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The Influence of Visual Movement Priming on Novel and Conventional Metaphor Comprehension: An Eye-Tracking Study

Authors

Çağatay Çora[1] *

Affiliations

[1]Master's Program in Cognitive Science, Graduate School of Social Sciences Yeditepe University, Istanbul, 34755, Turkey.

*To whom correspondence should be addressed; E-mail: cagatay.cora@yeditepe.edu.tr.

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Abstract

Understanding metaphors is key to language processing. This research examined the influence of visual priming on action metaphor comprehension, addressing a critical gap in understanding cognitive mechanisms behind language comprehension. Based on the principles of embodied cognition, the research investigated how visual priming impacts comprehension of action metaphors, both novel and conventional, and literal action verbs. An experimental design was adopted, with eye-tracking technology used to capture eye movements as participants read metaphor-rich sentences. We executed a repeated measures ANOVA to analyze various eye movement metrics such as initial reading durations, the length of forward fixations, and the times spent on initial rereading. This was done to assess the influence of priming across varying categories of text. Results highlighted a significant effect of visual priming on first-pass reading times, especially for novel action metaphors, and forward-fixation and first-pass rereading times for all text types. The priming effects were confined to the target sentence. The study emphasized the facilitating role of visual priming in metaphor comprehension, hinting at the involvement of perceptual and sensorimotor systems in language comprehension. It also sets the stage for further research into the neural underpinnings of metaphor comprehension and broader priming modalities.

Keywords

Embodied cognition; eye-tracking; metaphor; visual priming

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INTRODUCTION

1.1.Background

Metaphors are a common feature in language and thought, crucial in communicating and making sense of the world. The purpose of this dissertation is to meticulously explore the impacts of visual movement priming on deciphering both novel and traditional metaphors, all through the perspective of embodied cognition. Embodied cognition is a theory suggesting that thinking is not just in the brain but is also based on the body's interaction with the environment (Barsalou, 2008; Lakoff & Johnson, 2003).

Studying how metaphors are understood is an area that has intrigued researchers from various fields like psychology, linguistics, and philosophy. The interest lies in how essential metaphors are in human thinking and communication. Metaphors are generally categorized into two main types: novel metaphors and conventional metaphors. While conventional metaphors are simple to understand since they are a common aspect of language, novel metaphors need more mental effort to comprehend because they are unfamiliar (Bowdle & Gentner, 2005; Glucksberg, 2001).

Embodied cognition is a theory that says our thinking processes are connected to our physical experiences, not just mental concepts. According to this theory, when we understand language, including metaphors, we mentally simulate experiences that are associated with words, phrases, and utterances. This study aims to see if visual movement priming can make it easier to understand metaphors and will help shed light on how embodied cognition and language processing are connected.

Eye-tracking is a method that helps gather data about how we process language by watching eye movements (Rayner, 1998). It has been used to study various aspects of how metaphors are processed (Akkök, 2018; Frisson & Pickering, 1999; Guerra & Knoeferle, 2014; Olkoniemi et al., 2016) but the effect of visual priming with movement on understanding metaphors have not been explored extensively in the previous literature.

The central objective of this thesis is to delve into the manner in which visual movement priming influences the interpretation of these metaphor type. Visual movement priming is when seeing moving visuals affects how we process related information afterwards.

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The present study utilizes eye-tracking methodology in an attempt to investigate the nature of this impact.

In this study, participants are prompted to watch videos containing movements conceptually related to the contents of a selected set of metaphors before reading texts that have been specifically designed to contain those metaphors. To give an example, when a metaphor about pushing is involved in the task, participants get exposed to a video in which a figure pushes an object. By analyzing eye movements, this study aims to see if watching these videos makes it easier to understand metaphors.

We consider the present study to be a significant one not only because of the potential theoretical contributions it could make but also because of its practical contributions. Specifically, understanding how we process metaphors can help in education by developing better teaching methods for language skills.

In conclusion, this thesis aims to understand how visual movement priming affects the understanding of metaphors. The findings could be used for future research and have broader implications for teaching, language processing models, and therapy.

1.2.Metaphor Comprehension

In communication, metaphors act as bridges, adeptly connecting abstract or complex concepts to concrete, familiar terms. Their presence in a language is elegant and functional, guiding us through the nuances of human expression. The cognitive task of mapping metaphorical language onto literal meanings lies at the heart of understanding metaphors.

One of the famous theoretical models of figurative language comprehension is the Standard Pragmatic View (Grice, 1975; Searle, 1979). The chief assertion of this perspective is that conversational maxims are modulated to aid the understanding of metaphorical and other non-literal languages. These principles declare that the speaker must be insightful, pertinent, truthful, and articulate in their communication . Grice further explains the figurative language comprehension process in three steps. At the commencement of this process, the literal interpretation of the expression is initially processed. "Following this, the discord between the literal interpretation and the context

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is identified. Finally, an alternative, non-literal interpretation of the phrase is contemplated(Grice, 1975; Searle, 1979). As the comprehension of non-literal language necessitates the involvement of a more complex mechanism, according to this view, the processing time for a figurative sentence should be longer than its literal counterpart. Given that the original purpose of the conventional pragmatic approach was to offer a holistic philosophical explanation of the process through which a figurative meaning of an utterance is generated, it does not account for individual differences (Bach, 2006).

The Direct Access View, put forward by Gibbs (1994), is an alternative theory that pertains to figurative language processing. Unlike the Standard Pragmatic View, the Direct Access View asserts that there is no need for distinct cognitive functions to understand or produce figurative language compared to literal language. When the context surrounding a statement endorses a non-literal understanding, individuals can comprehend the meaning of the figurative expression as seamlessly as they would a literal one. Consequently, the time it takes to process a figuratively framed statement does not have to be longer than that needed for the same statement in a literal context. However, the theory also posits that if the context does not pave the way for an immediate understanding of the figurative meaning, individuals are likely to face challenges in assimilating the figurative language with the context. This difficulty manifests as extended reading times for figurative language compared to literal language (Gibbs & Colston, 2012).

