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Unlocking Metaphorical Minds: Associations of Working Memory and Contextual Support With Iranian L2 Learners' Metaphor Comprehension

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Abstract

Current studies probe the essence of using language that conveys a meaning different from its literal interpretation. Although figurative language has been widely studied, metaphors have received less attention (e.g., Lee & Choi, 2023; Tocaimaza-Hatch, 2019). This study used an online experiment to investigate how working memory (WM) resources are associated with metaphor processing in nonnative sentence comprehension. Sixty teaching-English-as-a-foreign-language (TEFL) students at Shahrekord University participated in the study and were classified as intermediate or advanced according to their scores on the Cambridge Proficiency English (CPE) test. Before the experiment, 100 TEFL postgraduates rated the familiarity of base words from Cardillo et al. (2017). A self-paced reading task, which included critical sentences such as "The gossipy coworker was an amplifier, spreading rumors and gossip," was designed using E-Prime software. Participants' WM (storage and recall) was measured using a computerized test based on Shahnazari's (2013) reading span test (RST) corpus. Data were analyzed using E-Prime and SPSS. Results showed better performance in storage than in recall in the RST. Reading times for metaphorical sentences were slightly faster with metaphorical versus literal context. Higher WM capacity was associated with the quicker reading of metaphorical sentences. These findings suggest that metaphor processing is more cognitively demanding than literal language, and L2 learners with higher WM tend to comprehend metaphors more efficiently.

Keywords: literal meaning, L2 processing, metaphorical meaning, self-paced reading, working memory

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1. Introduction

Metaphors are a fundamental type of figurative language that play a central role in conveying meaning across languages. They are expressions whose meanings arise from the semantic alignment between two seemingly unrelated concepts (Cardillo et al., 2010). Native speakers frequently use metaphors (e.g., Life is a journey) as conceptual tools to communicate complex thoughts, emotions, and abstract ideas that literal language alone cannot fully express (Yin & Yang, 2022). Critically, metaphor comprehension is considered a hallmark of advanced cognitive and higher-level language processing (Tan et al., 2013; Wang et al., 2019), which has important implications for second language (L2) learners' linguistic development (Chen, 2019; Zhou et al., 2022). Moreover, metaphors often introduce novel meanings that challenge literal interpretations, thereby fostering perception and provoking thought (Cardillo et al., 2017). They also serve as cognitive tools for conceptualizing abstract ideas (Gallese & Lakoff, 2005; Jamrozik et al., 2016; Kövecses, 1986, 2005; Lakoff & Johnson, 1980, 1999).

Beyond individual cognition and communication, metaphors are deeply embedded in culture, shaping cultural understanding through conventionalized expressions (Rossetti et al., 2018). As Columbus et al. (2015) note, metaphor processing often relies on memory retrieval of previously learned meanings rather than novel construction. Without metaphor comprehension, individuals risk misinterpreting speakers' intentions by relying solely on the literal meanings of sentences (Mitchell & Crow, 2005).

Language comprehension involves multi-layered processes requiring linguistic knowledge, reasoning, analogy detection, pragmatic understanding, theory of mind (Bryan, 1995, as cited in Karabanowicz et al., 2020), and semantic-syntactic knowledge alongside nonlinguistic cognition (Dzikovska et al., 2008). Despite this foundation, real-time metaphor processing in L2 learners remains understudied. Recent research using diverse offline and online methods (Campbell, 2014, 2017; Citron et al., 2020; Ifantidou & Hatzidaki, 2019; Ikuta & Miwa, 2021; Pambuccian & Raney, 2021; Tang et al., 2022) shows promise but faces limitations due to methodological variability and participant diversity, hindering generalizability. This research seeks to illuminate how L2 learners process metaphors in real time.

Since L2 processing imposes greater mental effort than L1 (Harrington, 1992), it is essential to examine core cognitive capacities like working memory (WM). Language comprehension relies heavily on one's working memory capacity (WMC) by enabling the active maintenance and manipulation of information during processing (Chiappe & Chiappe, 2007; Conway et al., 2008). Numerous studies have linked WMC to L2 reading comprehension (Huang et al., 2022; Indrarathne & Kormos, 2018; Jung, 2018; Molokopeeva & Simard, 2024; Rączy & Orzechowski, 2021; Shin et al., 2019).

