

RESEARCH ARTICLE

Is Metaphoric Anaphor a Tough Nut to Crack? A Systematic Review of Referential Metaphor Processing Research

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Abstract:

This article presents a systematic review of eleven experimental studies on metaphoric anaphor processing. Beyond predicating specific properties to a subject (e.g., “Peter is an angel”, where *angel* conveys a set of possible features, such as kindness and helpfulness), metaphors can simultaneously fulfill a referential function, re-mentioning an established discourse entity through a metaphorical noun, in this case called a ‘metaphorical anaphor’ (e.g., “That angel is always willing to help”, where *angel* also serves to refer to Peter). Given the experimental evidence that a higher processing cost is involved for referential metaphors relative to their literal counterparts and predicative metaphors, a special nature of metaphorical anaphors has been proposed. In this review paper, we offer a comprehensive overview of the recurrent research topics and findings on metaphorical anaphor by adopting a structured procedure of study identification and selection. We systematically compare the methodological and stimuli design variables to highlight their implications for processing and experimental outcomes. The review concludes with a discussion on the procedural costs of referential metaphors and a preliminary framework advocating for the development of an interactive model of processing.

Keywords: metaphoric anaphor, nominal metaphor, anaphoric metaphor, metaphor comprehension

1. Introduction

The cognitive cost associated with metaphor processing has been investigated in a substantial number of psycholinguistic experiments, particularly in comparison to literal language. In 1990, a study published by Gibbs stood out against the backdrop of the extensive evidence in the literature at the time in favor of the direct access model. One key idea of this model is that, in supportive contexts, understanding metaphorical language does not require any more effort than understanding literal language (e.g., Gerring & Healy, 1983; Gildea & Glucksberg, 1983; Glucksberg et al., 1982; Inhoff et al., 1984; Ortony et al., 1978; Keysar, 1989; Shinjo & Myers, 1987). Gibbs’s investigation, which reported on three experiments on the relative difficulty in processing metaphoric referential



descriptions, metonymic referential descriptions and literal anaphors, showed longer reading times for the final sentences in the metaphoric reinstatement condition (e.g., “The creampuff didn’t even show up”, where *creampuff* refers to a weak boxer) than in the literal reinstatement condition (e.g., “The fighter didn’t even show up”). These results marked the turning point for referentiality to be considered as a potentially relevant dimension modulating metaphor processing cost.

The distinctive finding by Gibbs (1990) is believed to stem from one key difference, namely metaphor being used referentially rather than predicatively (e.g., Onishi and Murphy, 1993; Carston and Yan, 2023). The meta-analysis performed by Carston and Yan (2023) revealed that the experimentalists who provided support for the direct access model mainly used predicative “A is B” constructions in their target stimuli (e.g., “Her marriage was an icebox” or “His smile was a razor” in Shinjo & Myers, 1987). Onishi and Murphy (1993) made the first attempt to compare, albeit indirectly, the processing cost of the predicative metaphor with the processing cost of the referential metaphor. While the results of Experiment 1 and Experiment 2 showed longer reading times for the metaphoric sentences (e.g., “My princess won’t eat”, where *princess* refers to a cat) than literal sentences (e.g., “My cat won’t eat”), the reading time difference between the literal and metaphoric conditions was eliminated in Experiment 3, in which the critical sentences of the same items were placed in a predicative construction (e.g., “My cat is my princess”). Carston and Yan (2023) performed a self-paced reading task to directly compare the processing demands of referential uses of metaphors (e.g., “The creampuff is bound to lose again”) with those of predicative uses of metaphors (e.g., “That guy is a creampuff”). The results demonstrated that, while metaphorical referring expressions took longer to process than corresponding literal expressions, no significant difference was found between the reading times of metaphorical predications and literal predications. These two studies provide evidence in line with the hypothesis that the referential metaphor construction imposes higher processing demands on the cognitive system.

One possible explanation for the observed increase in processing difficulty relates to the informational complexity of referential metaphors (Skirl, 2007). The internal structure of this type of metaphor can be decomposed into three interdependent elements, all of which are essential for comprehension. In Skirl’s (2007) example, where the metaphoric expression *elephant* is used to refer to a man (“A man lies on the sofa. The elephant is probably dreaming”), the figurative term, or the ‘vehicle’, functions as a non-repetitive anaphor which simultaneously establishes a reference to the previous discourse element *a man*, or the ‘topic’, and attributes conceptual domain-specific properties, such as being clumsy, strong, or having an exceptional memory. This relationship between the topic and vehicle terms, which a reader or listener needs to infer, is called the ‘ground’ (see Figure 1). Whereas understanding predicative metaphors only requires one to grasp the ground (i.e., establishing a mental connection between the topic and the vehicle), referential metaphors impose a dual task for the cognitive system: 1) to establish co-reference, that is, referential dependency between the topic (or ‘antecedent’) and the vehicle (or ‘anaphor’); and 2) to infer specific information about the referent (Skirl, 2007; Heredia & Muñoz, 2015).



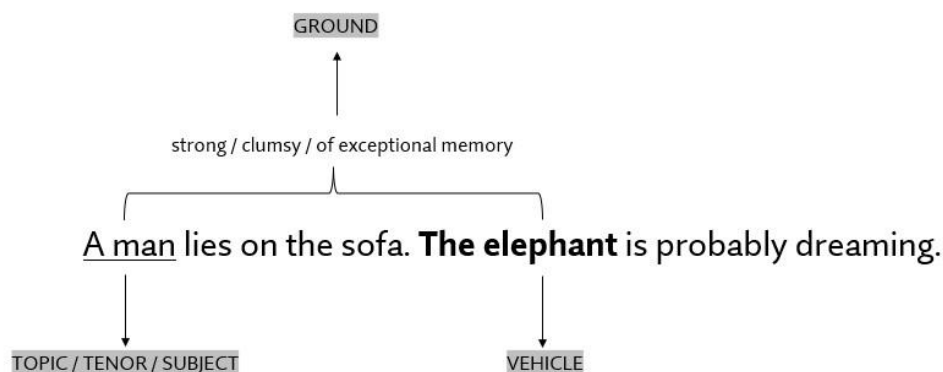


Figure 1. Constituents of a Metaphor (Authors' Own Creation; Example by Skirl, 2007)