Research on metaphor processing provides evidence in favor of this view, demonstrating that the processing speed of metaphorical sentences can be on par with that of a literal sentence (Mcelree & Nordlie, 1999). In this study, participants were shown sentences that could have one of three interpretations – literal, metaphorical, or nonsensical – The specific term utilized in the sentence can influence this. For example, the sentence "Some tunnels/mouths/lamps are sewers" could be interpreted differently based on word choice. The findings indicated that the time taken to process metaphorical sentences was not longer than that for literal sentences. Interestingly, despite the comparable processing times, participants were more likely to regard metaphorical sentences as lacking meaning.

Further endorsement for the Direct Access View is derived from a study by Inhoff, Lima,

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and Carroll (1984), which scrutinized eye movements as participants read metaphorical and literal sentences. They discovered that if an extensive context preceded metaphorical sentences, they were processed just as swiftly as their literal counterparts. However, when preceded by a brief context, the reading times for metaphorical sentences were longer. This implies that a sufficiently supportive context is critical in facilitating the processing of metaphorical expressions without additional time compared to literal expressions.

With regard to the types of metaphors, we find two broad categories that elegantly illustrate the spectrum of human creativity: conventional and novel metaphors. Imagine conventional metaphors as old friends; they are familiar and comfortably integrated into everyday language. The ease with which we interpret them stems from the well-worn paths they have tread in our minds (Gibbs Jr., 1994). Their novel counterparts, however, are akin to strangers with intriguing stories. These creative expressions challenge our cognitive faculties as we actively forge new links between the metaphor and its intended meaning (Bowdle & Gentner, 2005).

These two theories briefly outlined above pay no attention to the issue of conventionality in figurative utterances. One theory that addresses the effects of conventionality is the Graded Salience View (Giora, 1997, 2003). This perspective posits that the prominence of the utterance is a decisive factor in decoding its meaning. In light of this, literal meaning is usually the most salient meaning, which is why it is accessed first. However, an alternative meaning is searched if there is a contrast or a discrepancy between the context and the literal interpretation. This searching process culminates in longer processing durations for non-literal utterances (Bohrn et al., 2012; Giora et al., 1998). Giora further explains (2003) that contextual information can help activate the nonsalient meaning, facilitating the comprehension of figurative utterances. For example, in the case of conventional metaphors, figurative meaning should be accessed first as it is the most salient meaning. Therefore, literal meaning may not even be considered at all. This concept argues that a well-known figurative phrase is processed just as quickly, if not faster, than its literal equivalent (Giora, 1997, 2003). Similarly, it is worth noting that non-familiar (novel) metaphors can also possess salient meanings in specific contexts.

Pexman, Ferretti, and Katz conducted a study (Pexman et al., 2000) investigating the

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reading times for metaphorical statements that were either familiar or unfamiliar. They observed that the participants read familiar metaphors more quickly than unfamiliar ones. In a similar vein, Blasko and Briihl (1997) conducted an eye-tracking study to investigate the processing of familiar versus unfamiliar metaphors and discovered that familiar metaphors resulted in shorter eye-fixation durations than unfamiliar ones. Intriguingly, the research also demonstrated that a preceding context that was thematically associated with the metaphor facilitated the processing of novel metaphors, as indicated by the eye-fixation durations. Additionally, brain imaging studies (Bohrn et al., 2012) have indicated that novel metaphors trigger activation in a distinct set of brain regions compared to familiar metaphors, which lends support to the Graded Salience View.

Following this view, familiarity became a key element in metaphor comprehension research. Glucksberg (2001) proposed his Dual-Process Model of metaphor comprehension, suggesting that metaphors are processed through direct comparison or categorization. Conventional metaphors, he posited, are processed through categorization. Picture them as members of a familiar category, where the literal meaning is just one of many instances that the metaphorical term can exemplify. On the other hand, novel metaphors are processed by direct comparison, in which characteristics of the source and target domains are contrasted to determine the intended meaning.

Adding a dynamic twist to this narrative, Bowdle and Gentner (2005) unfurled the 'career of metaphor' hypothesis, which posits that metaphors undergo a conventionalization process over time. When a metaphor first appears, it is processed as a novel metaphor through structural alignment and comparison between the source and target domains (Gentner & Wolff, 1997). However, as the metaphor becomes more conventional and familiar, it is processed more readily using categorization mechanisms (Giora, 2003). This hypothesis highlights the dynamic nature of metaphor processing and the role of familiarity in shaping the cognitive demands of metaphor comprehension.

Decoding the cognitive mechanisms that play a role in processing novel and traditional metaphors is essential for gaining insight into the intricacies of human language and communication (Gibbs Jr., 1994; Giora, 2003). Researchers can better understand how

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individuals interpret and make sense of metaphorical language in various contexts by investigating these mechanisms. More recent investigations have further underscored the significance of incorporating both cognitive and contextual aspects in the understanding of non-literal language processing (Giora, 2003), thereby broadening our comprehension of metaphor interpretation and its foundational cognitive processes.

1.3.Embodied Cognition and Metaphor Comprehension

Embodied cognition suggests that cognitive processes are rooted in the body's engagements with the world and accentuates the role of sensorimotor experiences in molding mental representations (Barsalou, 2008; Lakoff & Johnson, 1980). Fischer and Zwaan's (2008) paper, "Embodied Language: A Review of the Role of the Motor System in Language Comprehension," argues that language comprehension involves the simulation of motor experiences related to the meaning of the language being processed. They review research from neuroscience and psychology that supports the idea of embodied language, suggesting that abstract concepts are grounded in sensory-motor experiences. This perspective aligns with Lakoff and Johnson's (Lakoff & Johnson, 1980) concept of embodied metaphors.