Nevertheless, the specific cognitive mechanisms by which L2 learners construct coherent meanings from metaphorical texts remain insufficiently understood. Kintsch's (1998) dual-process model of comprehension—comprising construction (generation of a text base with inferences) and integration (alignment with prior knowledge)—offers a valuable framework for exploring metaphor comprehension complexities (Grabe, 2009; Nassaji, 2002). However, previous studies have not specifically explored how L2 metaphor processing and WMC interact within this model.

To address this void, this study investigates the associations between WMC, contextual support, and Iranian L2 learners' processing of metaphorical sentences. Using response times in a self-paced reading task, this research examines how individual differences in WM and varying contexts relate to metaphor comprehension. The findings aim to contribute to theoretical psycholinguistic models and inform pedagogical practices for supporting metaphor understanding in L2 education.

2. Literature Review

2.1. WM and L2 Processing

The WM model was first introduced by the foundational work of Baddeley and Hitch (1974). Unlike short-term memory, which briefly retains information (Baddeley et al., 2010), WM involves both storage and processing, serving as a foundation for sophisticated cognitive tasks such as processing and analytical thinking (Baddeley, 2000). Their model describes WM as a system with a central executive controlling two subsystems: the phonological loop, which holds auditory information and refreshes it via rehearsal, and the visuospatial sketchpad, which manages spatial and visual data (Baddeley, 2000, 2010; Baddeley & Hitch, 1974; Wang et al., 2021). However, it was criticized for lacking a component integrating information with long-term memory (Hannula et al., 2006; Jonides et al., 2008). To address this, Baddeley later added the episodic buffer, which synthesizes information into coherent chunks, enhancing the model's application in higher cognitive functions (Baddeley, 2000, 2010; Kofler et al., 2018; Kouvatsou et al., 2020).

Daneman and Carpenter (1980) noted that WM retains information for 15–30 seconds without rehearsal. Furthermore, Miller (2020) quantified its limited capacity as about seven plus or minus two (7±2), while Cowan (2012) suggested a capacity of 2–4 chunks excluding interference. Building on this, for measuring WMC, Daneman and Carpenter (1980) formulated the reading span test (RST), which interrupts item presentation with a secondary task; this task reliably assesses WMC and correlates with reading comprehension (Conway et al., 2008). Specifically, this study employs

Shahnazari's (2013) adaptation of the RST, as detailed in the methods section, which is based on Daneman and Carpenter (1980).

Although WM has been considerably studied in learning (Anderson et al., 1996; Baddeley, 2000; Baddeley & Hitch, 1974; Baddeley et al., 2010), its role in L2 learning is more recent. Consequently, given the importance of cognition in information processing, WM has gained attention in L2 research. Specifically, studies have examined WM's role in L2 processing broadly (Karimi & Naghdivand, 2017; Li et al., 2015; Martin & Ellis, 2012; Santamaria & Sunderman, 2015) and specifically in L2 reading comprehension (Chow et al., 2021; Joh & Plakans, 2017; Indrarathne & Kormos, 2018; Jung, 2018; Molokopeeva & Simard, 2024; Shin et al., 2019).

Indrarathne and Kormos (2018) found that WM closely relates to learning target syntactic constructions, underscoring WM's role in language processing. Similarly, Shin et al. (2019) showed that Korean L2 English learners with higher WMC benefited more from background knowledge, improving reading comprehension. Moreover, Molokopeeva and Simard (2024) further found that WM modestly supports text processing at various levels. Collectively, these studies highlight WM's significant influence on language learning and reading comprehension across contexts.

2.2. L2 Metaphor Processing

Metaphor processing is a central pillar of language comprehension, enabling individuals to understand abstract concepts by linking them to more concrete domains (Feng & Zhou, 2021). Corpus analyses have revealed that metaphors are pervasive, constituting approximately one in every seven lexical units in texts. (Steen et al., 2010). The development of conceptual metaphor theory (Kövecses, 2003; Lakoff & Johnson, 2020) has significantly advanced research across linguistics, psychology, and neuroscience (Cienki & Müller, 2008; Langacker, 2016; Menashe et al., 2020; Thibodeau & Boroditsky, 2011).

