	259.44	111.697	18
	Total	235.23	108.959	44
Neutral Low Arousal	Low	186.31	83.700	26
	High	229.89	143.735	18
	Total	204.14	112.741	44

Low Anxiety. (20-50), High Anxiety: (50.01-80)

In contrast to the mood data, no clear, consistent pattern emerges from the state anxiety data, as also visualized in Figure 2. For some word types (e.g., Positive Low Arousal), high anxiety is associated with slightly slower processing (=306.11 ms) than low anxiety (=285.85 ms), while for others (e.g., Negative Low Arousal), the means are very close (=243.33 ms vs.=240.38 ms, respectively).

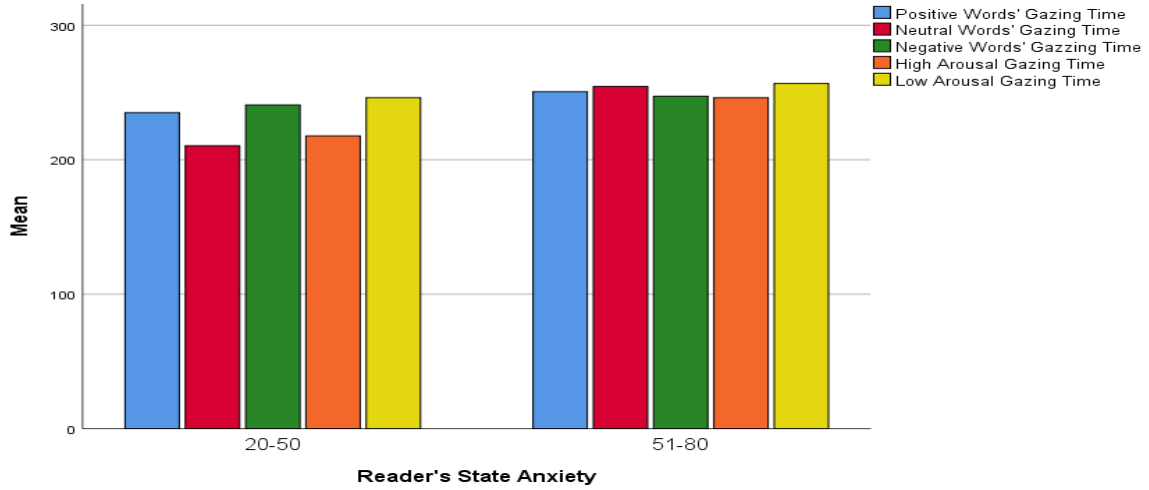

Figure 2. Comparing Means of Eye Fixation Time of 5 Types of Emotional Words in relation to State Anxiety Level

The results of the Kolmogorov-Smirnov test (Table 5) indicated that the assumption of normality was met for the GT scores across all conditions (p >.05).

Table 5. Results of the Kolmogorov-Smirnov Test to Check the Normality of Scores

	Reader's Mood	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Positive Words' Gazing Time	Positive	.126	20	.200*
	Negative	.155	24	.141
Negative Words' Gazing Time	Positive	.178	20	.095
	Negative	.106	24	.200*
Neutral Words' Gazing Time	Positive	.213	20	.058
	Negative	.113	24	.200*
High Arousal Gazing Time	Positive	.171	20	.128
	Negative	.176	24	.053
Low Arousal Gazing Time	Positive	.132	20	.200*
	Negative	.125	24	.200*

* This is a lower bound of the true significance.
a Lilliefors Significance Correction

Effects of Valence, Arousal, and Their Interaction on Word Recognition Time

To address the research questions 1, 2, and 3, a 3 (Valence: Positive, Negative, Neutral) by 2 (Arousal: High, Low) two-way ANOVA was conducted. Two-way analysis of variance upholds the assumption of sphericity in addition to the normality of scores presented above. Mauchly's Test of Sphericity (Table 6) was non-significant for the main effect of Valence (W=.979, p=.652). However, it was significant for the Valence× Arousal interaction (W=.509, p<.001).

