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# The Effect of AI-Generated Emotional Pictures and the Role of Working Memory on Vocabulary Learning

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**Abstract**

Drawing on the Cognitive-Affective Theory of Learning with Media (CATLM), this study explores how emotional design in multimedia instruction impacts vocabulary acquisition among English as a foreign language (EFL) learners. Considering working memory (WM) constraints, the research assesses the effects of Artificial Intelligence (AI)-generated pictorial stimuli with varying emotional loads—negative, neutral, and positive—on learning outcomes. Thirty-six vocabulary items, paired with emotionally differentiated pictures, were presented to elementary-level learners ($n$ = 348), with learning gains measured via pretest-posttest comparisons. Working memory capacity (WMC) was evaluated using the Reading Span Task. Results indicated that emotional load significantly influenced vocabulary retention, with positive and negative pictures yielding the strongest effects. While WMC predicted learning for positively and neutrally loaded words, its impact diminished for negatively loaded items, supporting CATLM's assertion that affective factors can supersede cognitive capacity in learning. These findings highlight the interplay between emotional engagement and cognitive processing, emphasizing the need for instructional materials that balance both elements. The study contributes to the understanding of the role of affective design and AI-generated visuals in

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optimizing language learning, offering practical implications for multimedia-based EFL pedagogy.

***Keywords:*** AI-generated pictures, emotional design, emotionally-loaded pictures, vocabulary learning, working memory capacity

## 1. Introduction

The integration of multimedia instruction in teaching foreign language (FL) vocabulary has grown significantly with the introduction of the Cognitive Theory of Multimedia Learning (CTML) and Cognitive Load Theory (CLT) (Mayer, 2009; Sweller et al., 2011). These theoretical constructs underscore the inherent constraints of working memory capacity (WMC) and stress the need to minimize cognitive load through careful information presentation. Studies have demonstrated that combining visual and auditory elements enhances learning (e.g., Cromley & Chen, 2025; Liu & Wang, 2025). The Cognitive-Affective Theory of Learning with Media (CATLM), introduced by Moreno and Mayer (2007), integrates affective components, highlighting the influence of motivation and emotional states on the learning process. Emotional factors have been documented as consequential for academic achievement more broadly (Pishghadam & Shakeebaee, 2020). However, findings on emotional design—adding elements to evoke emotions—remain inconsistent (Mutlu-Bayraktar, 2024), warranting further exploration of its impact on cognitive load and learning outcomes (Brom et al., 2018). Emotional design also influences WMC, a key factor in individual learning differences (Plass et al., 2010), making it a central focus of this study. WMC plays a critical role in FL vocabulary retention, and its interaction with emotional design is essential for developing effective instructional materials. The emergence of artificial intelligence (AI), particularly generative AI, offers new opportunities to enhance teaching and learning (Li & Kesen Mutlu, 2025). By customizing emotional design to diverse needs and goals, AI can improve educational outcomes. AI-generated visuals based on textual cues show promise for advancing FL learning materials and teaching practices (Vigna-Taglianti, 2024). Grounded in CTML and CLT, and extending them through the lens of CATLM, this study explores the intersection of cognitive-affective theory and multimedia learning, examining how AI-generated pictures with varying emotional loads impact WMC and learning new words in English as a foreign language (EFL) learners.

## 2. Literature Review

### *2.1. Multimedia and Affect in Vocabulary Learning*

Vocabulary is crucial for effective language use, relying more on memorization than on grammar, which is rule-based (Thornbury, 2006), and the teaching of vocabulary is essential for language proficiency, as it forms the foundation for language development (Marques, 2019). Additionally, research has shown that visual aids, such as pictures, significantly enhance understanding, memory retention, motivation, and information processing in language learning (Boers et al., 2017). They are particularly effective for vocabulary acquisition, mind mapping, and improving descriptive skills (Kruk et al., 2023).

Among cognitive theories, the CTML and CLT provide robust support for the integration of visual aids in education (Mayer, 2009; Sweller et al., 2011). CLT emphasizes the critical role of WMC in processing information, indicating that an overload of single-channel input can hinder comprehension. The modality effect, also known as multimodal instruction, is a proven technique designed to alleviate the burden on WM (Sweller, 2010). CTML asserts that coherently presented multimedia—incorporating pictures, videos, or animations, charts, graphs, and so forth —can enhance learning by engaging both visual and auditory channels (Mayer, 2009). Research consistently supports the positive impact of multimedia on vocabulary learning (Ramezanali & Faez, 2019; Teng, 2022).