Gibbs (2013) highlights metaphor as a core focus in language science, although empirical findings remain complex and nuanced. For instance, Stringaris et al. (2007) identified separate neural mechanisms for literal and metaphorical sentence processing, with an emphasis on the left thalamus, whereas Benedek et al. (2014) demonstrated that generating metaphors predominantly activates regions in the brain's left hemisphere. However, hemispheric involvement remains debated; Brownell (2000) supports right hemisphere engagement, whereas Forgács et al. (2014) found no such evidence. Overall, these mixed results underscore the complexity of metaphor processing and motivate exploration of WM's role in Iranian L2 learners' metaphor comprehension.

Contrary to traditional views (Grice, 1975; Searle, 1979) that literal meanings precede metaphorical interpretation, research suggests both can be

processed simultaneously (Gibbs & Coulson, 2006; Glucksberg, 2003). Psycholinguistic studies indicate that some metaphors are processed as rapidly, or even more swiftly, than literal phrases (Gibbs, 2013; Gibbs & Coulson, 2006; Glucksberg, 2008). Although conceptual metaphor theory, pioneered by Lakoff and Johnson (1980), is widely supported as a fundamental cognitive mechanism, debates persist due to conflicting evidence and alternative perspectives (Gibbs, 2017; Steen et al., 2010; Zibin et al., 2024). Gibbs (2013) cautions against a one-size-fits-all model, noting comprehension varies by metaphor type, participants, and methodology. While conceptual metaphor theory posits that abstract understanding arises from concrete experiences, some empirical findings question its universality and ease of processing (Lakoff & Johnson, 1980; Romman, 2025).

Research on metaphor comprehension has focused on native speakers (Kintsch & Bowles, 2002; Mashal et al., 2015) and increasingly on L2 learners, who face unique challenges due to unfamiliar linguistic and cultural contexts (Feng & Zhou, 2021; Ifantidou & Hatzidaki, 2019; Ikuta & Miwa, 2021; Lü et al., 2019; Scucchi, 2022). WM is critical in L2 metaphor processing; interventions targeting WM improve L2 learning and metaphor comprehension (Tsai et al., 2016). Eye-tracking studies show literary metaphors in L2 impose a higher cognitive load, resulting in slower processing than literal expressions (Płużyczka et al., 2024). Furthermore, WMC moderates the effects of input modality and glossing on L2 reading comprehension (Jung, 2021), underscoring WM's essential role in managing metaphorical constructs and enhancing L2 comprehension.

2.3. The Present Study

The crucial role of WM in L2 acquisition (Liu et al., 2024; Tadayyon & Farrokhi, 2025; Teng, 2024; Wallace, 2022) and reading comprehension (Chow et al., 2021; Joh & Plakans, 2017; Shahnazari, 2023) is well recognized. Interest has grown in WM's role in L2 figurative reading (Kim, 2023; Yin & Yang, 2022) and specifically metaphorical reading comprehension (Yin & Yang, 2022). However, few studies have precisely examined WM's role in L2 metaphor comprehension, with varied findings and limitations in WM assessment. It also remains unclear how processing modes affect the WM–metaphor comprehension relationship.

Despite growing evidence that WM is associated with L2 learning and figurative language processing, research on how WM relates to contextual support during real-time metaphor comprehension remains limited and methodologically inconsistent. By focusing on Iranian L2 learners and using robust WM assessment, this study provides new insight into the cognitive factors linked to metaphor understanding, thereby broadening theoretical and practical perspectives in second language research. Therefore, this study

examines the associations between WM capacity, contextual support, and metaphor comprehension during online processing, addressing the following research questions:

1. How do Iranian L2 learners comprehend metaphorical expressions in different contextual supports (metaphorical vs. literal) during online processing?
2. Is there a significant association between WM capacity and Iranian L2 learners' processing of metaphorical sentences during online reading?

3. Method

3.1. Participants

The participants comprised 60 (22 males and 38 females) university students who had been majoring in TEFL at Shahrekord University, Iran. They were split into two groups of intermediate (mean age = 21.03, *SD* = 2.59) and advanced (mean age = 24.50, *SD* = 2.57) L2 participants based on the English section of a practice Cambridge Proficiency: English (CPE) test (Cronbach's α = 0.68). Their L1 was Persian, and they were without language or reading disorders and had vision that was normal or adequately corrected. Moreover, they had never resided in a country where English is the primary language, which was a condition for participating in this study. Written informed consent was obtained from all participants following Shahrekord University Research Ethics Committee guidelines, and a participation fee was provided.