Beyond the topic-vehicle-ground explanation, Skirl (2007) offers additional explanations in his theoretical account, which treats metaphoric anaphors as a phenomenon at the semantics-pragmatics interface, while other researchers make more isolated remarks in their studies that use this type of metaphor. However, a more integrated account is needed to capture a broader range of factors involved in referential metaphor processing. For example, if Gibbs (1990) consistently used highly conventionalized metaphoric expressions in his experimental materials, without including creative metaphors like *creampuff*, would this control have reduced processing differences between the metaphoric and literal conditions? Moreover, it may be productive to inspect whether this processing is equally demanding across different experimental paradigms, conditions, and populations. Had Gibbs (1990), Onishi and Murphy (1993) and Carston and Yan (2023) used a more sensitive methodology than self-paced reading and accounted for metaphoric anaphor processing in isolation—rather than measuring reading times for the whole sentences containing metaphoric anaphors—, it might have produced a different outcome or new insights into the specificities of referential metaphor processing.

2. Aims of the Present Study

The questions described above have thus motivated us to conduct a systematic review of the experimental research on the processing of referential metaphor, in order to provide a comprehensive account of the factors that influence it. More specifically, findings will be documented in relation to variation in participant characteristics, stimuli design, experimental methods and measurement techniques across studies. After explaining the procedure for the selection of articles (Section 3), we delineate the scope of the studies and the variables that have been investigated in relation to this phenomenon (Section 4), detailing the findings to establish whether the referential metaphor construction always incurs a higher processing cost and, if not, which variables have a facilitatory effect for the processing. We then systematically compare the reviewed experimental studies across a range of parameters, discussing the implications of taking certain methodological and stimuli design decisions (Section 5). We end the study with a discussion on the interaction of factors that might come into play when processing referential metaphors, and identify potential avenues for future research (Section 6).

By synthesizing the evidence on the different variables involved in referential metaphor processing studies, the systematic review aims to provide a tentative framework for future research. A structured overview of the field and factors involved in referential metaphor comprehension might be beneficial to theorists concerned with metaphoric reference from the perspectives of both the scientific domain of metaphor and that of anaphor. The list of relevant stimuli design and methodological considerations and possibilities are intended to inform choices of linguists and psychologists conducting experiments on (referential) metaphor processing.

3. Procedure for Article Selection

The search was conducted in the electronic databases APA PsycInfo (via ProQuest) and PubPsych using the terms '(metaphoric* AND anaphor) AND processing', '(metaphoric* AND anaphor) AND comprehension', '(anaphoric* AND metaphor) AND processing', '(anaphoric* AND metaphor) AND comprehension', '(metaphoric* AND referen*) AND processing', '(metaphoric* AND referen*) AND comprehension'. The last date of the search was 6 August 2025.

A total of 120 records were initially retrieved (80 records from APA PsycInfo and 40 records from PubPsych) and exported into the Rayyan systematic review management platform for screening. After removing the duplicates ($n = 21$) and excluding records not published in English ($n = 1$) and records of non-eligible publication types specified below ($n = 40$), abstracts were screened ($n = 58$). Out of 58 screened abstracts, 45 were further excluded for irrelevance to the review topic, and 2 were excluded due to non-eligible study designs despite referencing 'nominal metaphors' in the abstract (norming experiments in Cardillo et al., 2017; computational modeling in Su et al., 2017), leaving 11 publications for full review. It is important to note that there is considerable variation in the terminology used to refer to this phenomenon (see Appendix 1 for an overview of the terminology employed by different authors). The terminological dispersion may have resulted in the inadvertent omission of some eligible studies from the review.

Studies were eligible if they met the following criteria: (1) peer-reviewed journal articles and book chapters written in English; (2) psycholinguistic studies with an experimental design involving human participants; (3) studies approaching metaphoric reference from the anaphoric perspective. Conversely, studies were excluded if they met any of the following criteria: (1) non-peer-reviewed work, such as doctoral dissertations or proceedings; (2) theoretical, computational, or norming studies; (3) studies not related to metaphoric reference or studies investigating metaphoric anaphor within the framework of semantics and philosophy of language. The review exclusively focused on English-language publications owing to resource constraints (i.e., challenges related to costs, time, and expertise in other languages).



The selection procedure is schematized in Figure 2.

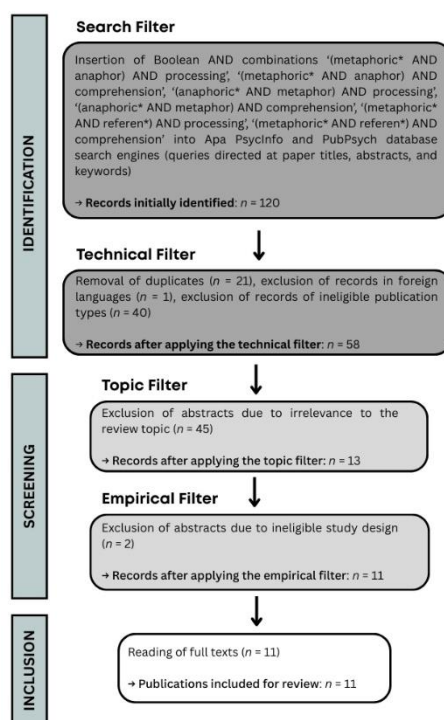


Figure 2. Procedure for the Identification of Studies

4. Overview of Selected Studies: Scope and Findings

This section provides a general overview of the selected studies. Section 4.1 outlines participants' age group (i.e., adult vs. children), participants' first language, and the language in which experimental stimuli are presented. Section 4.2 categorizes the selected studies according to their primary research focus and summarizes their findings regarding processing costs.