Lakoff and Johnson's (1980) seminal work, "Metaphors We Live By," introduced the concept of embodied metaphors, arguing that many metaphors are not just linguistic expressions but are deeply rooted in our bodily experiences. They proposed that the way we think, reason, and understand abstract concepts is fundamentally shaped by our physical experiences in the world. For example, the metaphor "time is money" reflects the cultural and experiential association between the allocating time and using financial resources.

Barsalou (2008) further developed the embodied cognition framework by introducing the Grounded Cognition Theory. Grounded cognition posits that cognitive processes, including those involved in metaphor comprehension, are grounded in sensorimotor experiences and neural systems responsible for perception, action, and introspection. This viewpoint implies that metaphor understanding is not solely an abstract procedure, but also involves the activation of relevant sensorimotor representations.

Casasanto and Boroditsky (2008) provided empirical support for the role of

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embodied cognition in metaphor comprehension by demonstrating the influence of spatial experiences on the understanding of time-related metaphors in English speakers. Their study showed that these speakers exhibited patterns of thinking about time-based on their language's spatial metaphors, specifically examining the influence of spatial orientation (left-to-right, right-to-left, or top-to-bottom) in processing temporal information.

In a separate study by Boroditsky (2001), the effect of language on thinking about time was investigated among English and Mandarin speakers. This study showed that Mandarin speakers, known for using more vertical metaphors for time, were more inclined to conceptualize time vertically compared to English speakers, who typically use horizontal spatial metaphors. The distinct patterns of thinking about time between the two language groups demonstrate the influence of spatial metaphors on temporal cognition.

In a related study, Gibbs (2006) investigated the role of embodied simulation in understanding metaphors. Participants were asked to interpret metaphors while performing congruent or incongruent bodily actions. The results showed that performing congruent actions facilitated metaphor comprehension, providing evidence for the embodied nature of metaphor processing.

The embodied cognition perspective provides a compelling framework for understanding the cognitive mechanisms involved in metaphor comprehension. By recognizing the role of sensorimotor experiences in shaping mental representations, this approach sheds light on the intricate relationship between the body, mind, and language in processing both novel and conventional metaphors. These empirical studies (Boroditsky, 2001; Casasanto & Boroditsky, 2008; Gibbs & Colsont H, 2007; GIBBS, 2006) further reinforce the significance of embodied experiences in shaping the cognitive processes underlying metaphor comprehension.

1.4.Eye-tracking Research on Metaphor Processing

Eye-tracking research has emerged as a pivotal methodology in elucidating the cognitive processes entailed in reading and information processing, particularly in the domain of metaphor comprehension. By measuring eye movements, including fixations and saccades, scholars can acquire invaluable data about real-time cognitive processes

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subsumed under language comprehension (Rayner, 1998).

One of the salient advantages of utilizing eye-tracking in research is its capacity to non-intrusively record momentary cognitive processing during reading, thereby facilitating natural reading behavior (Rayner, 1998, 2009). This stands in contrast to alternate methodologies, such as the probe reaction time or the moving window paradigm, which are restrictive in offering singular processing time measurements and may inadvertently perturb normal reading behavior (Giora et al., 1998; Ivanko et al., 2004; Pexman et al., 2000; Rayner, 1998). In eye-tracking, fixations - instances where the eye remains relatively static while absorbing information - can be bifurcated into those transpiring during the initial reading of a sentence and subsequent regressions that are triggered by later portions of the text. The former category can be further subdivided into forward fixations, focused on unread segments of the sentence, and first-pass re-readings, where fixations revert to antecedent portions of the sentence (Liversedge et al., 1998). Forward fixation times encompass gaze durations on sequential words, indicative of word recognition efficacy in the context of a sentence (Rayner, 1998, 2009), whereas first-pass rereading is postulated to denote comprehension challenges (Hyönä et al., 2003; Liversedge et al., 1998). The high-resolution data procured via eye-tracking is particularly germane for dissecting sentence-level phenomena such as metaphors, where the region of interest frequently encompasses a phrase or sentence rather than an isolated word (Refer to Table 1).

The examination of metaphorical language processing is a common theme across many eye-tracking studies. As an example, Frisson and Pickering (Frisson & Pickering, 1999) probed into the processing of metonymic expressions and discerned comparable levels of processing complexity between metonymic and literal expressions. Although this study did not exclusively target metaphors, it underscored the potency of eye-tracking as a powerful tool for investigating diverse forms of figurative language.

Moreover, individual differences in non-literal language understanding have been analyzed through eye-tracking. Olkoniemi et al. (2016), for instance, discovered that the processing of sarcasm and metaphor levied discrete cognitive demands on readers, with reader attributes such as working memory capacity and need for cognition exerting a pronounced influence on figurative language comprehension. This revelation

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accentuates the imperative to consider individual disparities in metaphor processing research.

Moreover, the interplay between visual context and language comprehension has been probed via eye-tracking. A seminal study by Guerra and Knoeferle (2014) investigated the ramifications of spatial proximity between words and objects on reading times for sentences conveying similarity or dissimilarity between abstract nouns. The findings attest to the consequential impact of visual context on language comprehension and underscore its relevance to the exploration of visual priming in metaphor processing.

Lastly, the role of familiarity as a determinant in metaphor comprehension has been highlighted through eye-tracking studies. For instance, a study by Akkök and Uzun (2018) examined metaphor processing in the Turkish language, concentrating on prototypical and peripheral concepts and metaphors with varying degrees of familiarity. The findings indicated that peripheral concepts and less familiar metaphors necessitated a longer processing duration.

In summation, eye-tracking research has proven instrumental in investigating the cognitive processes implicated in metaphor comprehension. The research has yielded invaluable insights into the multifaceted interplay between language, cognition, and sensorimotor experiences and the factors influencing the processing of both novel and conventional metaphors. Additionally, eye-tracking studies have illuminated the influence of cultural and linguistic contexts in shaping metaphor comprehension.