Table 6. Mauchly's Test of Sphericity

	Mauchly's W	Approx. X^2	df	p-value	Greenhouse-Geisser ε	Huynh-Feldt ε	Lower Bound ε
Valence	0.972	1.213	2	0.545	0.972	1.000	0.500
Valence ✻ Arousal	0.511	28.177	2	< .001	0.672	0.685	0.500

Consequently, the degrees of freedom for this interaction were corrected using the Greenhouse-Geisser adjustment to avoid inflating the Type I error rate (Table 7).

RQ1 (Valence Effect)

The analysis revealed a statistically significant main effect of valence on Gazing Time, as shown in Table 9 ($p = 0.035$, $\eta^2 = 0.076$, $F = 3.534$).

Table 7. Results of Two-Way ANOVA for effects of Valence and Arousal

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Valence	Sphericity Assumed	59919.644	2	29959.822	3.534	.034	.076
	Greenhouse-Geisser	59919.644	1.945	30812.850	3.534	.035	.076
Arousal	Sphericity Assumed	10818.561	1	10818.561	1.090	.302	.025
	Greenhouse-Geisser	10818.561	1.000	10818.561	1.090	.302	.025
Valence * Arousal	Sphericity Assumed	143907.644	2	71953.822	7.027	.001	.140
	Greenhouse-Geisser	143907.644	1.343	107120.427	7.027	.006	.140

The highest gazing time was observed for the negative emotional words. The results of post-hoc analysis in Table 8 show that words with neutral emotional valence were processed significantly faster than the words with both positive and negative valence since neutral

words indicated a lower GT. However, the difference between positive and negative-valenced words was not significant.

Table 8. Pairwise Comparisons for Valence Effect

(I) Valence	(J) Valence	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Positive	Negative	9.818	14.494	.502	-19.412	39.048
	Neutral	35.716*	12.657	.007	10.191	61.241
	Negative	-25.898	14.414	.079	-54.967	3.171

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

RQ2 (Arousal Effect)

The main effect of Arousal was not statistically significant ($F=1.09$, $P = 0.302$, $\eta^2=.025$). This indicates that, when collapsed across valence and mood, the arousal level of a word does not independently affect L2 word recognition time.

RQ3 (Interactional Effects of Valence and Arousal)

The analysis revealed a statistically significant two-way interaction between valence and arousal ($F=7.027$, $p=.006$, $\eta^2=.140$). This significant interaction indicates that the effect of a word's valence on recognition time is dependent on its arousal level. Post-hoc pairwise comparisons (Table 9) revealed that the interaction is driven almost entirely by the Positive Low-Arousal (Pos-LA) word category.

Table 9. Post Hoc Comparison of Valence * Arousal

		Mean Difference	SE	t	Cohen's d	p_{holm}	
Positive, Low	Negative, Low	52.545	22.775	2.307	0.399	0.311	
	Neutral, Low	90.000	19.339	4.654	0.683	< .001	***
	Positive, High	77.477	17.659	4.387	0.588	0.001	**
	Negative, High	44.568	23.505	1.896	0.338	0.582	
	Neutral, High	58.909	18.381	3.205	0.447	0.033	*

		Mean Difference	SE	t	Cohen's d	p_{holm}
Negative, Low	Neutral, Low	37.455	18.638	2.010	0.284	0.508
	Positive, High	24.932	16.994	1.467	0.189	1.000
	Negative, High	-7.977	29.601	-0.269	-0.061	1.000
	Neutral, High	6.364	16.486	0.386	0.048	1.000
Neutral, Low	Positive, High	-12.523	16.725	-0.749	-0.095	1.000
	Negative, High	-45.432	28.160	-1.613	-0.345	0.912
	Neutral, High	-31.091	13.926	-2.233	-0.236	0.339
Positive, High	Negative, High	-32.909	25.853	-1.273	-0.250	1.000
	Neutral, High	-18.568	12.449	-1.492	-0.141	1.000
Negative, High	Neutral, High	14.341	22.115	0.648	0.109	1.000