4.1 General overview

Table 1 presents the complete list of selected studies ordered chronologically, including information on the study population, stimuli language, and participants' language status. As shown, research on referential metaphor processing has been conducted with both adult and child populations, using experimental stimuli in English and French. Since the scientific discussion has mostly been focused on the comparison of the processing load involved in literal versus figurative language processing, the majority of the reviewed studies examined native speakers, with only two dealing with bilingual processing, in which the stimuli were presented in the participants' second language. The sections below detail the scope and findings of these studies.



Table 1. General Overview of the Reviewed Studies

Study Reference	Population	Stimuli Language	Participants' Language Status
Gibbs (1990)	Adult	English	L1 English
Onishi & Murphy (1993)	Adult	English	L1 English
Budiu & Anderson (2002)	Adult	English	L1 English
Stewart & Heredia (2002)	Adult	English	L1 English
Almor et al. (2007)	Adult	English	L1 English
Heredia & Muñoz (2015)	Adult	English	Highly fluent bilinguals in English (Exp. 1) English-Spanish/Spanish-English bilinguals (Exp. 2)
Heredia & Cieślicka (2016)	Adult	English	English-Spanish/Spanish-English bilinguals
Seigneuric et al. (2016)	Children	French	L1 French
Carston & Yan (2023)	Adult	English	L1 English
Seigneuric et al. (2024)	Children	French	L1 French
Petit et al. (2025)	Children	French	L1 French

4.2 Manipulations of context and stimulus design

A subset of the reviewed studies applied a range of contextual and stimulus design manipulations to investigate whether these factors result in decreased processing cost for referential metaphors. Apart from the manipulations on the types of target domain mappings (see Section 1 for a discussion on referring and predicating), alterations on contextual informativeness (Onishi & Murphy, 1993), referent salience (Onishi & Murphy, 1993), and metaphorical composition (Budiu & Anderson, 2002) have been made. In a follow-up to Gibbs's (1990) finding that reading metaphoric referential descriptions took longer than reading literal anaphors, Onishi and Murphy (1993) used a self-paced reading task to test the hypotheses that greater contextual support and reference explicitness eliminating the potential ambiguity about the referent would contribute to successful metaphor interpretation and would thus reduce the difference between reading times for metaphoric and literal anaphors. In the first experiment, Onishi and Murphy (1993) endowed the story characters with mutually shared knowledge of the referent (e.g., by adding phrases such as "He was well aware of Felicia's dotting attitude towards



her pets”), while the stimuli in the second experiment emphasized the referent prior to the metaphor. Contrary to what was expected, neither of these stimuli manipulations reduced the reading time difference for the target sentence between the two conditions.

Budiu and Anderson (2002) manipulated subject verb metaphoricity (e.g., “The hens/women clucked/talked noisily”) in which some readings could be considered literally anomalous (e.g., “The hens talked noisily” in the Metaphoric-Literal Condition). While no significant differences were found between the reaction times for the target sentences across conditions, individual reaction time data from the sentence reading task revealed longer reading times for metaphoric nouns than for literal nouns, and longer reading times for verbs preceded by a metaphoric noun than by a literal noun. Moreover, accuracy data from the sentence verification task showed lower accuracy for target sentences starting with metaphoric rather than literal nouns. Thus, the evidence for extra processing effort demanded by metaphoric anaphor seems to hold under different contextual conditions.

4.3 Cognitive abilities

Some of the reviewed studies explore the relationship between referential metaphor processing and cognitive abilities, such as working memory (Almor et al., 2007) and Theory of Mind (ToM) (Petit et al., 2025). In Almor et al.’s (2007) investigation, low-span and high-span subjects took part in a self-paced reading task in which the referent salience was manipulated. The data showed that low-span participants consistently read sentences with metaphoric referential descriptions more slowly than sentences with literal referential descriptions. In contrast, participants with high working memory capacity did not exhibit a slowdown in reading times for sentences with metaphoric anaphors when the context was just rich enough to facilitate anaphor resolution. However, when contextual information was overly abundant (e.g., when the context “He was as soft as a creampuff. He was too fat and was spongy through the middle. He looked like a wimpy ball of dough and seemed destined to lose” preceded the metaphoric anaphor *creampuff*), high-span participants did read sentences with metaphoric referential descriptions slower than sentences with literal referential descriptions. These results are interpreted in light of the cost-function balance view described in the discussion section.

In a recent study, Petit et al. (2025) employed referential metaphor to investigate the development of metaphor comprehension skills in childhood with regards to the age-related progression of the ToM and formal language skills. 6- to 10-year-old children listened to short stories containing synonymic (e.g., *fountain* referring back to water jets) and metaphoric (e.g., *fountain* referring back to a crying baby) references and had to select the correct referent from vignettes featuring visual metaphoric and literal representations of the referent. The results demonstrated that, while metaphoric reference comprehension was consistently more challenging than synonymic reference comprehension, this skill strengthened with age, with ToM and formal language skills playing a significant role in two different age windows: in younger children, higher ToM scores predicted greater pictorial choice accuracy and shorter response times, whereas in older children, higher formal language performance predicted these same outcomes.



4.4 Text comprehension

Since text comprehension and metaphoric anaphor understanding share similar processing mechanisms, including relying on contextual clues and inference making, research has been conducted on the link between the two abilities (Seigneuric et al., 2016; Seigneuric et al., 2024). In the experiment by Seigneuric et al. (2016), children of poor and good comprehension skills read stories that either ended with a literal or metaphorical referent to the previous mention (e.g., *snake* referring back to a viper or *butterflies* referring back to dancers) and which included different combinations of semantic categories (e.g., human topics being referred to in terms of human, animal or object vehicles). The accuracy data from the subsequent referent identification task showed a significant interaction between the reading skill group and text type: while more skilled comprehenders showed no difference in performance on texts including literal and metaphorical references, the performance of less skilled comprehenders in the metaphorical condition was lower and strongly modulated by the degree of semantic incongruence between the topic and vehicle terms of the metaphoric anaphors.