1.5.Visual Priming and Metaphor Comprehension

Visual priming, as a subcategory of priming, refers to the process by which exposure to a visual stimulus influences the processing of a subsequent, related stimulus. In the context of metaphor comprehension, visual priming can potentially affect the way individuals understand metaphorical language by activating relevant mental representations and facilitating the mapping between the source and target domains of the metaphor (Zwaan & Taylor, 2006).

Zwaan and Taylor (2006) conducted a series of experiments to investigate the role of motor resonance in language comprehension, which is closely related to the embodied cognition perspective. They posited that understanding language involves simulating the described

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actions and events in the mind, a process that draws on the same neural systems responsible for perception and action. Their study demonstrated that participants were faster at verifying sentences when primed with images depicting objects that matched the orientation implied by the sentence. These findings suggest visual priming can impact language comprehension by activating relevant sensorimotor representations consistent with the embodied cognition framework.

Stanfield and Zwaan (2001) explored the mental representation of object orientation in language comprehension, focusing on perceptual symbol systems. In their study, participants were presented with sentences that implicitly suggested a particular orientation for an object. For example, "the ladder was leaning against the wall" would imply a vertical orientation for the ladder. After reading the sentence, participants were shown pictures of the object in either implied or different orientation. The results showed that participants were faster at recognizing the picture when its orientation matched the one implied by the sentence, providing evidence for the role of perceptual symbol systems in language comprehension.

Overall, the role of visual priming in language comprehension is a complex and multifaceted topic that continues to be explored in current research. Visual priming can impact metaphor comprehension by activating relevant mental representations, thereby facilitating the mapping process between the source and target domains. Investigating the effects of visual priming on metaphor comprehension can provide valuable insights into the cognitive mechanisms underlying metaphor processing and the role of embodied cognition in shaping our understanding of metaphorical language.

1.6.Pariticpants

60 Yeditepe University (Turkey) students (32 women, M_{age}= 23.5, SD_{age}= 4.9) participated in the study. All were native speakers of Turkish and had a normal or corrected-to-normal vision. A written informed consent form was provided to the participants before the experiment.

1.7.Materials

Each participant read 24 paragraphs on a computer screen (font: Calibry (body), font size: 24 pt) and their eye movements were recorded. Eight paragraphs included conventional action metaphors, eight novel metaphors, eight literal utterances about the

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action. he sequence of the video clips and passages was randomized for each participant to counterbalance potential order effects. Participants used the spacebar to change the paragraphs after reading them.

Each paragraph had a specific structure which consisted of an introductory part, a critical context, a target sentence and a spillover section. The critical context part was used in framing the target sentence by giving critical information about the context. An examplestory is shown in Table 2.

1.8.Norming

The content used in the experiment underwent tests for familiarity and metaphoricity. Data collection was performed using an online survey tool (Surveyplanet, www.surveyplanet.com). None of the respondents in this preliminary test took part in the actual eye-tracking experiment. The survey for familiarity and metaphoricity was undertaken by twenty native Turkish speakers ranging in age from 18 to 53 (8 females, Mean Age = 26.2, Standard Deviation Age = 6.32).

Participants saw the target sentences, and they evaluated them on a scale from 0(never) to 10(very often). They were asked how often they have seen/used the sentence; they were also asked to give ratings for how metaphorical the utterances are, between 0 and 10. Experimental material was chosen according to these tests; they all had similar familiarity and metaphoricity scores.

After choosing the action verbs/metaphors, contextual material was prepared. All the words in the target sentence had similar frequency scores. Familiarity scores were gathered from The Word Frequency Dictionary of Written Turkish (Göz, 2020).

Another set of twenty-one native Turkish speakers between the ages of 18 and 56 (12 women M_{age} = 29.42, SD_{age} = 7.51) named the videos with the verbs they can think of. The videos were shown one at a time, and the participants were asked to come up with any number of verbs they could think of. Statistical summary of the total number of verbs associated with the videos are also given in Table 3.

1.9.Procedure

Each participant was tested individually, and upon their arrival, they were told that the experiment was a reading assessment test. The exact objective of the experiment was explained after the experiment was over. At the beginning of the experiment, the eye-

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tracking device was introduced, and the procedures for the experiment were explained. The main task had two parts: video presentation and text reading. For each of the 24 trials, participants watched a short video clip (approximately 5-10 seconds in length) depicting an action verb (e.g., "pushing", Figure 3). Following the video, they were presented with a passage that contained a novel action metaphor, a conventional action metaphor, or a literal verb. After reading the passage, participants were given five seconds to press the spacebar if the video and the text matched.

The presentation order of the video clips and passages was randomized across participants to control for potential order effects. Additionally, the matching of videos to passages was counterbalanced such that four novel metaphors, four conventional metaphors, and four literal verbs were matched with their corresponding videos, while the remaining paragraphs were mismatched.

RESULTS

2.1.Data Preparation

Fixations shorter than 50 ms were meticulously handled in the data cleaning process. Specifically, if the distance between the fixations was over 1°, they were merged with a nearby fixation; otherwise, they were removed from the data. This step was crucial to ensure the accuracy and reliability of the eye-tracking data.

2.2.Sentence-Level Measures

For the target sentences, containing either Novel Action Metaphor, Conventional Action Metaphor, or Literal Action Verb, sentence-level measures were computed from the eye movement data. The first-pass reading duration, a key metric in this study, was determined by adding up the fixation durations that occurred within the sentence during the first-pass reading. Importantly, the first-pass reading time was broken down further into the duration of forward fixations and times spent rereading. We also calculated the look-back fixation time, which represents the total duration of fixations returning to the sentence from different parts of the text following the first-pass reading. Another metric, termed as the look-from fixation duration, was calculated as the total duration of look-back fixations that

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originated from the sentence itself. All these reading time measures were systematically analyzed for the different text types.