* p < .05, ** p < .01, *** p < .001

Note. P-value adjusted for comparing a family of 15

- Pos-LA words (=294.14 ms) were processed significantly slower than Positive High-Arousal words (=216.66 ms) (Mean Difference = -77.312, p =.001).
- Pos-LA words were also processed significantly slower than Neutral Low-Arousal words (=204.14 ms) (Mean Difference = 89.954, p<.001).
- Furthermore, Pos-LA words were processed significantly slower than Neutral High-Arousal words (=235.23 ms) (Mean Difference = -59.167, p=.037).

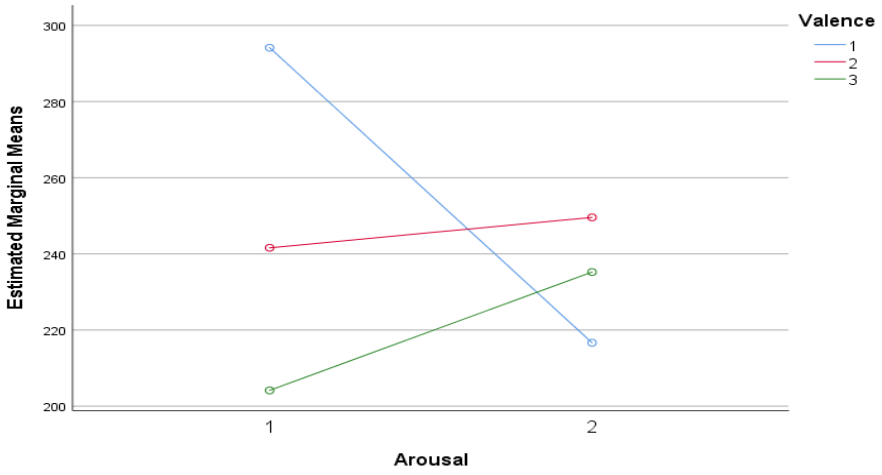

Figure 3. Interaction Between Valence and Arousal

No other comparisons involving negative words reached statistical significance. It was not all positive words that caused a processing delay, but specifically Positive Low-Arousal words (e.g., dream, truth, and bliss) that uniquely and significantly slowed L2 readers' recognition time.

Main and Interaction Effects of Mood

To address the research questions concerning word emotionality and the reader's mood (RQs 4 and 5), a 3 (Valence: Positive, Negative, Neutral) by 2 (Arousal: High, Low) by 2 (Mood: Positive, Negative) three-way mixed-effects ANOVA was conducted. This test requires the assumptions of normal distribution, normality of variances, and sphericity of within-subject variables which were already ascertained with the previous test of ANOVA. Two additional assumptions of mixed between-within-subjects RM-ANOVA are the homogeneity of variances and equality of covariances. Levene's Test of Equality of Error Variances (Table 10) was non-significant for all levels of the dependent variable ($p>.05$), indicating that the assumption of homogeneity of variances for the between-subjects factor (Mood) was met.

Table 10. Levene's Test of Equality of Error Variances

Levene Statistic		df1	df2	Sig.
Positive High Arousal	3.136	1	42	.084
Positive Low Arousal	.012	1	42	.914
Negative High Arousal	.944	1	42	.337
Negative Low Arousal	.080	1	42	.779
Neutral High Arousal	3.836	1	42	.057
Neutral Low Arousal	2.301	1	42	.137

Box's Test of Equality of Covariance Matrices uses a significance level of $\alpha = .001$. The index was larger than α (Box's M = 46.806, F (21, 6024.583) = 1.880, p=.009), which attests to the rejection of the null hypothesis regarding the absence of equality of covariances.