To address the gaps identified in the CTML regarding affective processes and motivation, Moreno and Mayer (2007) introduced the CATLM, which highlights the significance of emotions in fostering cognitive engagement and improving learning outcomes. The CATLM emphasizes the constraints of WM while acknowledging the virtually limitless capacity of long-term memory. It also highlights the benefits of dual coding, emphasizing dual coding, motivational factors, and metacognitive influences. CATLM advocates for knowledge construction over mere information acquisition, urging learners to actively create mental representations for deeper comprehension (Schneider et al., 2022). Consistent with this affective orientation, qualitative work has shown that learners' emotional dispositions shape how they engage with and use the target language in authentic social situations (Rantala & Greenier, 2020).

Recent research underscores the importance of affective processes in multimedia learning, particularly how emotional design elements shape student experiences and outcomes (Chung & Cheon, 2020). Scholars have examined how learning materials with varying emotional loads can affect learners' moods prior to instruction, impact classroom goals, and inform the selection of different instructional resources (Li et al., 2020). However, findings regarding the effects of anthropomorphisms and colors are mixed, with some studies showing positive impacts (e.g., Schneider et al., 2018), others indicating no effect (e.g., Münchow et al., 2017), and some yielding inconclusive results (e.g., Mayer & Estrella, 2014). This discrepancy in the results call for further exploration of emotional influences in learning outcomes (Amini et al., 2022). Moreover, aside from not reaching a consensus in previous studies, research on the effect of AI-generated emotionally-loaded pictures as multimedia instruction for EFL vocabulary learning remains scarce. Consequently, one of the questions addressed in this research was if pictures of three different emotional loads would result in differing effects regarding vocabulary retention of elementary learners.

### *2.2. The Role of WM in Learning Vocabulary*

The second variable studied in this research is the WMC, defined as a mechanism that manages both the storage and processing of information while tackling cognitive challenges like understanding, reasoning, or various distractions (Baddeley, 2015). Baddeley's multi-component model, originally introduced in 1986, provides a foundational framework for understanding WM's role in learning a new language, initially comprising the phonological loop, the visuo-spatial sketchpad, and also the dominant executive. Later models like Baddeley (2000) added a fourth component named episodic buffer, to further elaborate on how information is integrated across different memory systems. The central executive system, often referred to as complex WM, is a vital component of WM that functions as an attention management tool. It orchestrates the activities of the phonological loop and the visuo-spatial sketchpad. This subsystem plays an important role in allocating attentional resources, concentrating on task-relevant information, and facilitating task-switching during complex operations (Engle, 2002).

Research consistently highlights the pivotal role of WMC in foreign language learning (Andrade & Baddeley, 2011). However, there remains considerable debate regarding which component of WM—phonological short-term memory (PSTM) or the central executive—more significantly influences vocabulary retention (Teng & Cui, 2023). PSTM, typically measured through straightforward tasks such as forward digit spans, has been linked to second language vocabulary acquisition (Engel & Gathercole, 2012). Others have provided support for the role of executive WM, gauged by means of multifaceted tasks, like reading, listening, speaking or backward digit spans (Nemati et al., 2022; Yang et al., 2017). Therefore, one of the primary aims of this study is to deepen our understanding of the relationship between executive WM and FL vocabulary acquisition among young adults at the elementary level.

On the other hand, the findings of various researchers have highlighted the idea that cognitive mechanisms, notably memory and attention, are intrinsically driven by their ties to emotional processes (Tucker, 2007). Numerous studies have indicated that positive emotions facilitate information processing, improve negotiation abilities, improve decision-making, and enhance innovative problem-solving, among cognitive functions (Erez & Isen, 2002). A key element of this motivational mechanism is that alterations in emotional states affect higher cognitive functions (Rutherford & Lindell, 2011), at the core of which is WMC (Conway et al., 2005). Given the clear role of cognitive functions, namely WMC, in language acquisition, it becomes increasingly important to take emotions into account in educational contexts.

While some studies have examined how mood or emotional state impacts WMC, or how various stimuli influence mood and, in turn, cognitive abilities (Dörnyei & Ryan, 2015), few have specifically investigated the effect of emotionally-charged words on WMC (Garrison & Schmeichel, 2018). In their study, Garrison and Schmeichel (2018) investigated how emotionally-loaded words influence WMC using an operation span task. They created two versions of the WMC test: one featuring positive and negative words, and the other utilizing neutral words. Their findings revealed that participants who completed the neutral span task demonstrated higher WMC scores, an outcome consistent with other studies (Osaka et al., 2013; Spachtholz et al., 2014). However, Hou and Cai

(2022) raise important concerns about the unexplored facets of the interplay between emotions and WMC. Notably, there has been a lack of research investigating how FL vocabulary learning is influenced by emotionally-loaded pictures in relation to WMC. Thus, this study seeks to fill that gap, highlighting a different approach to understanding the influence of affective factors in instructional materials on the learning process.