3.2. Materials and Instruments

3.2.1. WM Test

The WM assessment employed an RST adapted from Shahnazari (2013), which effectively assesses both the storage and processing aspects within WM to calculate an overall WMC score. Complex span tests like the RST have been validated as reliable WMC measures in L1 (Daneman & Carpenter, 1980) and L2 contexts (Erçetin & Alptekin, 2013; Leeser, 2007; Shahnazari, 2023). Since WM functions independently of language (Miyake & Friedman, 1998), using the Persian RST helps distinguish WM capacity from L2 proficiency. The test verified good internal reliability (Cronbach's α = 0.83 for processing, 0.74 for recall).

The RST comprised 64 Persian sentences with general content, avoiding technical terms. Ten sentences served as practice. Sentences were active, affirmative, and contained 13–16 words. Half were semantically anomalous, created by rearranging words to form nonsensical statements (Chun & Payne, 2004), ensuring participants processed meaning rather than rote memorization.

Administered individually via PowerPoint in a controlled setting, each sentence appeared for seven seconds. Sentences ended with unique verbs,

reflecting Persian's subject-object-verb (SOV) syntax, consistent with RST designs in Japanese (Osaka & Osaka, 1992) and German (Roehr & Gánem-Gutiérrez, 2009). Verbs within sets were semantically unrelated. Sentences were sorted into sets containing three to six items.

Participants read sentences aloud, judged their coherence, and retained the final word of each sentence. When prompted to recall (indicated by three hash marks and a two-second audio signal), they recalled final words in order to avoid recency effects (Baddeley & Hitch, 1993). The test began with three sentences, increasing to six, with slide times adjusted from 12 to 18 seconds. Scoring awarded one point per correct judgment and one per accurate recall, totaling 54 points. The composite score of processing and recall provided a stable WMC measure, following procedures from Daneman and Carpenter (1980) and Leeser (2007).

3.2.2. Word Rating Task

To collect ratings for familiarity with the words used in the metaphorical sentences, a word set comprising 120 English base words was developed based on the database created by Cardillo et al. (2017). This questionnaire aimed to collect the ratings of familiarity for each word. Accordingly, the developed questionnaire was administered to a total of 100 TEFL postgraduate participants, including M.A. students, Ph.D. candidates, and M.A. and Ph.D. holders. Each base word's familiarity was assessed using a 5-point semantic differential scale, with ratings from 1 (unfamiliar) to 5 (familiar) (Osgood et al., 1957).

3.2.3. Self-Paced Reading Task Materials

The stimulus set for the self-paced reading activity comprised 40 metaphorical sentences: five practice sentences and 35 experimental sentences. The metaphorical expressions incorporated into the experimental sentences for the reading-time task closely resembled those employed in the sentence completion task. The segment-by-segment presentation technique, as used in Altmann and Steedman's (1988) second experiment, was adopted because pilot results from Pan and Felser (2011) showed that L2 learners had difficulty understanding stimulus passages when information was presented sequentially, word by word. This finding suggested that a word-by-word presentation would likely lead to a high rate of comprehension errors, resulting in an unacceptable amount of unusable data. Consequently, each target sentence was divided into six segments to present meaningful multi-word units, rather than single words or isolated clauses, as segmentation at this level has been shown to reduce cognitive load (Liu, 2024) and facilitate more natural processing in sentence comprehension tasks, as designated by the slashes below:

- The gossipy coworker / was / an amplifier / spreading / rumors and gossip/ relentlessly.

All experimental sentences were counterbalanced across the two modes (metaphorical vs. literal), then randomized and mixed. To ensure participants attended to meaning, each experimental item was directly succeeded by a yes/no comprehension question.

3.3. Procedure

A word rating questionnaire was completed via online links in a Google Form. The participants were notified that they would receive a list of words and were instructed to rate each word based on familiarity. All consent details and task instructions were given in written English. The instructions made clear that there were neither right nor wrong responses, and participants were encouraged to rely on their initial impressions without spending too much time deliberating on their ratings, as these initial responses were of primary importance. Also, some examples were provided to verify the participants' understanding of the directions, using five words that did not appear in the list. After evaluating the mean value, 35 base words in Cardillo et al.'s (2017) stimuli database corresponding to the 35 sentence pairs (metaphorical/literal, five for practice, and 30 for the main experiment) were selected.