Mauchly's Test of Sphericity (Table 8) was non-significant for the main effect of Valence (W=.979, p=.652). However, it was significant for the Valence*Arousal interaction (W =.509, p<.001). Consequently, the degrees of freedom for this interaction were corrected using the Greenhouse-Geisser adjustment.

The mood effect was significant at the 95% probability level ($p = 0.013$, $\eta^2 = 0.072$, $F = 6.761$). Readers perceiving themselves in a positive mood (N=20) demonstrated a faster overall recognition of words regardless of words' emotional properties (Table 11).

Table 11. Effect of Mood on Word Recognition Time in L2 Reading

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Mood	338400.619	1	338400.619	6.761	0.013	0.072
Residuals	2.102×10+6	42	50051.896			

All other interactions involving the reader's mood were non-significant (Table 12). The interaction effect of valence and mood was not significant ($p = 0.274$, $\eta^2 = 0.005$, $F = 1.313$). The lack of a Valence-Mood interaction is a critical finding for RQ5. It fails to support the Mood Congruency Effect. Instead, the data support a main effect of mood that is independent of the word's specific emotional content; positive mood facilitates processing globally.

Table 12. Results of Mixed ANOVA for Effects of Mood, Valence, and Arousal

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Valence	61844.571	2	30922.286	3.674	0.035	0.013
Valence ✻ Mood	22103.253	2	11051.627	1.313	0.274	0.005
Residuals	706996.103	84	8416.620			
Arousal	10254.564	1	10254.564	1.011	0.320	0.002
Arousal ✻ Mood	649.473	1	649.473	0.064	0.801	1.384×10-4
Residuals	426040.300	42	10143.817			
Valence ✻ Arousal	142595.839	2	71297.919	6.818	0.002	0.030
Valence ✻ Arousal ✻ Mood	2293.248	2	1146.624	0.110	0.896	4.888×10-4
Residuals	878362.775	84	10456.700			

Arousal-Mood interaction was not significant either (Figure 4). That is, there was no significant difference in the amount of eye gazing time in different combinations of arousal and mood.

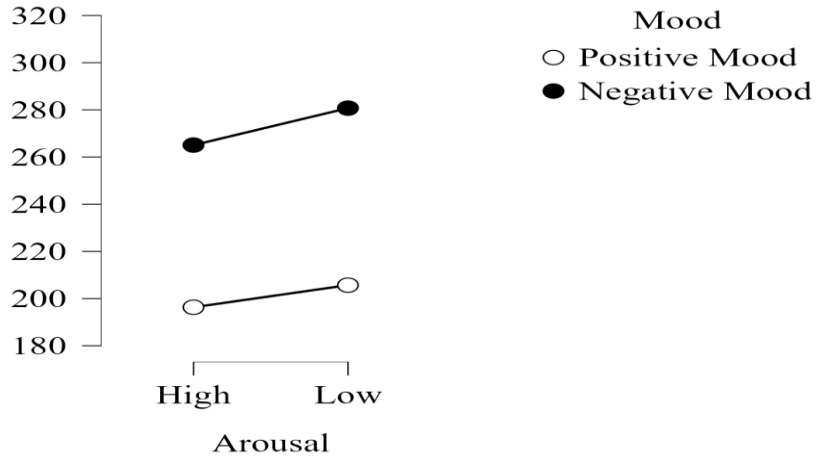

Figure 4. Estimated Marginal Means of Words' Arousal Levels Across Readers' Positive and Negative Mood

The three-way Valence-Arousal-Mood interaction was also not significant (F= 0.110, *p* =.896).