### *2.3. Generative AI in Language Teaching and Learning*

AI is a relatively new technology defined as a system created by humans that can replicate human intellectual and creative abilities. This includes the capacity to gather and analyze information, plan and enhance work, learn, and produce intellectual outcomes (Li et al., 2025; Moorhouse & Wong, 2025). AI technologies are utilized in various aspects of daily life for tasks such as machine translation, converting text to speech and vice versa, and content creation, as in generative AI. Lim and colleagues (2023) describe generative AI as a tool that leverages deep learning models to create content resembling authentic output, which can encompass both text and pictures, by responding to diverse and intricate prompts such as languages, commands, and inquiries.

The launch of ChatGPT, as a text-generator, by the US company OpenAI in 2022 marked a significant advancement in AI technologies, especially with the subsequent introduction of GPT-4 in 2023 (Rice et al., 2023). Specifically, generative AI employs different forms of media, including text, pictures, sound, and video, to autonomously produce innovative content using generative modeling, which has been enabled by remarkable progress in deep learning technology (Jovanovic & Campbell, 2022). AI technologies are increasingly becoming a vital component of the digital transformation in education, demonstrating their effectiveness in making both teaching and learning processes more efficient (Yu, 2024).

In addition to providing interactive and immersive educational experiences, AI-enhanced FL classrooms significantly boost opportunities for students to practice their listening, speaking (Kolegova & Levina, 2024), and writing skills (Stokel-Walker, 2022). Research indicates that these innovative teaching models

not only enhance engagement but also elevate student interest and overall satisfaction in learning (Kolegova & Levina, 2024). Emotional factors such as speaking self-efficacy and anxiety also interact in complex ways to shape willingness to communicate within GenAI-enhanced learning environments (Zhu et al., 2026), highlighting the need to examine how specific emotional stimuli influence cognitive and affective processing.

The research conducted by Vigna-Taglianti (2024) reveals that AI-generated pictures serve as an effective teaching tool. He asserts that these AI image generators are not only efficient and economical, but also Intuitive and accessible, allowing educators to create tailored visual aids for specific topics. By using these tools, educators enhance students' vocabulary retention and can help them build stronger communication and creative capacities. Others, Ali et al. (2024) for example, have studied the benefits of new curricula in which the use of picture-generative AI is taught to K-12 students. Dehouche and Dehouche (2023) examined how AI could revolutionize visual art education, suggesting that these novel tools for creating art can successfully impart essential ideas related to art history, aesthetics, and artistic methods. However, in the realm of AI, the effect of AI-generated pictures of different emotional loads on FL vocabulary learning is yet to be explored. As an attempt to fill the abovementioned gaps in the existing literature, we aim to explore how AI-generated pictures—with positive, negative, and neutral emotional loads—influence English vocabulary learning among young adult elementary students. Additionally, we will investigate the relationship between these pictures and WMC, as well as their potential interactions in enhancing FL vocabulary learning. We hope to contribute valuable insights to the existing literature by exploring these dynamics.

**Research Questions**

While the role of visuals in learning is established, critical gaps remain. First, the empirical findings on the efficacy of emotional design are inconsistent (Brom et al., 2018), and the impact of AI-generated pictures with specific emotional loads is virtually unstudied. Second, the moderating role of individual differences, particularly WMC, in this relationship is not well understood (Hou & Cai, 2022). To address these issues, we aim to examine how AI-generated pictures affect English vocabulary acquisition in young adult elementary learners and analyze

their relationship with WMC to enhance FL learning. Therefore, the present research endeavors to address the following key questions.

RQ1: Does the emotional load of pictorial stimuli (negative, neutral, positive) significantly affect the vocabulary gains of elementary EFL learners?

RQ2: Does WMC as a cognitive individual difference significantly mediate vocabulary gains of EFL learners exposed to pictorial stimuli with varying emotional loads (negative, neutral, positive)?

RQ3: Are there any interaction effects of WMC and different emotional loads on EFL learners' vocabulary gains?

## 3. Methodology

### *3.1. Participants*

The study initially included 382 young male students aged 12 to 16. However, after excluding those who missed the instructional session or any testing sessions, the final analysis comprised 348 participants. These students were selected from 12 intact classes across three secondary schools in Hamedan, Iran. In our sample, slightly more than half (51%) reported Persian as their sole language, whereas 49% identified as bilingual, with Turkish, Kurdish, or Luri as their second language. All participants had been studying EFL for a duration of one to two years and were classified as elementary English learners based on their school education. School personnel (both principals and teachers) attested that none of the selected students had documented learning difficulties, and all possessed uncorrected normal vision according to their school health records.