To estimate WMC, the RST was pilot tested with five L2 participants prior to the main experiment to identify possible issues with the test. The test was taken individually and in a PowerPoint. After reading each sentence, participants had to decide whether it made sense and verbalize their judgments aloud, while the researcher recorded their responses via a voice recorder. Next, the participants were asked to retain the last word of each sentence until the entire set was completed. At that point, they recalled the sentence-ending words aloud while the researcher recorded their answers.

Two weeks after taking the RST—due to participant availability, not methodological design—L2 participants completed the online self-paced reading task assessing their comprehension of metaphorical expressions, with stimuli selected based on the database's word ratings. The experiment was carried out in a quiet room dedicated to psycholinguistic studies at Shahrekord University. The participants attended individually and were instructed to read sentences attentively and as quickly as possible. The self-paced reading task began with practice trials designed to acquaint participants with the procedure, followed by a two-minute break before the main task commenced. Participants regulated the pace of the presentation by pressing the spacebar whenever they were ready to view the subsequent segment that substituted the earlier one on the display. After each sentence was completed, a *yes/no* question appeared on the desktop, posing a question related to the sentence they just read, and the

correct response was either in line with literal interpretation or metaphorical interpretation of the sentence.

3.4. Data Analysis

The response time data were used for statistical analysis, and the L2 participants' response accuracy to the end-of-trial questions was obtained by using E-Prime 2. They were then transferred to Microsoft Excel to eliminate the randomized orders that E-Prime programmed. E-Prime was used for stimulus presentation and analysis, providing millisecond-level timing accuracy as verified by the manufacturer's specifications. Finally, IBM SPSS Statistics version 26 was used for both descriptive and inferential analysis. After checking the data for accuracy, the mean reaction times for each subject and trial question for all six segments were calculated separately. Reaction time outliers, defined as responses exceeding ±2 standard deviations from the group mean within each condition, were eliminated prior to analysis to enhance data reliability and reduce noise, following common practice in cognitive research (Berger & Keifer, 2021).

4. Results and Discussion

4.1. Results

The composite score for WM was taken by adding up the processing and storage scores of the RST. The mean percentage of L2 participants' performances for these components was calculated, as displayed in Table 1:

Table 1

Descriptive Statistics for the Participants' Span in the Reading Span Test

	N	Min	Max	Mean	Std. Deviation
Processing	60	28	54	43.42	6.89
Recall	60	12	51	31.08	7.86
Composite WM	60	20.5	51	37.25	5.85
Total	60	41	102	74.50	11.70

Table 1 shows that the average score for processing is 43.42, while the average score for recall is 31.08. The mean composite score is 37.25 out of 54, which shows the average WM range of the participants in this study. To specify the level of WM among the participants, their total score was considered. Looking at the mean of the total score, which is 74.50, the participants' scores

of 75 or above were considered a high memory span, and those below 75 were considered a low memory span. Furthermore, an independent samples t-test (Table 2) was conducted to determine if the observed differences between the two groups (high and low working memory) were statistically significant in relation to proficiency level. The analysis revealed no significant difference in memory span between advanced participants (M = 76.43, SD = 10.21) and intermediate participants (M = 72.57, SD = 12.90) (t = -.51, p = 0.61, df = 58).

Table 2

Independent Samples t-Tests for the Participants' Differences in High WM and Low WM

		Levenes Test for Equality of Variances		**T-test for Equality of Means**				
		F	*Sig.*	*t*	*df*	*Sig.* (2-tailed)	Mean Difference	Std. Error Difference
Total	Equal variances assumed	.85	.35	-.51	58	.61	-.06	.13
	Equal variances not assumed			-.51	57.98	.61	-.06	.13

To address research question 1, an online self-paced reading experiment was carried out to investigate nonnative readers' interpretation preferences. Participants provided correct answers to the post-trial questions, 50.67% (range: 33-77%), indicating that more than half of them were accurately processing the stimulus items. Table 3 displays the participants' average reading times per segment for each interpretation preference after the dataset was trimmed.