Main and Interaction Effects of State Anxiety

To address the research questions concerning word emotionality and the reader's state anxiety (RQs 6 and 7), a second 3 (Valence: Positive, Negative, Neutral) by 2 (Arousal: High, Low) by 2 (State Anxiety: High, Low) three-way mixed-effects ANOVA was conducted. The following assumptions were tested:

- **Homogeneity of Variances:** Levene's Test was non-significant for all conditions (p >.05), confirming the assumption of equality of variances.
- **Equality of Covariance:** Box's Test (Table 14) was non-significant at α =0.001 (Box's M = 50.038, p =.004) for the null hypothesis. As with the first ANOVA, the analysis proceeded with ascertained to relatively equal group sizes (N=26, N=18).
- **Sphericity:** Mauchly's Test of Sphericity (Table 6) was non-significant for the main effect of Valence (W =.968, p =.519) but was significant for the valence-arousal interaction (W=.512, p <.001). Therefore, the Greenhouse-Geisser correction was applied to the degrees of freedom for the valence-arousal interaction.

The results of the second mixed ANOVA are presented in Table 13. According to the table, there is no significant difference in the amount of eye gazing time between low and high levels of Anxiety.

Table 13. Effect of State Anxiety on Word Recognition Time in L2 Reading

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Anxiety	61758.384	1	61758.384	1.090	0.302	0.013
Residuals	2.379×10+6	42	56638.616			

Unlike mood, the reader's level of state anxiety did not have a global effect on L2 word recognition time, which is consistent with the descriptive data in Figure 2. All other interactions involving state anxiety were non-significant, addressing RQ7 (Table 14).

Table 14. Results of Mixed ANOVA for Effects of State Anxiety, Valence, and Arousal

Cases	Sum of Squares	df	Mean Square	F	p	η^2
Valence	51905.859	2	25952.930	3.013	0.055	0.011
Valence ✻ Anxiety	5434.875	2	2717.437	0.315	0.730	0.001
Residuals	723664.481	84	8615.053			
Arousal	7998.431	1	7998.431	0.797	0.377	0.002
Arousal ✻ Anxiety	4990.840	1	4990.840	0.497	0.485	0.001
Residuals	421698.933	42	10040.451			
Valence ✻ Arousal	143972.420	2	71986.210	6.963	0.002	0.031
Valence ✻ Arousal ✻ Anxiety	12225.011	2	6112.506	0.591	0.556	0.003
Residuals	868431.011	84	10338.464			

- The Valence-Anxiety interaction was not significant (F = 0.315, p=.730.
- The Arousal-Anxiety interaction was not significant (p=.485).
- The three-way Valence-Arousal-Anxiety interaction was not significant (F= 0.591, p=.556).

This set of null findings indicates that, within this study's design, the processing of emotional words (both valence and arousal) is not modulated by the reader's state anxiety.

Discussion

This study aimed to investigate the complex interplay between word-level emotional features (valence and arousal) and reader-level affective states (mood and state anxiety) on L2 word recognition time, as measured by eye-gazing time. The findings reveal a processing pattern that both challenges and supports existing literature. The primary findings are: (1) a significant main effect of valence, characterized by a processing cost for positive words

relative to neutral words; (2) a significant main effect of mood, where a positive mood facilitated faster global processing; (3) a robust Valence-Arousal interaction, which specified that the processing cost for positive words was driven entirely by positive low-arousal words; and (4) a notable absence of any main effect for arousal or state anxiety, and a lack of any interaction effects involving mood or anxiety.

The first research question asked if valence affects L2 word recognition. The analysis confirmed a significant main effect of valence. However, contrary to the *emotionality advantage* reported in much of the literature—where both positive and negative words are processed faster than neutral ones (e.g., Knickerbocker, 2015; Kuperman et al., 2014; Scott et al., 2012; Sheikh & Titone, 2013, 2016)—this study found a *positive valence processing cost*. This finding aligns with other studies that have also failed to find a simple emotionality advantage (e.g., Amini et al., 2022; El-Dakhs et al., 2023; Tang & Ding, 2024).