2.3.Statistical Analysis

The eye movement data were subjected to repeated measures ANOVA, wherein text type (Novel Action Metaphor, Conventional Action Metaphor, Literal Action Verb) and priming (primed, unprimed) were treated as within-subject factors. Following the significant ANOVA result, post hoc tests using Tukey's HSD test were performed to control for multiple comparisons.

2.4.Measurements

First Pass Reading Times

The repeated measures ANOVA unveiled a significant main effect of priming ($p < .05$), indicating that priming had a widespread impact on first-pass reading times. Moreover, there was a significant interaction between text type and priming ($p < .05$), suggesting that the effect of priming varied across different types of texts. Post-hoc tests revealed that first-pass reading times were significantly shorter for all text types when they were primed, with the most substantial reduction observed for Novel Action Metaphor texts (68 ms) compared to Conventional Action Metaphor (32 ms) and Literal Action Verb texts (29 ms). These results are illustrated in Figure 3.

Forward-fixation times

The data showed a significant main effect of priming ($p < .05$) on forward-fixation times, coupled with a significant interaction between text type and priming ($p < .05$). It is noteworthy that Novel Action Metaphor texts exhibited the most significant reduction in forward-fixation times (38 ms) when primed, as illustrated in Figure 4. This suggests that priming was particularly effective for the novel metaphors.

First-pass rereading times

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There was a significant main effect of priming observed for first-pass rereadingtimes. However, the interaction between text type and priming was not significant, as shown in Figure 5.

Look-back fixation times

Analogously to the first-pass rereading times, a significant main effect of priming was observed for look-back fixation times, but no significant interaction between text type and priming emerged, as depicted in Figure 6.

Reading of the Spillover Region and Critical Context

No significant effects of priming or text type were detected in the spillover region or the critical context. This suggests that the influence of priming was specific to the target sentence and did not extend to adjacent regions.

DISCUSSION

3.1 Summary of Findings

The present study aimed to explore the effect of visual priming on metaphor comprehension in reading, with a particular emphasis on action metaphors. Our findings offer significant insights into the interaction between visual priming and metaphor processing and extend our understanding of the cognitive mechanisms underlying metaphorical language comprehension.

Drawing on the framework of embodied cognition, the results of this study reveal that visual priming, through the presentation of short video clips, impacts the comprehension of novel and conventional action metaphors and literal action verbs. This aligns with Zwaan and Taylor (2006) and Stanfield and Zwaan (2001), who emphasized the role of perceptual and sensorimotor information in language comprehension.

The most salient finding of this research is the differential impact of visual priming on first-pass reading times for novel action metaphors compared to conventional action metaphors and literal action verbs. The significant reduction in first-pass reading times, particularly for novel action metaphors, supports to the hypothesis that visual priming activates relevant mental representations, facilitating the mapping process between source and target

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domains. This suggests that sensorimotor information might play a critical role in understanding novel metaphors, which is consistent with the embodied cognition perspective. However, these may as well be the effect of visual priming alone rather than sensorimotor involvement.

Lacey, Stilla, and Sathian (2012)found that sensory experience could influence the interpretation of metaphors. Our study builds upon this and shows that visual priming has a more pronounced effect on novel action metaphors compared to conventional ones. This can be attributed to the fact that novel metaphors require more cognitive resources for mapping, as they lack established connections in the mental lexicon.

Furthermore, the significant main effect of priming on forward-fixation times and first-pass rereading times across different text types indicates that visual priming enhances processing efficiency during reading. However, the absence of significant effects in the spillover region or critical context implies that the impact of visual priming is localized to the target sentence. "This suggests that visual priming expedites the immediate integration of information into the mental depiction of the sentence.

3.2 Theoretical Implications

The findings of this research enrich the burgeoning field of literature on embodied cognition and metaphor understanding. By demonstrating the differential impact of visual priming on the novel and conventional metaphors, the study advances our understanding of the cognitive mechanisms involved in metaphor processing and underscores the importance of perceptual and sensorimotor systems in language comprehension.

In light of the results, it is imperative to consider the intersection of the Dual Process Model of Metaphor Comprehension, the Career of Metaphor Hypothesis, and the Gradient Salience Hypothesis. The Dual Process Model posits that metaphor comprehension involves both analytic and holistic processing. Our findings, which indicate that priming significantly impacts the first-pass reading times, particularly for novel action metaphors, suggest that visual priming may be influencing the analytic processing component by providing a frame of reference that aids in mapping the source and target domains. Meanwhile, the Career of Metaphor Hypothesis, suggests that metaphors evolve from a novel to a more conventional state, which may explain the observed differential effects of

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priming on novel versus conventional metaphors. This could imply that conventional metaphors are processed more holistically due to familiarity, whereas novel metaphors demand more analytic processing. Furthermore, the Gradient Salience Hypothesis, which proposes that the salience of the metaphor's constituents influences interpretation, can be tied into the current findings. The priming could be modulating the salience of the metaphor's components, thereby affecting the comprehension process. The more substantial reduction in first-pass reading times for novel metaphors might be indicative of a heightened salience granted by the visual primes, facilitating the analytic processing required for these metaphors. Collectively, these theories offer a comprehensive framework to elucidate the cognitive underpinnings of metaphor comprehension and the observed effects of visual priming on this process.

Moreover, this study also has implications for psycholinguistics and cognitive psychology, as it demonstrates the importance of considering multimodal inputs (e.g., visual information) in understanding how people process language.

3.3 Implications for Learning and Language Disorders

The implications of this study extend beyond pure theory and hold potential relevance for understanding and addressing metaphor comprehension difficulties in individuals with learning and language disorders, such as those on the autism spectrum. These individuals often grapple with metaphor comprehension due to characteristics associated with their disorders, including deficits in central coherence, theory of mind, and executive functions (Kalandadze et al., 2018).