In another study, Seigneuric et al. (2024) tested the reverse causal direction by examining whether metaphoric reference resolution skills could predict reading comprehension skills in children, given that both abilities require active text-based and knowledge-based inference making. The same task was used to establish children's referential metaphor comprehension skills, and the two types of inference making ability were operationalized together with other variables such as nonverbal reasoning and vocabulary. The findings indicated that the ability to identify the referent of metaphoric anaphors showed a stronger correlation with text comprehension than literal reference resolution, nonverbal reasoning, vocabulary, or word reading. What is more, metaphoric anaphor resolution was strongly associated with the two measures of inference making, providing support for the importance of text-based and knowledge-based inference drawing in the process of resolving metaphoric anaphors.

4.5 Bilingual metaphor processing

Two of the reviewed studies provided experimental evidence on the specificity of bilingual processing of metaphoric referential descriptions (Heredia & Muñoz, 2015; Heredia & Cieśllicka, 2016). Heredia and Muñoz (2015) used a cross-modal naming task in which story passages containing a referential metaphor were presented to highly fluent L2 English bilinguals from a predominantly English-speaking area (Experiment 1) and to Spanish-English/English-Spanish bilinguals from a bilingual community (Experiment 2). As participants listened to a passage, a visual target—literally related (e.g., *pastry*) to the metaphoric anaphor (e.g., *creampuff*), figuratively related (e.g., *boxer*), or an unrelated control (e.g., *pirate* or *camel*)—appeared for naming at the metaphor offset (Experiments 1 and 2), 1000 ms post-offset (Experiment 1) or 300 ms post-offset (Experiment 2). This allowed us to account for how meaning activation unfolded in real-time processing. The results seemed to lend support to the process of direct access to metaphoric meaning under high proficiency conditions: bilinguals from predominantly English environments activated the antecedent immediately at the offset of the metaphoric anaphor (although only literal interpretation remained viable 1000 ms after the appearance of the metaphoric referential description). Meanwhile, less proficient bilinguals from Experiment 2 activated both literal and figurative meanings, particularly 300 ms post-offset.



Heredia and Cieřlicka (2016) used text-based eye-tracking data to investigate bilingual metaphoric anaphor processing in its early and late stages. English-dominant, Spanish-dominant, and balanced bilinguals read passages in English in which the preceding context was either figuratively biased (e.g., describing a soft and weak fighter) or literally biased (e.g., describing a donut and bakery shop) and ending with a critical sentence containing a metaphoric anaphor (e.g., *creampuff*). First fixation duration data revealed that meaning activation was modulated by language dominance: Spanish dominant bilinguals read literal condition targets faster than figurative ones, while English dominant bilinguals were equally fast in reading both types of targets. In other words, while Spanish-dominant bilinguals showed preferred access to the literal meanings, English-dominant bilinguals had access to both literal and figurative meanings.

Table 2 provides a summary of the variables investigated in the reviewed studies, together with the study findings.

Table 2. Investigated Variables and Findings

Variable	Study Finding*
Contextual Informativeness	Onishi & Murphy (1993) : endowing the characters with mutually shared knowledge of the referent does not reduce metaphoric anaphor reading time (between-study).
Referent Salience	Onishi & Murphy (1993) : making the referent highly salient does not to reduce metaphoric anaphor reading time (between-study). Almor et al. (2007) : moderate referent salience benefits readers with high working memory ability, but excessive referent salience results in longer reading times for sentences containing a metaphoric anaphor (between-study).
Target Domain Mapping	Onishi & Murphy (1993) : using explicit target domain mapping (i.e., predicative construction) rather than implicit target domain mapping (i.e., referential construction) reduces the processing cost (i.e., reading time) (between-study). Carston & Yan (2023) : metaphorical references take a significantly longer time to process than literal references, while no such difference is observed between metaphorical and literal predication (within-study).
Metaphorical Composition	Budiu & Anderson (2002) : verbs preceded by metaphoric nouns take longer to read than those preceded by literal nouns (i.e., spillover effect) (within-study).
Working Memory Capacity	Almor et al. (2007) : low-span readers read sentences with metaphoric anaphors more slowly than sentences with literal anaphors; in sufficiently supportive contexts, high-span readers do not take



	longer to read sentences with metaphoric anaphors than sentences with literal anaphors; in overly supportive contexts, high-span readers take longer to read sentences with metaphoric anaphors than sentences with literal anaphors (between-study).
Language Proficiency & Dominance	Heredia & Muñoz (2015) : highly fluent bilinguals show metaphoric meaning activation at the anaphor offset; balanced bilinguals show activation of both literal and metaphorical meanings, particularly 300 ms post-offset. Heredia & Cieřlicka (2016) : bilinguals more dominant in a target language show comparable first fixation durations for literal and metaphoric anaphors, while less dominant bilinguals exhibit longer first fixations for metaphoric anaphors (within-study).
Text Comprehension Skills	Seigneuric et al. (2016) : less-skilled comprehenders show significantly lower accuracy with texts containing a metaphoric reference than texts containing a literal reference; no such difference is found in more-skilled comprehenders (within-study). Seigneuric et al. (2024) : metaphoric reference resolution correlates more strongly with text comprehension than literal reference resolution, nonverbal reasoning, vocabulary, and word reading (within-study).
Theory of Mind (ToM)	Petit et al. (2025) : higher ToM scores predict a higher accuracy on the metaphoric reference task compared to the synonymic controls at 6-8 years of age (within-study).
Formal Language Skills	Petit et al. (2025) : higher formal language performance predicts higher rates of accuracy on the metaphoric reference task compared to the synonymic controls at 8-10 years of age (within-study).

* Where applicable, the brackets indicate which type of study design the particular finding was produced in. In what is labeled “**within-study designs**”, the independent variable(s) (e.g., contextual support) are manipulated within a single experiment (e.g., long-context condition vs. short-context condition), allowing direct comparisons between conditions. Meanwhile, in what is called “**between-study designs**”, variables are manipulated across separate experiments, and the findings are compared post hoc to infer differences (e.g., comparing reading time differences of an experiment which focused on the variable of referent explicitness with reading time differences of an experiment which focused on the variable of target domain mapping, as in Onishi and Murphy (1993)).