### *3.2. Instruments and Procedure*

This study utilized a within-subjects design, where all participants were exposed to the same vocabulary items under different emotional conditions. The sequence of the study was as follows: a vocabulary pretest in week one, a working memory test in week two, the instructional session, and an immediate vocabulary posttest in week three. Throughout all testing sessions, participants worked individually

without access to phones, dictionaries, or other aids to ensure the integrity of the data.

### *3.2.1. Instructional materials and implementation*

The core treatment involved presenting participants with slides featuring AI-generated pictures designed to evoke positive, negative, or neutral emotions. Each slide displayed an English word alongside its Persian equivalent, which was read aloud by the teacher-researcher.

The development of these materials began with a pool of 324 vocabulary words. Through pilot testing and feedback on emotional associations, this was refined to a final set of 36 target items (see Table 1). These were evenly divided into three emotional sets (positive, negative, neutral), with each set containing four nouns, four verbs, and four adjectives. The 36 slides were presented in a randomized order over an 18-minute session. The sequence of item presentation was systematically varied across different classrooms to mitigate order effects.

**Table 1**
*Target* Words

| Positive | | | Negative | | | Neutral | | |
|---|---|---|---|---|---|---|---|---|
| Noun | Verb | Adjective | Noun | Verb | Adjective | Noun | Verb | Adjective |
| slide | obtain | celestial | carpenter | sweep | keen | pine | increase | mushy |
| hedgehog | float | huge | pedestrian | grate | narrow | attire | swing | solar |
| keg | assist | wavy | lung | arson | cautious | chain | ponder | circular |
| landscape | sew | urban | infant | dig | bald | clam | confirm | common |

To generate pictures with varying emotional loads, the study utilized Playground-v2.5, a generative AI. The emotional load of the pictures was determined by specific prompts provided to the AI, focusing on color palettes and atmospheric descriptions (Um et al., 2012). These prompt parameters were informed by prior empirical research confirming their impact on emotional perception (Palmer et al., 2013), guaranteeing that the AI-generated pictures effectively communicated the desired affective responses. For example, to create a negative emotional load for the word 'narrow,' the AI was prompted to illustrate a dark, littered alley on a winter night using muted, blackish colors, evoking

unease and discomfort. Conversely, positive emotional loads were elicited by instructing the AI to generate vibrant and joyful scenes, such as a colorful park with blooming flowers, bright sunshine, and people enjoying a picnic, using vivid colors, like sunny yellows and cheerful pinks. Neutral pictures were designed by crafting prompts that avoided extreme lighting or emotionally charged colors, such as a serene landscape of a cloudy sky over a calm lake, rendered in soft grays and blues.

To establish robust emotional validity in the visual stimuli, a multi-phase verification procedure was implemented. Initially, the AI system generated three distinct picture variations for each target term. These outputs were subsequently evaluated by an independent panel comprising eight adjudicators (four adolescent non-participants and four experienced educators), who individually classified each visual according to its affective load (positive, negative, or neutral). Only pictures attaining the highest inter-rater agreement in emotional classification were retained to ensure measurement reliability. This iterative evaluation not only enhanced the ecological validity of the emotional representations (see Appendices A-C), but also guaranteed that the final picture set effectively communicated the intended affective states, thereby fulfilling the study's experimental requirements.

### *3.2.2. Testing instruments*

Vocabulary Test. The study employed a systematic vocabulary assessment protocol to evaluate lexical acquisition while controlling for participants' prior knowledge. A pretest was administered before the instructional phase to establish baseline familiarity with the target vocabulary items. Furthermore, the pretest served to identify and control for the variable of prior private education; students who demonstrated knowledge of a significant number of the target words on the pretest were considered to have prior exposure outside the school curriculum, and their data were excluded from the final calculations. The test included all 36 words to be presented during treatment along with four additional distractor words not covered in instruction, allowing for the detection of potential incidental learning effect.

Vocabulary knowledge was measured using a Persian adaptation of Paribakht

and Wesche's (1997) Vocabulary Knowledge Scale (VKS), an instrument widely validated in second language acquisition research (File & Adams, 2010; Yang et al., 2017). The VKS utilizes a five-point scale combining self-reported and demonstrated word knowledge. For the purposes of this study focusing on receptive vocabulary gains, only the first four scale items were implemented. The first option, worth one point, indicated no prior word recognition ("I do not recall encountering this word before"). The second option, worth two points, reflected passive familiarity without comprehension ("I have seen this word before, but I am unsure of its meaning"). The third and fourth options required active demonstration of knowledge through provision of synonyms or translations, with the third option ("I have seen this word before, and I think it means _____") worth three points and the fourth ("I know this word, and it means _____") worth four points when answered correctly.