The efficacy of visual priming, as indicated by our findings, could be instrumental in developing intervention techniques to improve metaphor comprehension for this population. Considering that visual processing is often a relative strength in these individuals, particularly those on the autism spectrum (Samson et al., 2015), incorporating of visual primes might aid their understanding and assimilation of metaphors.

Although they were related to metaphor generation rather than processing, some studies found that the creation of conventional and novel metaphors is dependent on varying cognitive capabilities (Bowdle & Gentner, 2005). In light of these, another study was conducted on children with autism spectrum disorder (Kasirer & Mashal, 2016), in which

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they found out that children with ASD had difficulties in comprehension and generation of conventional metaphors compared to their typically developing (TD) peers. Interestingly, no differences were found between the groups for novel metaphor comprehension. Children with ASD also were more successful in creating novel and creative metaphors. These studies indicate different mechanisms involved in metaphor processing for novel and conventional metaphors, which might explain the differences in reading times in our study.

Nonetheless, while our findings open up a potentially promising avenue for enhancing metaphor comprehension in individuals with learning and language disorders, it is crucial to approach these implications with due caution. These implications are currently inferential, extrapolated from the results of a study not directly aimed at this population. Consequently, further empirical examination is warranted to ascertain the viability and efficacy of visual priming as a strategy for improving metaphor comprehension in these individuals. Future research could probe into whether the application of visual primes can facilitate metaphor comprehension in these populations and determine the conditions under which such enhancement is optimal. Within this larger research agenda, a specific focus on autism might provide intriguing insights, given its unique relevance to metaphor comprehension.

3.4 Limitations and Future Research

While offering insightful observations, the present study exhibits certain limitations that pave the way for future research directions. First, it's imperative to note that the current investigation was confined to action metaphors and incorporated a diversity of actions. However, this extensive approach may have glossed over nuanced differences in processing distinct types of actions, such as bodily, mechanical, or interpersonal actions. Future research could narrow the focus and investigate specific classes of action metaphors separately to delve deeper into the intricacies of metaphor comprehension.

Moreover, the current study did not explore the neural underpinnings of action metaphor comprehension and the possible involvement of sensorimotor systems. Understanding the neural mechanisms and activations associated with metaphor processing can provide more comprehensive insights into the cognitive processes involved. Future

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research should consider employing neuroimaging techniques, such as fMRI or EEG, to examine the neural bases of metaphor comprehension, particularly to discern if there is any sensorimotor involvement in understanding action metaphors.

Additionally, the present study utilized visual movement priming, which, though valuable, does not encapsulate the entire spectrum of priming modalities. Implementing real movements as primes could offer another dimension of understanding the facilitation effects on metaphor comprehension. This would require participants to engage in physical movements corresponding to the action metaphors before or while processing them. To facilitate this, mobile eye-tracking devices could be employed, allowing for the combination of physical movement with eye movement data. Such an approach could uncover novel interactions between physical experiences and cognitive processes in metaphor comprehension and potentially augment the ecological validity of the findings.

CONCLUSION

In conclusion, this study reveals that visual priming has a pivotal role in facilitating metaphor comprehension, especially for novel action metaphors. These findings lend support to the theory of embodied cognition and highlight the integral role of the interaction between perceptual information and linguistic processing in metaphor comprehension. However, while the results suggest a possible involvement of sensorimotor systems in the processing of metaphorical language, this is merely a hypothesis that is extrapolated from the findings. The current study does not provide direct evidence for this as it does not investigate the neural mechanisms underpinning metaphor comprehension. Therefore, the potential sensorimotor involvement, suggested by the observed priming effects, necessitates further scrutiny through future research incorporating neuroimaging techniques.

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Tables and Figures

Tables

Table 1

Description of eye movement measures used in this study

Measure	Description
First-pass reading time	The total fixation duration on the target sentence before shifting attention to the next one.
Forward-fixation time	The total fixation duration that occurs on the target sentence's unread portions during the first pass reading.
First-pass rereading time	The total fixation duration that was made before going on to the following sentence during the target sentence's re-inspection.
Look-back fixation time	The cumulative fixation length for glances that shift back to the target sentence from different sections of the text, following the initial reading.
Look-from fixation time	The combined length of fixations that originated from the target sentence.

Table 2

Example experimental material – translated from Turkish

	Text Type	
Text Region	**Conventional Metaphor**	**Novel Metaphor**
Introduction	Ahmet always struggled to understand math.	Batu had a brilliant idea for a startup.

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Critical Context	One day, his teacher explained some of these concepts using visual aids and graphs.	He was excited to share his vision with the team, but they were hesitant to get on board.
Target Utterance	Ahmet was able to grasp the concept.	Batu kept pushing his idea.
Spillover Region	The importance of visualization helped him with his grades.	Eventually, the team saw the value behind the idea.

Table 3

Statistical summary of the familiarity scores and the total number of verbs associated with a video

	Novel Action Metaphors		**Conventional Action Metaphors**		**Literal Verbs**	
	M	SD	M	SD	M	SD
Familiarity score	2.81	2.13	3.84	1.78	3.89	1.54
Total number of verbs	1.24	.30	1.26	.25	1.22	.34

Table 4

Statistical summary of the fixation duration measurements

		Text Type											
		Novel Metaphor				**Conventional Metaphor**				**Literal Verb**			
		Primed		**Unprimed**		**Primed**		**Unprimed**		**Primed**		**Unprimed**	
Text	**Measure**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**

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region													
Target sentence	**First-pass reading time**	541	305	619	294	498	319	530	288	510	316	539	292
	Forward fixation time	330	229	368	224	333	217	357	222	302	217	324	218
	First-pass rereading time	290	219	322	221	286	212	305	220	279	185	296	186
	Look-back fixation times	561	420	594	484	539	446	560	507	528	468	548	502
Spillover Region	**First-pass reading time**	398	412	412	457	396	405	406	449	397	385	404	428
	Look-back fixation time	362	362	393	359	359	351	381	357	352	344	372	350