5. Systematic Comparison of Studies: Methodological and Stimuli Characteristics

The reviewed experimental studies on referential metaphor processing differ across several methodological (see Table 3) and stimuli design (see Table 4) parameters. This section aims to provide a systematic overview of these factors. It highlights key aspects that reflect potential methodological strengths and limitations. These are considerations that are crucial when comparing the results across studies, interpreting the findings, and informing the design of future experiments.

5.1 Methodological characteristics

5.1.1 Stimuli presentation modality

The items are presented in written modality in the majority of studies, with the exceptions of the work by Stewart and Heredia (2002), Heredia and Muñoz (2015), and Petit et al. (2025). The distinction is important to make as reading and listening are qualitatively different processes. When a reader encounters a metaphoric anaphor, they can engage in slower, more deliberate and controlled processing given that there is a possibility to advance at their own-pace, pause or, in the case of some tasks, re-examine previous portions of text to aid comprehension (Stewart & Heredia, 2002). Meanwhile, spoken language conveys additional information through prosodic features such as variations in word duration, pitch variations, intonation, and pauses. At the same time, however, it imposes greater demands on working memory and increases the difficulty of word recognition and decoding, which is a particularly significant consideration in research performed with L2 speakers. Because the cross-modal lexical priming task in Stewart and Heredia's (2002) investigation showed activation of metaphoric meaning at the metaphor offset—contrary to earlier evidence of referential metaphor processing difficulty (Gibbs, 1990; Onishi & Murphy, 1993)—the researchers suggested that the facilitatory effect could be related to the presentation of the metaphoric anaphor in the unfolding speech stream. Within the scope of this review, no direct investigation was carried out into the processing cost of metaphoric reference in spoken discourse as compared to its processing in written discourse.

5.1.2 Task and measurements

Steward and Heredia (2002) also attributed their results to the temporal sensitivity of the employed methodology. The methodologies used in the reviewed studies differ in their precision of temporal resolution or processing stages measured, and the data they yield provide insight into different aspects of processing. Some methods capture only global metaphor processing, as in studies that measure response times for the entire critical sentence containing the metaphoric anaphor (e.g., Gibbs, 1990; Onishi & Murphy, 1993). Sentence-level measures are useful in pointing to integrative processes and the temporal differences in literal and metaphoric reference processing, but have the limitation of conflating various subprocesses (e.g., discourse integration, lexical access) and not being sensitive enough to account for the extent to which the processing difficulty is due to the metaphor itself and for what occurs at the precise moment the referential metaphor is encountered. By contrast, tasks such as probe response paradigms or eye-tracking (e.g., Stewart & Heredia, 2002; Stewart & Muñoz, 2015; Stewart & Heredia, 2016) provide fine-grained temporal resolution, showing how metaphoric anaphor processing unfolds in real time. Yet other tasks reveal post-processing products, as in studies by



Seigneuric et al. (2016), Seigneuric et al. (2024) and Petit et al. (2025) where children had to identify a referent after receiving written or spoken input containing the referential metaphor. While accuracy measures can reflect challenges in metaphor processing, they do not provide evidence of the exact temporal point when the interpretation was made or whether it would have been made at all had the participants not been asked to make the interpretation (Seigneuric et al., 2024). Petit et al.'s (2025) study results show that the complementary measure of the time it takes to identify the referent might be a valuable methodological addition to this type of study. In this research, metaphor-related slowdowns were observed even in the second-picture selection-stage which was downstream from processing the metaphoric reference.

Table 3. Systematic Overview of Tasks and Measures

Study Reference	Modality*	Task Type**	Measure Precision***	Reported Measures
Gibbs (1990)	Written	Self-paced reading & probe recognition task	Integrated metaphor processing (target sentence)	Reading times, Probe recognition times
Onishi & Murphy (1993)	Written	Self-paced reading task	Integrated metaphor processing (target sentence)	Reading times
Budiu & Anderson (2002)	Written	Self-paced reading & sentence verification task	Isolated metaphor processing (reaction times for metaphoric nouns)	Reaction times, Truth Judgment Accuracy, Truth Judgment Latency
Stewart & Heredia (2002)	Oral	Cross-modal lexical priming (naming version)	Isolated metaphor processing (at metaphor offset)	Response times to probes
Almor et al. (2007)	Written	Self-paced reading task	Integrated metaphor processing (target sentence)	Reading times
Heredia & Muñoz (2015)	Oral	Cross-modal lexical priming (naming version)	Isolated metaphor processing (at metaphor offset)	Response times to probes, Accuracy
Heredia & Cieślicka (2016)	Written	Eye-tracking-while-reading	Isolated metaphor processing	First fixation duration,



				Gaze duration, Go-past duration, Total reading time
Seigneuric et al. (2016)	Written	Paper-based reading comprehension & referent identification task	Post-metaphor processing (referent identification)	Accuracy
Carston & Yan (2023)	Written	Self-paced reading task	Integrated metaphor processing (target sentence)	Reading times
Seigneuric et al. (2024)	Written	Paper-based reading comprehension & referent identification task	Post-metaphor processing (referent identification)	Accuracy
Petit et al. (2025)	Oral	Self-paced tablet-based listening & picture selection task	Post-metaphor processing (picture selection)	Accuracy, Response times

* This aspect refers to the modality of stimuli presentation.

** This aspect refers to the tasks that produced metaphor-related measures included in the main analysis.

*** This aspect refers to the measure of the target metaphor.

5.2 Stimuli design characteristics

5.2.1 Norming

Metaphor processing has been shown to be affected by factors such as conventionality, familiarity, and aptness (e.g., Blasko & Connine, 1993). In its explanation of metaphor processing, the Graded Salience Hypothesis (Giora, 1997, 1999, 2003, 2004) shifted the focus of the literal-figurative distinction to meaning salience. In this framework, more salient meanings—meanings that are more cognitively accessible because of their conventionality, familiarity, frequency, or prototypicality—are retrieved more quickly. Considering the potential effects of individual metaphor characteristics, the reviewed studies have also been compared in terms of whether the stimuli were normed. Two types of norming have been identified: 1) norming of the features of complete stimuli (e.g., relatedness of the prime-probe pairs in Stewart and Heredia, 2002), and 2) norming of individual metaphor-related properties (e.g., conventionality and familiarity in Onishi and Murphy, 1993). These factors are typically not included as covariates in the statistical analyses.