To ensure scoring validity, participants selecting options three or four only received the corresponding points if their translations or synonyms were accurate. Incorrect responses were scored as two points, equivalent to option two, thus preventing inflation of scores through overestimation of knowledge. This scoring adjustment maintained the integrity of the measurement by prioritizing demonstrated competence over self-assessment.

Post-treatment, vocabulary growth was analyzed using two methods: comparing aggregate scores from pre- and post-tests, and tracking individual word progression across VKS proficiency levels. Of particular interest was the movement of words from lower levels (options one or two) to higher levels (options three or four), indicating substantive vocabulary acquisition. Both pretest and posttest contained identical 40-item sets (36 target words plus four distractors) to ensure measurement consistency. This comprehensive assessment approach provided robust evaluation of treatment efficacy while accounting for baseline knowledge and potential self-reporting biases.

Working Memory Test. The study assessed participants' WMC using the Reading Span Task (Unsworth et al., 2005), which evaluates both storage and processing components. The test was administered in Persian to ensure clarity and avoid language-related confounding effects. Participants, all proficient in Persian, judged the plausibility of sentences while memorizing the initial word of each

sentence. Initial words included nouns, adjectives, or adverbs to ensure variability in the storage aspect of the task.

The test was administered in the school's computer lab. Participants were scheduled in groups of eight, corresponding to the number of available computers/laptops. To ensure proper standardized conditions, each participant completed the test individually under the direct supervision of the teacher. Participants received instructions in Persian about the task, which involved judging sentence meaningfulness and recalling initial words. Two trial sets familiarized participants with the procedure, though these scores were excluded from the final results. The main test consisted of 42 sentences, divided into 12 sets of 2 to 5 sentences each. Each sentence was displayed for 8 seconds, during which participants judged its plausibility by selecting "meaningful" or "meaningless." Half of the sentences were plausible, while the other half were implausible. After each set, participants recalled and selected the initial words from a list of options, with the number of options being three times the number of sentences in the set. Participants had 5 seconds to recall each word, and the answer sheet order differed from the presentation order.

The measure of storage capacity was operationalized as the aggregate count of correctly recalled words (Friedman & Miyake, 2005), whereas processing capacity was measured by the total number of sentences accurately judged. Both storage and processing scores had a maximum possible score of 42, which were converted to z-scores, and their average was calculated to obtain composite scores. This method aligns with prior research emphasizing the need to measure both sentence processing and recall for task reliability (Alptekin & Ercetin, 2009; Waters & Caplan, 1996), providing a comprehensive assessment of WMC by integrating storage and processing dimensions.

### *3.3. Data Analysis*

Data were analyzed to answer the three research questions guiding this investigation, beginning with the calculation of descriptive statistics for both vocabulary and WMC tests. To isolate the impact of the instructional treatment, learning ratios were calculated exclusively for newly introduced words, excluding

the ones participants already knew. This approach, recommended by Suárez et al. (2021), ensured that the assessment focused solely on the acquisition of new vocabulary. For instance, if a participant knew 2 out of 12 words in a set prior to the treatment and later recalled the meaning of 8 out of the 10 new words, their learning ratio was calculated as 80% (8/10), rather than 66% (8/12). This method provided a more accurate measure of the treatment's effectiveness in teaching new vocabulary and participants' learning progress, emphasizing their ability to retain newly introduced content rather than relying on pre-existing knowledge. Each participant had four sets of ratio scores: one overall vocabulary gain ratio and three ratios corresponding to emotional-load sets (positive, negative, and neutral).

To test the impact of emotional load on vocabulary learning (RQ1), a Repeated-Measures ANOVA was conducted, supplemented by a Bonferroni post-hoc test... To examine RQ2, regression analysis evaluated WMC's predictive relationship with vocabulary learning using composite scores. An additional linear regression model analyzed how composite WMC scores related to vocabulary retention ratios across the different emotional load sets to address RQ3. Statistical processing was carried out in SPSS, Version 23.

## 4. Results

The descriptive results detailing participants' scores from the vocabulary pretest and posttest based on the presentation style of vocabulary items—negative, positive, and neutral—are summarized in Table 2. This comparison reveals the ratio of words that participants actually learned versus those they might have learned. Descriptive statistics for the processing and storage aspects of the reading span test are provided in Table 3. The 'processing' column displays sentence judgment task performance, while the 'storage' column presents accurate word recall totals.