Figures

Figure 1

Trial block of the experiment

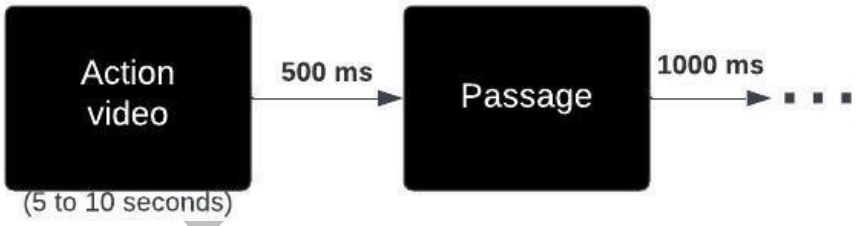

Figure 2

Example passage with the region of interest highlighted

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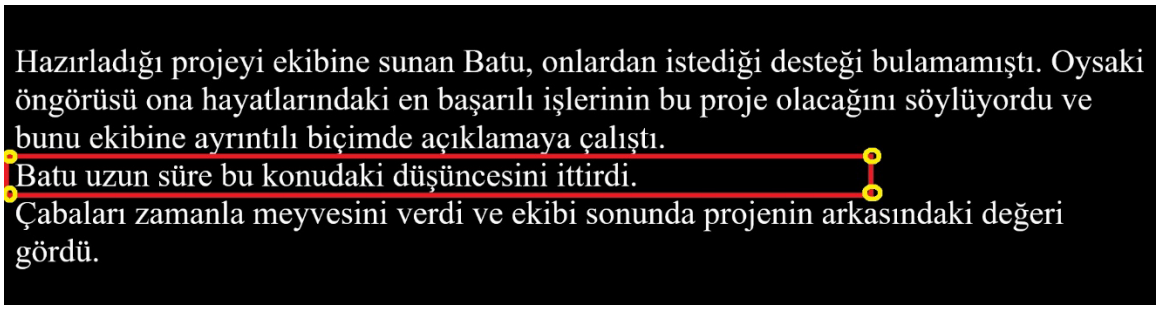

Figure 3

An example screenshot of a video (Çağatay Çora, 2023)

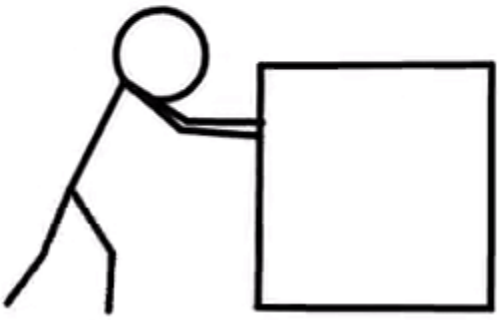

Figure 4

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Impact of the nature of text on the first pass reading duration.