Table 3

Mean Reading Times (MRTs) and Corresponding Standard Deviations by Segment and Condition

Region	(RT1) *The gossipy coworker*	(RT2) *was*	(RT3) *an amplifier*	(RT4) *spreading*	(RT5) *Rumors and gossip*	(RT6) *relentlessly*
Literal interpretation	1439 (856)	1168 (483)	1216 (449)	1922 (521)	1307 (349)	1591 (746)
Metaphorical interpretation	1526 (844)	1220 (560)	1219 (440)	1914 (889)	1446 (416)	1578 (553)

As recorded in Table 3, the mean RTS in all segments except segments 4 and 6 took a little longer processing time for metaphorical interpretation than for literal interpretation. Additionally, the means plots in Figures 1 and 2 indicate that segment 4 is a critical region in this experiment, as the mean RTs diverge when participants reach the phrase located in the fourth segment. Additionally, segment 5 is the study's primary emphasis. The RTs of the two contexts can be seen in Figures 1 and 2.

Figure 1

Means Plot for Participants' RTs in Items Involving Metaphorical Interpretation

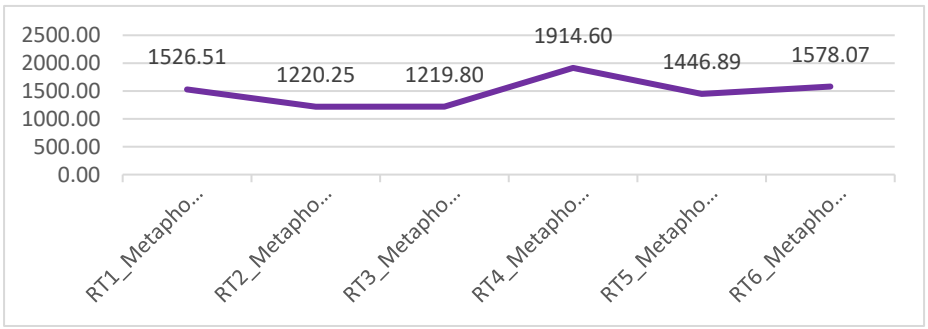
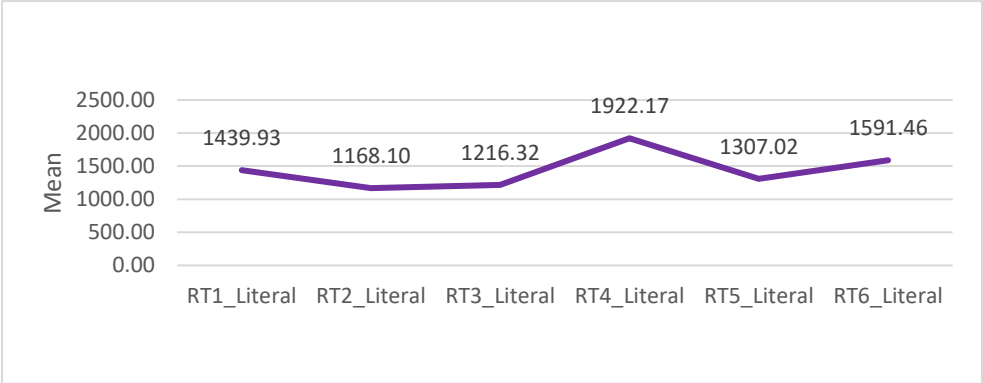


Figure 2

Means Plot for Participants' RTs in Items Involving Literal Interpretation



A paired-sample t-test (Table 4) was carried out to compare the participants' online processing of metaphorical sentences in both literal and metaphorical interpretation contexts for each individual segment. There were marked differences in mean response times in the first (t = 2.75, p = .00), second (t = 1.97, p = .05), and fifth (t = 6.73, p = .00) segments.

Table 4

Results of Paired Sample t-Tests in All Segments Per Condition for All Experimental Items

		Mean	Std. Deviation	Std. Error Mean	*t*	*df*	*Sig.*
Pair 1	Metaphorical_RT1 Literal_RT1	86.57	243.67	31.45	2.75	59	.00
Pair 2	Metaphorical_RT2 Literal_RT2	52.14	204.69	26.42	1.97	59	.05
Pair 3	Metaphorical_RT3 Literal_RT3	3.47	160.91	20.77	.16	59	.86
Pair 4	Metaphorical_RT4 Literal_RT4	-7.57	327.07	42.22	-.17	59	.85
Pair 5	Metaphorical_RT5 Literal_RT5	139.86	160.97	20.78	6.73	59	.00
Pair 6	Metaphorical_RT6 Literal_RT6	-13.38	309.31	39.93	-.33	59	.73

To answer research question 2, to uncover whether the differences in reading times might be related to the variations in participants' WMC, an independent-samples t-test with *Memory* as an independent variable and *RTs*

mean as the dependent variable was conducted. The preliminary analysis showed no violation of normality assumptions. There were significant differences for the participants with high WM (M = 1192.62, SD = 349.81) and low WM (M = 1829.43, SD = 127.17) (t = -4.52, p = .00, df = 36.01). The degree of the difference in the means was large (eta squared = .26). Table 5 depicts the results.