**Table 2**

*Descriptive Results of the Vocabulary Pretest and Posttest Scores*

| Test | N | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| Ratio* positive | 348 | 0 | 91.66 | 45.50 | 28.07 |
| Ratio negative | 348 | 8.33 | 100 | 45.01 | 28.13 |
| Ratio neutral | 348 | 8.33 | 90.9 | 42.68 | 28.28 |
| Ratio total | 348 | 2.77 | 97.22 | 44.40 | 25.56 |

* Ratio = ratio of potentially learnable to actually learned meaning of words

**Table 3**

*Descriptive Statistics for the Reading Span Test*

| | Processing | Storage | Composite |
|---|---|---|---|
| Mean | 26.795 | 29.560 | 0 |
| SD | 6.496 | 5.450 | 0.823 |
| Min. | 4 | 6 | -2.323 |
| Max. | 40 | 42 | 2 |

### *4.1. Emotionally-Loaded Pictures and Vocabulary Acquisition*

Prior to conducting the Repeated-Measures ANOVA for RQ1, key assumptions were tested. Levene's test confirmed homogeneity of variances ($p > .05$), while Mauchly's test indicated a violation of the sphericity assumption ($\chi^2(2) = 8.33$, $p = .16$), necessitating the use of the Huynh-Feldt correction ($\varepsilon = .982$).

The ANOVA showed a statistically significant difference in vocabulary retention across the three emotional-load conditions, $F$ (1.964, 91675.55) = 5.981, $p = .003$, with a small effect size (partial $\eta^2 = .017$). This led to the rejection of the null hypothesis, confirming that the emotional loads of pictures significantly influenced word recall.

Post-hoc pairwise comparisons with Bonferroni adjustment demonstrated that participants recalled words significantly better when presented with emotionally positive ($M = 45.50$, $SD = 28.07$) and negative ($M = 45.01$, $SD = 28.13$) pictures compared to neutral pictures ($M = 42.68$, $SD = 28.28$). The difference between positive and neutral conditions was significant ($p = .002$), as was the difference between negative and neutral conditions ($p = .025$). However, no significant difference was found between positive and negative emotional loads ($p = 1.000$), indicating that both positive and negative loads similarly enhanced vocabulary retention compared to neutral loads. Although the effect sizes suggested a slightly

larger impact for positive load (Mean Difference = 2.821) than for negative load (Mean Difference = 2.329) relative to neutral load, this difference was not statistically significant. These findings highlight the facilitative role of emotional content, whether positive or negative, in enhancing vocabulary retention compared to neutral stimuli.

### *4.2. WMC and EFL Vocabulary Retention*

The ability of WMC scores to predict vocabulary retention in EFL learners was tested using simple linear regression. The results revealed a moderate positive correlation between WMC and vocabulary retention, as depicted in Table 4. The regression model was significant [$F(1, 346) = 67.67$, $p < .001$], indicating that WMC is a significant predictor of vocabulary scores. The regression equation, Vocabulary score = 44.404 + 13.045 × WMC composite score, showed that for each one-unit increase in WMC, vocabulary scores increased by approximately 13.045 points ($\beta = 13.045$, $p < .0001$). Approximately 16.4% of the variance in vocabulary retention was explained by WMC ($R^2 = .164$).

**Table 4**
*Regression Results (Total) – The Predictive Power of WMC on Vocabulary Retention*

| | r | p | $R^2$ | F | β | α | Sig. |
|---|---|---|---|---|---|---|---|
| Total score | .404 | .0001 | .164 | 67.666 | 13.045 | 44.404 | .0001 |

### *4.3. Interaction between WMC and Emotional Load of Pictures*

Through the third research question, we aimed to explore any interaction effect between WMC and emotional load of pictures on vocabulary learning. The results of simple linear regression for the predictive power of WMC on vocabulary learning in each emotional load condition; that is, positive, negative, and neutral, are presented in Table 5.

**Table 5**
*The Predictive Power of WMC on Learning Vocabulary with Emotionally-Loaded Pictures*

| | r | p | $R^2$ | F | β | α | Sig. |
|---|---|---|---|---|---|---|---|
| Positive | .423 | .0001 | .179 | 75.439 | 14.433 | 45.505 | .0001 |
| Negative | .329 | .0001 | .109 | 42.128 | 11.260 | 45.013 | .0001 |
| Neutral | .390 | .0001 | .152 | 62.149 | 13.408 | 42.684 | .0001 |

$p < .05$

Significant positive correlations were found between WMC and vocabulary learning across all emotional conditions (all $p < .0001$). For positively loaded pictures, WMC was the strongest predictor, with a regression equation of vocabulary scores = 45.505 + 14.433 × WMC scores, explaining 17.9% of the variance ($R^2 = .179$). For negatively loaded pictures, the regression equation was vocabulary scores = 45.013 + 11.260 × WMC scores, accounting for 10.9% of the variance ($R^2 = .109$). In the neutral condition, the equation was vocabulary scores = 42.684 + 13.408 × WMC scores, explaining 15.2% of the variance ($R^2 = .152$).