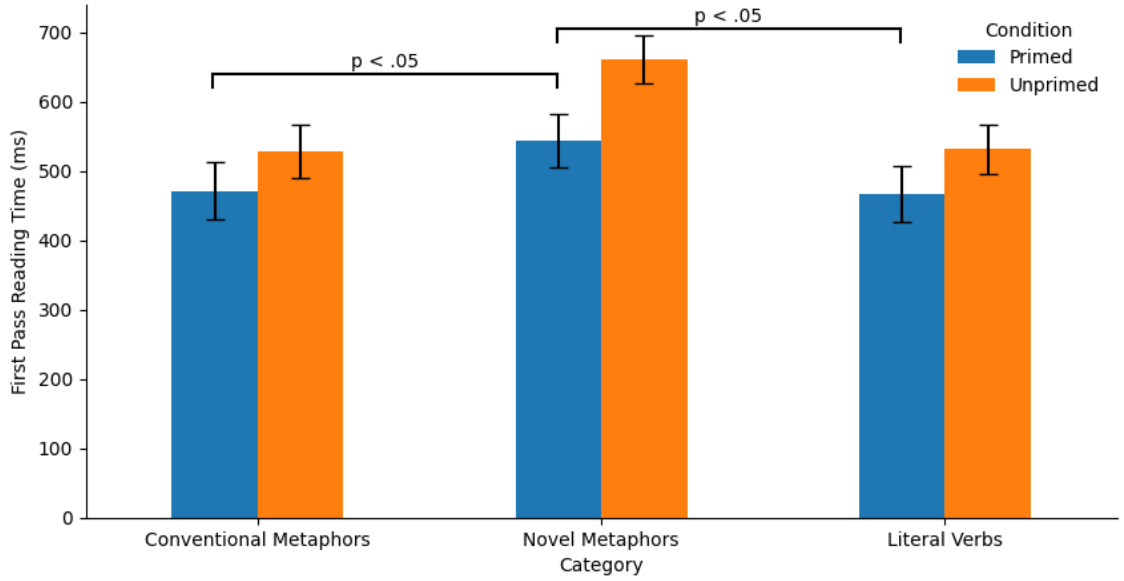

Figure 5

Impact of the nature of text on the Forward-fixation Time

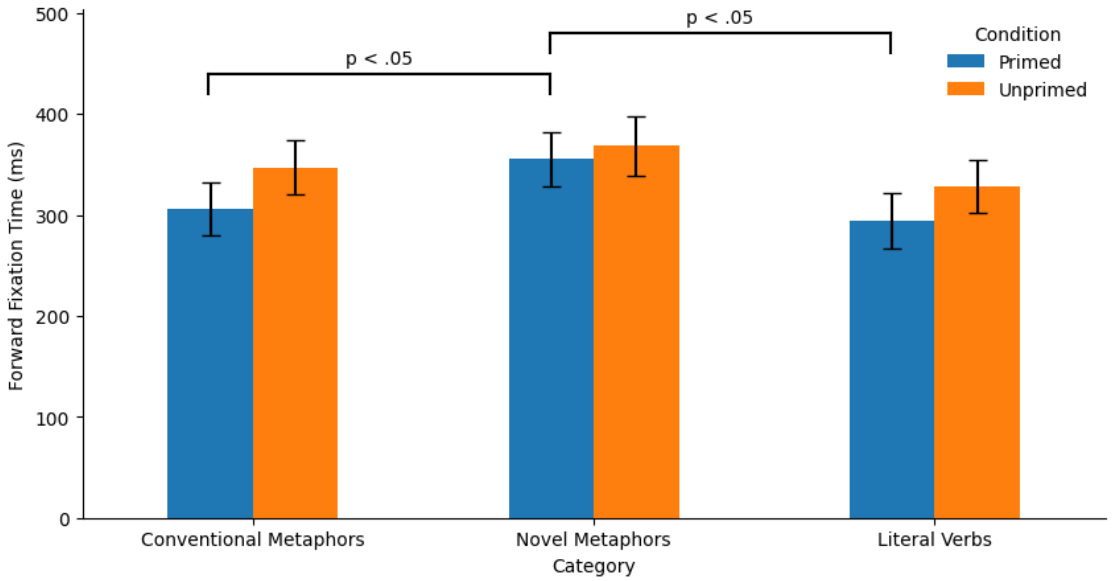

Figure 6

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Impact of the nature of text on the First Pass Rereading Time

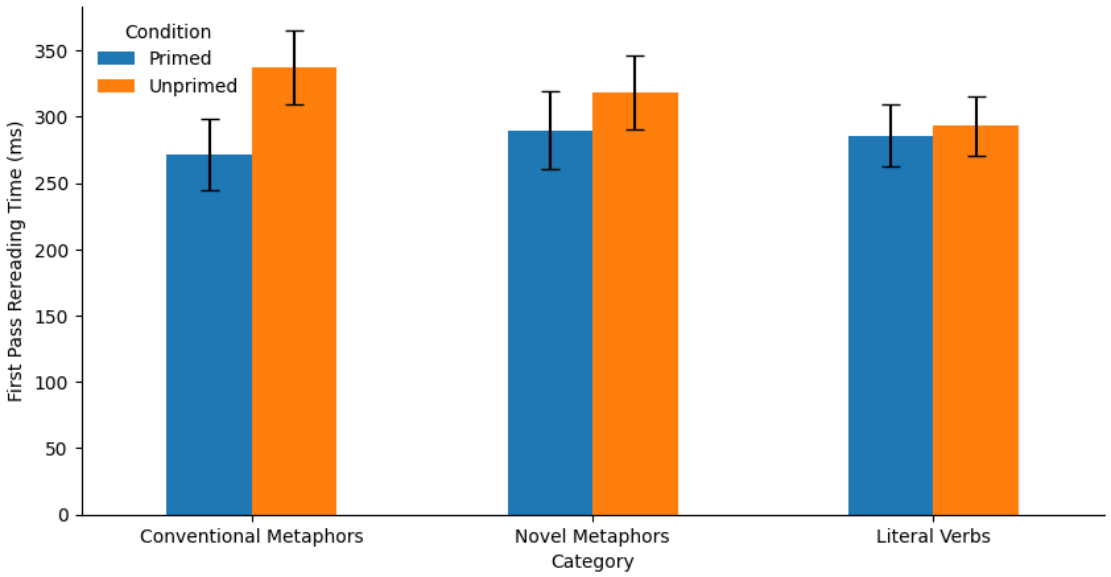
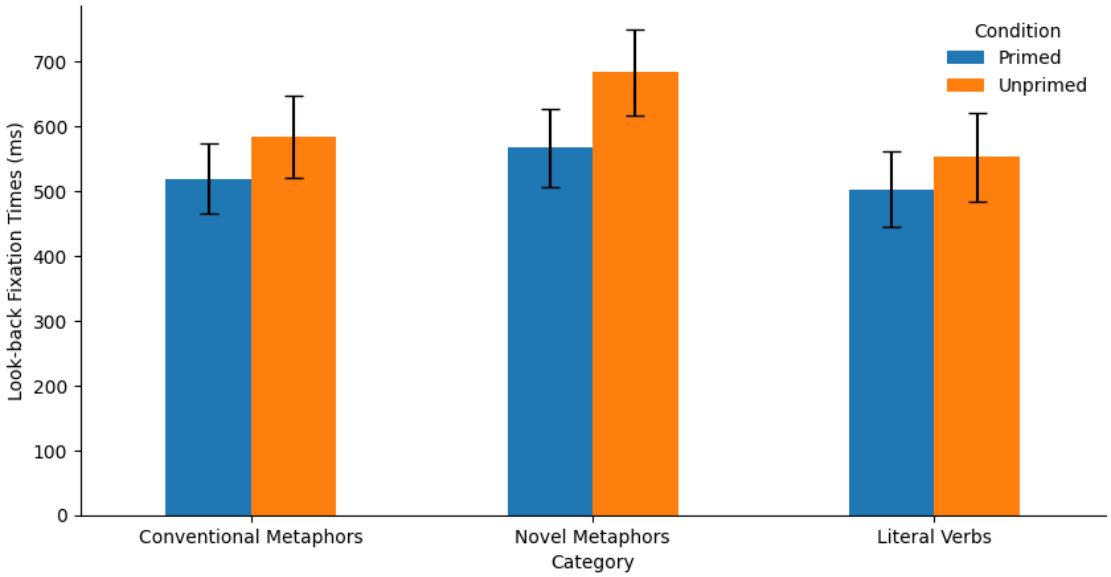


Figure 7

Impact of the nature of text on the Look-back Fixation Times



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