This main effect was powerfully qualified by the significant Valence × Arousal interaction. The data revealed that the processing cost was not due to positive words in general, but was specifically and robustly driven by positive low-arousal words (e.g., dream, truth, bliss). This finding is in line with Tang and Ding (2024) but in contrast with El-Dakhs et al. (2023). Positive low-arousal words impose a processing burden. A plausible explanation is that these words, which are often more abstract and conceptually complex (e.g., bliss, truth), demand deeper cognitive engagement and semantic integration than concrete high-arousal words (e.g., famous, cheer) or neutral words. While many high-arousal negative words (e.g., pain, crisis) may be processed quickly due to their direct threat-relevance, abstract positive concepts may require more elaborate, time-consuming cognitive operations for an L2 reader to fully activate and integrate their meaning within the sentence context (Yao et al., 2024).

Arousal did not have a significant main effect on recognition time. This indicates that it was not a key factor. Instead, the role of word intensity was purely interactive, serving to moderate the effect of valence. This supports the body of research that points to an inevitable interaction between valence and arousal in word processing (e.g., El-Dakhs et al., 2023; Scott et al., 2012), while challenging Knickerbocker et al. (2015) and Kuperman et al. (2014), who reported an absence of this interaction.

Regarding the reader's mood, this study yielded a robust finding, a significant main effect of mood regardless of the words' valence or arousal. This result strongly supports theories that link positive affect to more efficient cognitive processing, such as Fredrickson's

(2001) broaden-and-build theory, or the proposal by Leung et al. (2019) that positive states enhance global reading strategies and reduce cognitive load.

The present study found no evidence for a Valence × Mood interaction, which directly challenges the Mood Congruency Effect (Gerrig & Bower, 1982). This finding is in agreement with Sereno et al. (2015), who also found that mood facilitated emotional word processing but not in a strictly congruent manner. The data suggest that for L2 reading, the benefit of a positive affective state is not specific, but rather a global enhancement of cognitive processing.

This study revealed no main effect of state anxiety on L2 word recognition time. Furthermore, there were no significant interactions between state anxiety and either valence or arousal. This set of null findings is consistent with the descriptive data, which showed no clear pattern, and aligns with a significant portion of the recent literature. For instance, Tang and Ding (2024) were similarly unable to demonstrate any robust effect for the anxious and depressive states of the participants in processing emotional words. While Knickerbocker et al. (2015) found that higher anxiety sped up the processing of negative words, this study (like El-Dakhs et al., 2023) found no such interaction. For the cohort of L2 learners in this study, a general feeling of state anxiety did not modulate the cognitive processing of emotional words. This may suggest that the "baseline" cognitive load of L2 reading (Kim et al., 2018) is already substantial, and the reader's self-perceived affective state (as measured by STAI) may not be a powerful enough factor to further modulate the specific, online processing of emotion-laden words.

Conclusion

This study contributes two primary findings to the field of L2 emotional word processing. First, the effect of valence is not a simple advantage but is moderated by arousal, with positive low-arousal (often abstract) words creating a unique processing cost for L2 readers. Second, a reader's mood has a global effect, with positive mood facilitating faster processing of all words, whereas state anxiety appears to have no significant impact.

These findings have significant implications for L2 reading and vocabulary acquisition. The "positive valence cost" suggests that educators cannot assume that positive words are inherently easier or more motivating. Abstract positive words may, in fact, be harder to process and require more explicit instruction and contextual support than neutral or even high-arousal negative words. Furthermore, the findings on reader-level affect are plausible. This study underscores that for L2 learners, positive affect appears to broaden attention and

reduce overall cognitive load, facilitating the difficult task of reading in a second language. Accordingly, fostering a positive, low-stress environment is more likely to enhance overall reading fluency than any attempt to match text emotionality to a reader's perceived mood.