Overall, WMC significantly predicted vocabulary learning in all conditions, with the strongest effect for positively loaded pictures, followed by neutral and negative conditions. These findings highlight the role of WMC in vocabulary acquisition, particularly when words are paired with emotionally loaded pictures.

## 5. Discussion

The first research question examined the effects of emotional loads on vocabulary acquisition. Repeated-measures ANOVA revealed that the emotional load of pictures significantly influenced vocabulary gains, underscoring the impact of emotional design on learners' retention. These findings align with prior research demonstrating the advantages of visual aids in enhancing learning (Ramezanali & Faez, 2019; Zhang et al., 2022) and support studies indicating that positive emotions improve learning outcomes (Irrazabal & Burin, 2020; Mayer & Estrella, 2014; Navratil et al., 2018; Schneider et al., 2018, 2020). Specifically, empirical evidence indicates that chromatic characteristics such as high saturation, warm hues, and vibrancy elicit positive affective responses while concurrently boosting learner motivation and attentional engagement (Um et al., 2012; Gong et al.,

2017). In this study, color, along with picture design, played a significant role in eliciting emotional responses, consistent with findings from Ponari et al. (2018, 2020), which highlighted the influence of emotional load on vocabulary acquisition in younger learners. These results reinforce the importance of emotional design principles in multimedia learning.

Contrary to some previous research, which suggested that negative emotions hinder learning (Chung & Cheon, 2020), this study found that learners benefited more from vocabulary items presented through negative visual aids than from neutral pictures. This suggests that negative emotions can also be potent and enhance learning experiences, complementing the established benefits of positive emotions. The neutral stimuli demonstrated limited efficacy in capturing learner attention, underscoring the critical role of affective engagement in instructional design. A similar trend was observed in a study by Kumar and others (2016), where learners in a Multimedia Learning Environment (MLE) showed a slight preference for negative designs, despite no statistically significant differences in learning consequences across emotional conditions. The preference for darker themes in this study, particularly among teenage boys, may reflect common interests in video games and darker aesthetics, suggesting that negative pictures can enhance processing due to their salience.

Overall, the findings support the affective picture superiority effect, indicating that emotionally charged pictures—whether positive or negative—are more memorable than neutral ones. By demonstrating the memory-enhancing effects of emotional stimuli, this research extends current knowledge and offers practical guidance for educators regarding the strategic selection of affectively potent visual materials. The study contributes to understanding how emotional experiences, mediated by WMC, influence vocabulary learning, offering valuable insights for the integration of emotionally resonant materials in EFL instruction.

The study's second research question addressed the role of WMC in L2 vocabulary acquisition. The findings revealed that WMC accounted for 16.4% of the variance in word retention, underscoring its significant role in English vocabulary learning. These results align with prior research demonstrating the influence of WMC on various aspects of FL acquisition, including reading comprehension (Gyselinck et al., 2008), listening comprehension (Satori, 2021),

grammar learning (McCormick & Sanz, 2022), and vocabulary learning (Ansarin et al., 2021; Teng & Cui, 2024).

Our study used a Reading Span Task to assess executive WM, yielding results that differ from earlier research (Engel & Gathercole, 2012; Yang et al., 2017). While prior studies emphasized PTSM's role in vocabulary acquisition for beginners and isolated word retention, executive WM was more influential for advanced learners. Engel and Gathercole (2012) focused on vocabulary size rather than post-instruction retention, and Linck and Weiss (2015) found executive WM more correlated with L2 outcomes in beginners than PTSM. Similarly, our study suggests executive WM is key in early learning stages, regardless of whether the learning is contextualized or decontextualized. (Kempe et al., 2010), though it only explained 16.4% of word retention variance. This suggests that while executive WM plays a role in vocabulary acquisition, other factors may also contribute significantly to the learning process. The findings highlight the complexity of memory systems in FL learning and the necessity for further study to explore the relationship between WMC, instructional methods, and vocabulary retention, particularly in elementary-stage language learners.

The third research question explored the relationship between WMC and vocabulary learning through pictures of varying emotional loads, aiming to identify any interaction effect between WMC and the emotional load of the pictures. The results revealed a medium correlation between WMC and vocabulary retention across all emotional loads, indicating that WMC has predictive power in all three conditions. These findings align with prior research demonstrating the influence of WMC on vocabulary learning (e.g., Perez, 2020; Schüler & Mayer, 2020; Teng, 2024).