Table 5

Results of Independent Samples t for the Effect of WM on Metaphor Processing

		Levene's Test for Equality of Variances		T-test for Equality of Means				
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	Mean Difference	Std. Error Difference
RT-Mean	Equal variances assumed	5.73	.02	-1.04	58	.30	-7.58	7.30
	Equal variances not assumed			-1.01	45.60	.31	-7.58	7.49

4.2. Discussion

Our findings indicate that the type of contextual support—metaphorical versus literal—was associated with differences in the online processing of metaphorical sentences, suggesting context may play a constructive role in meaning-making. This pattern implies that L2 learners appear to utilize contextual cues to navigate the complexity of metaphorical language, likely involving the integration of multiple semantic and pragmatic elements. The increased cognitive effort involved in processing metaphorical expressions compared to literal ones reflects the layered nature of metaphor comprehension, where both literal and metaphorical meanings must be constructed and reconciled. These associations align with prior research showing that referential context is related to nonnative speakers' interpretation of ambiguous and figurative language (Pan et al., 2015; Beck & Weber, 2020; Jankowiak et al., 2017), further suggesting that context is important for meaning construction in L2 metaphor processing (Scucchi, 2022). These results are consistent with interactive models of metaphor comprehension, such as Kintsch's (1998) Construction-Integration model, which emphasizes that multiple information sources—context, knowledge, and linguistic factors—jointly contribute to interpretation. Our findings further confirm that

contextual cues may be central in real-time meaning construction, as theorized in cognitive linguistics.

In this study, context appears to play an active, ongoing role that is associated with differences in real-time comprehension. L2 learners may evaluate and re-evaluate contextual information to resolve ambiguity and construct coherent interpretations. This process is cognitively demanding because it involves the simultaneous activation and inhibition of multiple potential meanings, requiring efficient coordination of semantic and pragmatic knowledge. The present findings suggest that the ability to utilize contextual cues is associated with more effective metaphor comprehension in L2 learners, and may have implications for instructional practices that emphasize context-rich learning environments. This pattern is consistent with conceptual metaphor theory (Lakoff & Johnson, 1980), which posits that metaphor understanding is rooted in mapping between conceptual domains and requires integration of contextual and experiential knowledge.

However, processing metaphorical language remains cognitively demanding for nonnative speakers, who often face challenges integrating multiple cues during real-time comprehension (Nakamura et al., 2020). These challenges may be associated with factors such as greater reliance on gestures to compensate for linguistic difficulties (Drijvers et al., 2019), limitations in cognitive resources (Felser, 2019), and a tendency to prioritize surface-level cues over deeper discourse analysis (Patterson et al., 2017). Such findings underscore that, despite contextual facilitation, metaphor comprehension in L2 learners involves complex cognitive coordination and may benefit from instructional interventions that raise awareness of figurative language use (Martín-Gilete, 2022). This suggests that teaching strategies should not only focus on vocabulary or grammar but also explicitly address the cognitive demands and strategies involved in processing figurative language, potentially incorporating multimodal cues like gestures to support comprehension.

This study's chief contribution is the demonstration that WMC was significantly associated with metaphor processing efficiency. Participants with higher WM exhibited faster and more accurate responses to metaphorical sentences, indicating a potent association between WM capacity and the cognitive demands of complex language comprehension (Chow et al., 2021). This finding accentuates the value of WM as a cognitive resource that supports the integration of multiple information sources, including contextual cues and lexical-semantic knowledge, during metaphor interpretation. While Chow et al. (2021) also highlight that reading anxiety may modulate this relationship, this factor exceeded the boundaries of the present study and remains an important avenue for future research. Moreover, Liu et al. (2024) emphasize that attentional factors alongside WM influence language learning, suggesting that metaphor comprehension depends on the interaction of multiple cognitive

processes. This broader cognitive perspective contrasts with the current study's focus on WM alone and points to the need for future investigations into how attentional strategies and environmental factors jointly impact L2 metaphor processing. Understanding these interactions could lead to more targeted cognitive and instructional interventions to support L2 learners with varying cognitive profiles. This link between WMC and comprehension supports Baddeley and Hitch's (1974) model, which identifies WM as essential for integrating and manipulating information in complex tasks (Baddeley, 2000; Conway et al., 2008).