5.2.2 Context-target relationship and target expressions

The experimental stimuli design of the reviewed studies differs in terms of context-target variations. One frequently recurrent variation can be labeled “same context-different target sentence”, in which the preceding context story is held constant across the experimental conditions while the target sentence containing the metaphoric anaphor differs in some respect, as in studies where the antecedent (e.g., a Siamese cat) is literally (e.g., *cat*) or metaphorically (e.g., *princess*) reinstated. The advantage of this design is that, since the surrounding context is held constant across conditions, any processing differences can be attributed to the target sentence rather than contextual variation. Another stimuli design variation can be labeled “different context-same target sentence”. In these cases, the preceding story is built differently to bias either a literal or a metaphorical meaning, while the target sentence containing the metaphoric anaphor remains the same. In some studies, this variation is even greater, featuring different target sentences embedded in different contexts. While the latter two study designs allow to strongly activate metaphoric meaning and to examine how it is shaped by prior context, it is difficult to isolate the effects of the target sentence. Table 4 provides examples of the different stimuli designs.

Table 4. Examples of Different Context-Target Variations*

Same Context-Different Target Sentence	Different Context-Same Target Sentence	Different Context-Different Target Sentence
<p data-bbox="316 981 614 1048">Onishi & Murphy (1993, Exp. 1)</p> <p data-bbox="292 1088 643 1559"><i>Felicia was a feline fanatic, who had two Persians and a Siamese. The Siamese was her favorite, and she treated it like a child. One day it would not eat its food, though Felicia tried to coax it. After babying it for an hour, to no avail, she became worried. She called Joseph, her usual veterinarian, for advice. He was well aware of Felicia's dotting attitude towards her pets.</i></p> <p data-bbox="292 1592 624 1688">Literal condition: “My cat won't eat,” she informed him.</p> <p data-bbox="292 1695 639 1792">Metaphoric condition: “My princess won't eat,” she informed him.</p> <p data-bbox="292 1825 639 1892"><i>Joseph said, “Bring her in, there's an open slot at noon.”</i></p>	<p data-bbox="679 981 970 1048">Petit et al. (2025, Exp. 1 & 2)</p> <p data-bbox="667 1104 970 1373">Synonymic reference condition: Josh visits his aunt Mary, she works at the park. He wants to show her his new outfit. But there's an issue with one of the park's water jets.</p> <p data-bbox="667 1406 978 1641">Metaphoric reference condition: Josh visits his aunt Mary, he wants to show her his new outfit. But she needs to take care of her baby, he won't stop crying tonight.</p> <p data-bbox="679 1675 970 1843"><i>They chat a little, then Mary says she has to go. Josh asks why. Mary answers: "I have to take care of the fountain."</i></p>	<p data-bbox="1035 1014 1281 1081">Heredia & Cieřlicka (2016)</p> <p data-bbox="1015 1088 1302 1592">Literal condition: Stu and his buddy went to the donut shop. There was a baker who made delicious pastries. Just before they ordered, Stu went to the bathroom. When he came back his buddy was outside the bakery shop. “What happened?” Stu asked, and his friend replied, “Aw, the creampuff wasn't even that good! I can't believe it.”</p> <p data-bbox="1015 1626 1302 1883">Metaphoric condition: Stu went to see the Saturday night fights. There was one boxer that Stu hated. This guy always lost. Just as the match was supposed to start, Stu went to get</p>



		<p>some snacks. He stood in line for ten minutes. When he returned, the bout had been canceled. “What happened?” Stu asked a friend. The friend replied, “The creampuff didn’t even show up.”</p>
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* In the examples, identical context is presented in italics, while the anaphors are highlighted in bold.

5.2.3 Literal equivalence and literal reading anomaly

In the reviewed study by Carston and Yan (2023), the researchers raise the issue that referentially used metaphors are often non-comparable with their literal counterparts in psycholinguistic studies, as their non-metaphorical, or literal, equivalents do not convey strong implicatures of the metaphor. While most studies comparing metaphoric and literal reference involve a literal counterpart with low metaphoric meaning activation and greater inferential demands (e.g., “The creampuff didn’t even show up” vs. “The fighter didn’t even show up”), Carston and Yan (2023) consistently use literal paraphrases that have a rich metaphor-related content and emphasize the implicated meaning of the metaphor (e.g., “The creampuff is bound to lose again” vs. “The weak fighter is bound to lose again”). This review of the empirical studies on referential metaphor reveals that, apart from Carston and Yan (2023), no studies consistently employ literal equivalents. Another aforementioned aspect that varies across the reviewed studies is whether the critical sentences showcase literal reading anomalies. While the stimuli of some studies include critical targets that admit both a metaphorical and a literal reading (e.g., “The hens clucked noisily”, where *hens* can refer to birds or women), other researchers use sentences that cannot be interpreted literally (e.g., “The creampuff didn’t even show up”). This is a significant stimuli design feature that can influence the speed of activating a metaphorical meaning or identifying the referent.

5.2.4 Target position

Metaphoric anaphor placement in the initial or later sentence position can also be considered a potential factor in processing metaphoric anaphors. Gerring and Healy (1983) ran a self-paced reading time experiment to investigate whether the position of the metaphor at the beginning of the sentence as subject or at the end of the sentence following a context will facilitate or hinder the comprehension of the metaphor. The results showed that target sentences like “The train followed the parallel ribbons” (i.e., non-referential metaphor in the object position) yielded significantly shorter reading times than target sentences like “The parallel ribbons were followed by the train” (i.e., non-referential metaphor in the subject position). However, when Carston and Yan (2023) applied this manipulation to their experiment on referential metaphors (e.g., “The toxic reptile is causing trouble again” vs. “I really must try to avoid the toxic reptile”), metaphoric anaphors still took a significantly longer time to process than their literal counterparts.