A follow-up analysis revealed a significant interaction between emotional loads and WMC, supporting the CATLM. Specifically, WMC accounted for 17.9% and 15.2% of vocabulary acquisition for words presented with positive and neutral emotional loads, respectively. However, its influence diminished to 10.9% for negatively-loaded pictures. This aligns with CATLM, which posits that affective factors often outweigh cognitive abilities in shaping learning outcomes. The enhanced retention associated with positive pictures underscores the theory's claim that emotions can significantly enhance learning experiences. These

findings extend CATLM by highlighting WMC as a critical factor that interacts with emotional influences in the learning process.

The study also addressed the complexity of cognitive load in relation to emotional load. While positive and negative emotions led to better word retention than neutral emotions, negatively-loaded pictures appeared to increase cognitive load, thereby reducing the effect of WMC. This finding is consistent with earlier research (Garrison & Schmeichel, 2018; Spachtholz et al., 2014), which suggests that negative emotions can hijack attention and diminish motivation, impairing memory functioning. Additionally, van Gog (2014) proposed that the positive impact of color on learning may stem from reduced cognitive load rather than enhanced emotional or motivational states. These insights suggest that positive and neutral pictures create a more favorable cognitive environment, supporting WM by enhancing attention and engagement, whereas negative pictures may introduce additional cognitive burdens, such as worry or nervousness.

Within CLT (Sweller et al., 2011), emotionally salient materials may decrease extraneous cognitive load through enhanced learner engagement, thereby optimizing the learning process. Our study provides partial support for this theory, as positively and neutrally-loaded pictures likely imposed a lower cognitive load, allowing learners to allocate more WMC to vocabulary acquisition. On the other hand, negatively-loaded pictures may have increased cognitive load, reducing available WM resources for processing new information. These findings highlight a critical distinction: while most studies focus on incidental vocabulary acquisition within contextual frameworks, this study examined intentional memorization of isolated items, which may explain the observed differences in cognitive load and emotional effects. Overall, the results emphasize the significant role of emotional load in cognitive processing and vocabulary learning, offering valuable insights for instructional design.

## 6. Conclusion

This study investigated the effects of AI-generated pictures with varying emotional loads on EFL vocabulary acquisition, considering the mediating role of WMC. The results demonstrated that the emotional load of pictorial stimuli

significantly influences vocabulary retention, with both positively and negatively loaded pictures yielding stronger learning outcomes than neutral ones. Furthermore, WMC was established as a significant predictor of vocabulary learning, accounting for 16.4% of the variance in retention. A key interaction was observed, whereby the predictive power of WMC was strongest for positive pictures, followed by neutral pictures, and was diminished for negative pictures.

These findings offer significant theoretical and practical contributions. Theoretically, they provide robust empirical support for the CATLM, demonstrating that affective factors can indeed supersede cognitive capacity in learning, particularly in the case of negative emotional stimuli. Practically, the study offers clear guidance for educators and instructional designers, underscoring the importance of selecting emotionally engaging visual media over neutral ones to enhance vocabulary learning for elementary-level learners. It also highlights the pedagogical potential of AI as an efficient tool for generating tailored, affectively potent visual aids. Realizing this potential requires investment in teachers' GenAI literacy and in professional development that addresses multimodal AI tools (Derakhshan et al., 2027), so that educators can select and deploy affectively potent visuals effectively.

Notwithstanding its contributions, this study has several limitations. First, the decontextualized presentation of vocabulary items, though common in the specific educational context, may limit the generalizability of the findings to more communicative learning environments. Second, the vocabulary assessment measured only receptive meaning recall, excluding other essential dimensions of lexical knowledge such as productive use and formal accuracy. Finally, the participant pool consisted exclusively of young male adolescents, and the potential influence of gender on the perception of emotional stimuli was not explored.

Building on these findings and limitations, future research should pursue several promising avenues. Subsequent studies could investigate the effects of emotionally-loaded visuals within more contextualized and communicative task-based frameworks. Employing more holistic assessments that capture productive vocabulary knowledge and grammatical accuracy would provide a more comprehensive understanding of learning outcomes. Furthermore, it is crucial to

explore these dynamics with more diverse demographics, including different age groups and female learners, to examine the role of gender and developmental stage. Finally, research could investigate the longitudinal effects of emotional design on vocabulary retention to determine its efficacy for long-term learning.

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## Appendix A

Positive Pictures





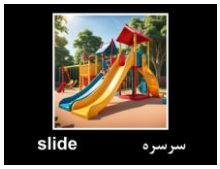





















## Appendix B

Negative Pictures

























## Appendix C

Neutral Pictures