Complementing these behavioral insights, Yin and Yang (2022) provide neuroimaging evidence demonstrating that WM capacity modulates neural mechanisms underlying metaphor and metonymy comprehension in bilinguals. Although their bilingual sample differs from the current study's monolingual L2 learners, their findings highlight the neural basis of WM's role in figurative language processing and suggest that language background and cognitive architecture interact to shape comprehension strategies. This neurocognitive perspective enriches our understanding of the multifaceted characteristic of metaphor processing and invites further interdisciplinary research.

Taken in aggregate, the results imply that metaphor comprehension in L2 learners is associated with the convergence of contextual support, cognitive capacity, and linguistic proficiency. This integrated view advances the field beyond isolated factors and stresses the importance of caring about cognitive-linguistic associations in both research and pedagogy. While effective metaphor comprehension may involve the dynamic interplay of multiple factors, the present correlational findings do not establish causality, and future research should clarify the nature of these relationships.

5. Conclusion and Implications

This study affords important insights into the cognitive mechanisms associated with metaphorical language processing among Iranian L2 learners, supporting key aspects of Kintsch's (1998) dual-process model of comprehension. The longer processing times observed for metaphorical compared to literal expressions were associated with increased cognitive demands required to construct and integrate multiple layers of meaning. WMC showed a significant association with metaphor comprehension, as individuals with higher WMC demonstrated comparatively more efficient performance. These findings suggest that WM may be an important cognitive resource in managing the complex demands of figurative language processing, aligning with theoretical perspectives that emphasize cognitive capacity alongside linguistic proficiency.

By situating WM within the broader framework of L2 metaphor processing, this research addresses an important gap in psycholinguistic studies and highlights the value of considering cognitive-linguistic associations in figurative language comprehension. The results recommend that language instruction could gain advantages from strategies designed to enhance learners' cognitive resources and attentional control, and from providing context-rich reading experiences that can scaffold metaphor interpretation.

Ultimately, these findings have practical implications for those involved in language instruction and curriculum development aiming to facilitate L2 learners' metaphor comprehension and reading skills. Instructional practices that strengthen cognitive capacities and leverage contextual cues could foster more effective and nuanced language acquisition, helping learners navigate figurative language in diverse settings.

Despite these contributions, a few noteworthy limitations deserve mention. The relatively small and homogeneous sample of Iranian L2 learners may restrict how broadly the findings apply to other L2 learners with miscellaneous linguistic and cultural backgrounds. The exclusive use of Persian in the RST to assess WM may introduce language-specific biases, potentially affecting the measurement of cognitive capacity and its relationship with metaphor processing. Furthermore, this study focused primarily on WM and did not incorporate other relevant cognitive factors, such as attentional control, reading anxiety, or prior knowledge, which have been shown to influence figurative language comprehension (Chow et al., 2021; Liu et al., 2024). Although the CPE's internal consistency ($\alpha = .68$) is slightly below ideal benchmarks, we acknowledge this as a limitation and advise interpreting proficiency-related results with appropriate caution due to possible measurement error. Lastly, the cross-sectional nature of the study constrains the ability to examine developmental changes in metaphor comprehension and WM capacity over time. To resolve these limitations, future studies should involve greater numbers and wider diversity among participants, employing multilingual cognitive assessments, integrating additional cognitive and affective variables, and adopting longitudinal designs to capture developmental trajectories in metaphor processing. Although associations between WM, context, and metaphor comprehension were found, other explanations, such as cultural familiarity or L1 processing strategies, may also have influenced results. Future research should directly examine these factors.

These findings suggest that teaching strategies like guided metaphor analysis, explicit discussion of contextual cues, and activities that strengthen working memory (such as rehearsal or chunking) could enhance L2 learners' metaphor comprehension. Future research should also investigate how cognitive factors such as attentional control and prior knowledge, in addition

to working memory, shape metaphor understanding over time through longitudinal and intervention studies.

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