Table 5. Systematic Overview of Stimuli Design Features

Study Reference	Stimuli Norming	Target Expression s*	Context-Target Relationship	Literal Reading Anomaly**	Target Position	Literal Equivalence
Gibbs (1990)	No (Exp. 1 & 2) Yes: Metaphor Conventionality & Aptness (Exp. 3), Probe Word Predictability (Exp. 3)	Reinstated (e.g., <i>boxer</i> → <i>creampuff</i> / <i>fighter</i> / <i>referee</i>)	Same context-different target sentence	Yes (e.g., <i>The creampuff didn't even show up</i>)	<i>Unclear</i>	No
Onishi & Murphy (1993)	Post-norming: Metaphoric Reference Comprehensibility, Context-Target Consistency (Exp. 1)	Reinstated (e.g., <i>Siamese</i> → <i>princess</i> / <i>cat</i>)	Same context-different target sentence	Yes (e.g., <i>The rooster didn't work</i>)	Subject/verb complement (Exp. 1 & 2) Subject complement (Exp. 3)	No
Budiu & Anderson (2002)	Yes: Metaphor Goodness, Metaphor Familiarity (Exp. 1), Probe Truthfulness (Exp. 1)	Reinstated (e.g., <i>Cinderella</i> → <i>swan</i> / <i>girl</i>)	Same context-different target sentence	Yes (e.g., <i>The hens talked noisily</i>)	Subject	No
Stewart & Heredia (2002)	Yes: Prime-Probe Pair Associativeness (Exp. 1)	N/A	N/A	Yes (e.g., <i>My rooster broke</i>)	Subject/verb complement	N/A
Almor et al. (2007)	Yes: Story Sensibility (Exp. 1)	Reinstated (e.g., <i>boxer</i> → <i>creampuff</i> / <i>fighter</i>)	Different context-different target sentence	Yes (e.g., <i>The creampuff didn't even show up</i>)	<i>Unclear</i> (Exp. 1) Subject (Exp. 2)	No
Heredia & Muñoz (2015)	No	N/A	N/A	Yes	Subject/verb complement	N/A
Heredia & Cieřlicka (2016)	No	Identical	Different context-different target sentence	Yes	Subject/verb complement	N/A
Seigneuric et al. (2016)	Yes: Metaphoricity of Target Nouns, Metaphor Aptness	Reinstated (e.g., <i>viper</i> → <i>snake</i> , <i>dancers</i> → <i>butterflies</i>)	Different context-different target sentence	Yes (e.g., <i>a dictionary <...> knew all the answers</i>)	Subject/verb complement	N/A
Carston & Yan (2023)	Yes: Naturalness & Comprehensibility of Target-Determiner Combinations, Metaphor Familiarity &	Reinstated (e.g., <i>Ralph</i> → <i>clanking tank</i> / <i>noisy machine</i>)	Same context-different target sentence	Yes (e.g., <i>The creampuff is bound to lose again</i>)	Subject/subject complement (Exp. 1) Subject/subject complement/object (Exp. 2)	Yes



	Meaningfulness (Exp. 1)					
Seigneuric et al. (2024)	No	Reinstated (e.g., <i>viper</i> → <i>snake</i> , <i>dancer</i> → <i>butterfly</i>)	Different context- different target sentence	Yes (e.g., <i>a dictionary <...> knew all the answers</i>)	Subject/verb complement	No
Petit et al. (2025)	No	Identical	Different context-same target sentence	<i>Unclear</i>	<i>Unclear</i>	N/A

* This aspect applies to experiments with at least two sets of comparable stimuli. For this reason, N/A is marked for the experiments using cross-modal lexical priming, for example.

** This aspect applies to studies that employ at least one item with a literal reading anomaly.

6. Discussion: Procedural Costs of Metaphoric Anaphor

This systematic review of eleven experimental studies on referential metaphor processing set out to determine whether the increased processing demands persist under varying experimental conditions, including variation in participant-related characteristics, item design, and operationalization of processing difficulty. The analysis revealed that studies assessing processing times in an integrated, sentence-level manner mostly reported higher processing effort for sentences containing metaphoric anaphors than for sentences containing literal anaphors (e.g., Gibbs, 1990; Onishi & Murphy, 1993; Carston & Yan, 2023). However, studies examining metaphoric anaphor processing at a fine-grained, isolated level mostly showed immediate activation of the metaphoric referent in highly proficient subjects (e.g., cross-modal lexical priming in Stewart and Heredia, 2002, and Heredia and Muñoz, 2015). Language dominance and proficiency, working memory capacity, ToM, text comprehension skills and formal language skills are the individual differences shown to modulate the cognitive demands of referential metaphors.

The findings suggest that the topic-vehicle-ground explanation, while informative, does not entirely capture the complexity of referential metaphor processing. For instance, this line of interpretation proposes that the main difficulty lies in the added mental task of linking the topic and the vehicle. Interestingly, however, making the referent more explicit in Onishi and Murphy's (1993) study has not eliminated the reading time differences between the literal and metaphoric anaphor conditions. As mentioned earlier, Petit et al. (2025) have offered evidence that metaphoric anaphor-related slowdowns were reported even in the posterior referent selection task, after the topic-vehicle matching process had already supposedly been completed.

One possibility, albeit a tentative one, is that part of the results by Onishi and Murphy (1993) may be accounted for by the individual differences in the working memory ability. In regard to this factor, Almor et al. (2007) explored the interaction between contextual informativeness of the discourse and this cognitive ability. Drawing on the cost-function balance framework (Almor, 1999, as cited in Almor et al., 2007), they showed that the balance between processing effort and discourse function (e.g., describing a referent or emphasizing certain information about a referent) varies as a function of



working memory ability. From this perspective, since readers with high working memory capacity make better use of contextual cues and thus experience enhanced inferential processing, they might process the metaphoric anaphors more easily than low-span readers. Nevertheless, this is applicable only if the context is supportive enough; if the context renders the metaphoric anaphor redundant, a compromise in the discourse function may cause imbalance and increase the processing cost. On the other hand, low-span readers may experience difficulties with metaphoric anaphor processing in both moderately supportive or redundant contexts. Thus, the redundancy resulting from excessive referent explicitness may have placed some participants in Onishi and Murphy's (1993) study at a disadvantage.