In this study, we focused on self-reported mood and anxiety in relation to emotional word processing within natural L2 reading tasks, where the nature of lexical processing can be scrutinized more closely than decontextualized word recognition tasks because the recognition and integration of word meaning operates through complicated affective and cognitive processes (El-Dakhs et al., 2023). There is also a wide range of academic emotions, e.g., anger, enjoyment, and hope, which future research can focus on. Readers' mood and anxiety during reading were assessed with self-reported instruments. Further nuanced research involving induced emotional states, like induced mood or anxiety is needed. Future research can also focus on the relevance of text type (narrative, descriptive, argumentative, etc.) to emotion word processing and its probable interplay with other reading-based variables. Overall, studying the interactive relationships between word features, task type, individual affects, and text features during contextualized reading tasks through advanced quantitative designs will proffer new insights into the dynamic processes involved in L2 reading.

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Declaration of Conflicting Interests

The authors declare that they have no known competing interests.

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Appendix

Reading Passages Including the Target Words

Reading 1

Joanne Rowling is the **famous** author of Harry Potter novels.

Joanne had a few **troubles** in her teenage life.

But she lived a normal, **quiet** life as a college student.

She always had the **desire** to become a writer.

After marriage she had no **Chance** of writing, she couldn't live with him anymore.

She got divorced and reached a **crisis** financially and mentally.

Joanne was mentally in **pain**, but her daughter was her only hope.

Finally, she earned back her **health** as she focused on writing again.

After divorce, she had time, so the **news** of writing Harry Potter's first book came out.

Although she was living **alone** with her daughter, she felt happier than before.

Joanne wrote the first novel in **detail** and gave it to a publisher.

That publisher could make her **dream** come true by selling so many copies.

Good to know that the **rough** theory of Harry Potter first occurred to her on a train.

The writing process of the first book was **slow**; it took Joanne six years to finish.

Joanne Rowling might have a **truth** to success; it was all in her mind.

She didn't have any special **methods**, luck, or money to help her through the way.

It was all about her **bliss** of imagination that made her J. K. Rowling.

The story of a boy who **fights** the evil, makes the books unique and unforgettable.

Based on the reading, are the following statements True or False?

1. Joanne was always dealing with difficulties until she published her first book.

A) True B) False

2. Joanne's daughter was the reason she could recover from her mental illness.

A) True B) False

3. Joanne got divorced so that she could start writing again.

A) True B) False

4. It took Joanne more than 3 years to finish the first book.

A) True B) False

5. Joanne was happy that she got divorced so that she could focus on writing again.

A) True B) False

Reading 2

Before Shawn Mendes became an **adult**, he rose to fame at the age of fifteen.

At first, he felt too **nervous** to sing before a crowd.

Although he wasn't a **noisy** student, he couldn't study well along singing.

After six years, now he's the **idol** of so many people in the world.

People from different countries, **customs** and tastes support him.

But he doesn't feel being **hindered** anymore singing to thousands of people.

He doesn't feel stressed or **insecure** either, he's trying to control it.

His relationship with his fans is **joyful**, they all love and adore him.

He's so caring, humble and **modest**; he says his fans are his friends.

Sometimes he might receive hatred, and **idiot** comments on him.

But he controls not to get **anxious** and focus on his music.

People love his music and **cheer** his songs in his concerts.

People from different races, **genders** and languages listen to him.

But money and fame haven't made him **moody**; he always keeps a simple lifestyle.

He might live like an **easygoing** person, but works hard for his music.

There are billboards and posters of him in **highways** in different cities of the world.

As a kid, he was **inspired** by John Mayor, the famous American singer.

And now that kid, who has never been a **loser**, is a legend that Mayor admires, too.

Based on the reading, are the following statements True or False?

1. Shawn Mendes has international fans

A) True B) False

2. Shawn now feels less stressed to sing before a crowd.

A) True B) False

3. Shawn Mendes has always been complimented by people.

A) True B) False

4. Shawn is nice to his fans and his friends.

A) True B) False

5. John Mayor was Shawn's inspiration to be a singer.

A) True B) False