Taken together, the analysis of Almor et al. (2007) and the effects of numerous other individual differences and contextual and stimuli design variables suggest that a more satisfactory explanation of how metaphoric anaphors are processed might lie in an interactive approach, in which comprehension can be viewed as a dynamic process modulated by multiple variables and their configurations. The theoretical framework proposed by Skirl (2007) provides additional insights into a possible temporal dimension of referential metaphor processing. It shows that textual cues can determine whether the reactivation of the antecedent and the recovery of the metaphor's descriptive content will unfold sequentially or in parallel. By way of illustration, in a sentence like "A man lies on the sofa. The elephant is probably dreaming", where there is a lack of a larger linguistic context or communicative context to relate such different ontological categories as 'MAN' and 'ELEPHANT', the definite article serves as the sole indication that the referent should be accessible in the reader's mental representation (Skirl, 2007). A sequential process might be initiated in this particular case, whereby the reader relies on the definite NP to relate *the elephant* to *a man*, with the retrieval of the semantic content remaining challenging. However, in "A strong man lies on the sofa. The elephant is probably dreaming", the recovery of the antecedent is favored by the adjective *strong* that makes salient a property shared by the two categories, as well as by the verb *dreaming* which presupposes a human subject. These elements facilitate the activation of the metaphoric descriptive content and, in turn, facilitate the recovery of the antecedent.

Thus, it is necessary to construct a flexible model that would allow us to acknowledge the particular and case-dependent nature of metaphoric anaphor processing, where the interaction of stimuli-related variables, metaphor-related variables, non-linguistic individual differences, linguistic background, and pragmatic variables (specified in Figure 3) contributes to the differing degrees of processing demands across referential metaphors. The framework proposed in Figure 3 offers a preliminary integrative account of the factors that can affect referential metaphor processing, including a meaningful configuration reported in Almor et al. (2007). However, further empirical work is required to enrich it with concrete mechanisms and extra dimensions like the order of processing, causality and directionality (e.g., a bidirectional relationship between metaphoric anaphor resolution and text comprehension skills, as shown in Seigneuric et al., 2016, and Seigneuric et al., 2024).



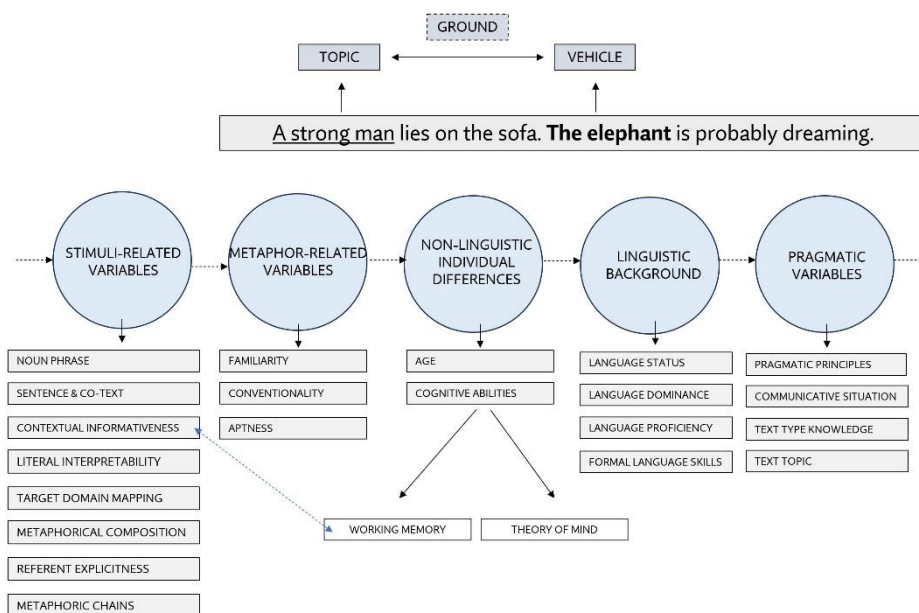


Figure 3. An Interactive Framework of Referential Metaphor Processing

Apart from the exploration of some of the configurations between the variables provided in Figure 3, future research on metaphoric anaphor processing could benefit from the use of online methodologies that enable a more direct examination of the referent identification process (e.g., through regression analyses in eye-tracking). It would also be useful to develop methods that would allow us to tap into the late metaphoric anaphor processing. Additionally, given the evidence that metaphoric anaphor resolution skills increase with age (Petit et al., 2025), more studies are needed on bilingual metaphor processing to determine whether this ability also increases with language proficiency. A direct comparison of metaphoric reference understanding in spoken and written discourse is also needed to better determine the effects of language modality. Finally, it is imperative to carry out corpus studies in various languages to objectively determine the degree of prevalence of referential metaphor in discourse. Following a search for a subset of metaphor-annotated nouns in an existing metaphor corpus, researchers could calculate the proportion of referential versus non-referential uses of metaphors using the surrounding context. If this linguistic phenomenon is shown to be relatively uncommon, the observed increase in processing cost might be attributable, at least in part, to the unexpectedness of encountering this linguistic form during an experiment.

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Appendix 1

Author(s)	Employed term(s)
Gibbs (1990)	figurative referential descriptions = metaphoric referential descriptions and metonymic referential descriptions
Onishi & Murphy (1993)	referential metaphors
Budiu & Anderson (2002)	anaphoric metaphors
Steward & Herredia (2002)	metaphoric reference / metaphorical reference / reference metaphor / metaphorical referent to the antecedent topic
Almor et al. (2007)	metaphoric anaphors / metaphoric reference
Skirl (2007)	metaphorical anaphors
Heredia & Muñoz (2015)	metaphoric referential description / anaphoric metaphor
Heredia & Cieřlicka (2016)	metaphoric reference / metaphoric referential description / anaphoric metaphor
Petit et al. (2025)	metaphoric reference
Seigneuric et al. (2016)	(referential) nominal metaphors / metaphorical reference
Seigneuric et al. (2024)	(referential) nominal metaphor / referential metaphor

